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**Investigating barriers and strategies to enhance the
implementation of Sustainable Stormwater Solutions**
A Qualitative analysis within stormwater management

Master's thesis in Infrastructure and environmental engineering

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MASTER'S THESIS ACEX30

Investigating barriers and strategies to enhance the implementation of Sustainable
Stormwater Solutions

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Abstract

This study investigates barriers hindering the implementation of sustainable stormwater solutions and promotes their adoption. By identifying and understanding these barriers, including previously unrecognized factors, insights into the planning and decision-making processes of stormwater management are provided. Findings from stakeholder interviews reflect established barriers in prior research while revealing overlooked factors like communication and operation and maintenance as significant barriers. Legislative ambiguities emerge prominently, suggesting clearer legal directives could mitigate several challenges. While planning processes align with existing literature, variations exist, particularly in overlapping design and detailed planning phases. Overcoming found barriers requires solutions such as enhanced visualization and early involvement of operations and maintenance. Incorporating the operational aspect in stormwater assessments ensures proposed solutions can be effectively implemented. Strategic documents at the municipality level can address institutional and governance barriers but also raise knowledge of the importance of stormwater related issues. Ultimately, sustainability's definition varies among stakeholders, highlighting the need for a precise and unified understanding to consistently promote effective stormwater management.

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1. Introduction

The last couple of decades cities have become more and more urbanised. With a growing urban density, the impermeable surface extends and reduces the capacity of infiltration (Science, 2016) . At the same time, another problem that arises as a result of climate change is the intensification of intense rainfall episodes that are alternated with longer periods of drought (Myhre et al., 2019). These two changes in the environment contributes together with a greater risk of flooding in our cities. Flooding is not only seen as a natural disaster, but it also contributes to damage on infrastructure and housing (Petit-Boix et al., 2017). To solve this there is a greater need for more sustainable stormwater management, as for example green infrastructure and more nature-based solutions (Dhakal & Chevalier, 2017).

Having recognized that pipe-based drainage systems alone are insufficient to address the challenges ahead, cities are exploring new methods for stormwater management that also support multiple sustainability goals (Liu et al., 2019). Therefore in recent decades, there has been a growing interest in nature-based infrastructures (Heidari et al., 2023). This trend has been accompanied by an increase in the variety of terms used to describe these installations. This shift reflects a broader recognition of the importance of sustainable and environmentally integrated solutions in infrastructure development.

Incentives for retaining stormwater within the urban landscape, rather than draining it out of cities, include preventing flooding, controlling pollution, utilizing stormwater as a resource, and creating green and blue spaces that enhance urban comfort (Ljung et al., 2016). These measures not only mitigate the risk of floods but also improve water quality, provide additional water resources, and contribute to the aesthetic and recreational value of urban environments. By integrating stormwater management into city planning, municipalities can foster more resilient, sustainable, and pleasant urban areas (Cui et al., 2021).

Despite the growing recognition of the value of sustainable drainage solutions, the transition from traditional piped drainage systems to green infrastructure remains slow in Europe and other parts of the world (Ljung et al., 2016). Although the benefits of green infrastructure are increasingly acknowledged, the adoption rate is still lagging, indicating that significant challenges and barriers to widespread implementation persist (Heidari et al., 2023). According to previous research on various barriers, the existence of institutional barriers among the numerous stakeholders that are involved in the stormwater management process is a significant contributing factor to the slow progress (Ljung et al., 2016). It includes both technical aspects and highlights a complex management issue.

To develop strategies to overcome the problem, it is essential to identify and investigate the barriers. Since this remains challenging, further investigation is needed to uncover unidentified barriers that may hinder the implementation of more sustainable stormwater solutions. Additionally, understanding the planning and decision-making process, from detailed planning to operation and maintenance, is crucial for fully grasping the issue. Furthermore, defining what constitutes a sustainable stormwater solution and identifying

its key parameters are essential steps to enhance the implementation of more sustainable stormwater solutions.

1.3 Aim

The aim of this study is to investigate how to enhance the implementation of sustainable stormwater solutions in urban areas. This will be addressed through the following objectives.

The objective of this study is:

- To investigate barriers hindering the implementation of sustainable stormwater solutions and promote their adoption. This involves identifying and understanding these barriers, including those that have yet to be fully recognized.
- The study seeks to gain insights into the planning and decision-making processes involved in stormwater management, from detailed planning to operation and maintenance.
- Provide a definition of what different stakeholders believe that a sustainable stormwater solution is and identify its key parameters.

1.4 Limitations

- This investigation will be limited to Sweden's building regulations, guidelines, and planning process.
- The thesis is limited within the planning process, specifically starting from the detailed planning stage and extending through to operation and maintenance. It will not consider earlier stages, such as the comprehensive plan.
- The thesis will be confined to the planning process, specifically starting from the detailed planning stage and extending through to operation and maintenance, rather than addressing the comprehensive planning phase.
- Only stormwater investigations up to design rainfall will be analysed and not cloudburst.
- The study is geographically limited to regions in Sweden. As a result, the findings may not be generalizable to other nations with different environmental, regulatory, and socio-economic contexts.

1.5 Research questions

The research questions that should be answered within this thesis are the following:

1. What is the planning and decision-making process for the implementation of stormwater solutions in Sweden?
2. What are the main challenges and barriers faced by stakeholders (i.e. municipalities and consultants) in the implementation of sustainable stormwater solutions?

3. How can these challenges and barriers be overcome in order to promote the implementation of sustainable stormwater solutions? What strategies can be applied?
4. Which are the most crucial parameters when selecting a stormwater solution?
5. What is the definition of a sustainable stormwater solution from the perspective of different stakeholders?

2. Background

This section defines the concept of stormwater and clarifies what this thesis considers a sustainable stormwater solution. It will be followed by a chapter outlining the laws and regulations surrounding stormwater management in Sweden. Additionally, the chapter will illustrate the planning process, from detailed planning to operation and maintenance. Various sustainable stormwater solutions will be presented. Finally, previous research on barriers within stormwater management will be described.

2.1 Definition of Stormwater

Stormwater refers to water that results from rain, as well as melting snow and ice, in urban areas. (Holm et al., 2014). It can infiltrate into the soil, but in urban areas, stormwater runoff is more likely to occur because it flows over impervious surfaces such as roofs, driveways, and roads (Lee & Kim, 2012). The stormwater runoff is traditionally led away with a series of pipes, that works as the stormwater drainage network, to the nearest natural water bodies. Before the urbanisation the stormwater was naturally handled by the infiltration and evaporation that nature contributed with. But as urbanization started, the more impermeable surfaces occurred. (European Commission, 2015) Therefore, a large amount of stormwater in urban areas, will have a large effect on the area such as flooding (US EPA, 2015). During larger stormwater events, the pipes do not have time to divert the water, which contributes to flooding in the cities (Göteborgs Stad, n.d.-a).

Stormwater contributes with several risks and challenges. One significant risk, as previously mentioned, is flooding, which can have a detrimental impact on urban areas. Other risks associated with stormwater are water pollution and stream erosion. When it rains, stormwater flows over surfaces such as roads, parking lots and rooftops, picking up various pollutants along the way (Al Bakri et al., 2008). The untreated stormwater can then contaminate natural waterbodies, which can lead to damage to the aquatic ecosystem. Stream erosion on the other hand, is an ongoing natural process in which sediments are continuously carried away and deposited by the flow of water, regardless of its strength or size (Fan & Li, 2004). However, when a watershed becomes urbanized, significant changes can occur in both the amount of sediments being transported and the flow patterns within the watercourse.

There are various classifications of stormwater, commonly referred to as rainfall events such as 10-year event and 100-year event. A 10-year event denotes a specific amount of rainfall that, on average, occurs once every ten years (SMHI, 2015). In simpler terms, a 10-year event can be considered twice as intense as a 1-year event, while a 100-year event is approximately twice as intense as a 10-year event (Svenskt Vatten, 2016).

2.2 Definition of a sustainable stormwater solution

Sustainability is a comprehensive concept that encompasses various interpretations depending on the specific context in which it is employed. According to the Brundtland Commission (1987), sustainability is defined as “Meeting the needs of the present without compromising the ability of future generations to meet their own needs”.

When applied to stormwater management, sustainability often refers to the implementation of a sustainable stormwater strategy (Naturvårdsverket, 2023).

Within this thesis, a sustainable stormwater solution refers to the reduction of polluted stormwater discharge into surface water and groundwater, as well as reduced risk of flooding that can pose threats to the environment, properties, and community functions (Naturvårdsverket, 2023). Moreover, these solutions aim to foster urban ecosystems and facilitate cities' adaptation to a changing climate. This can be done using nature-based solutions (NBS) and by designing waterways to allow water to be delayed and diverted. From the European Commission (2015) the definition of a nature-based solution is defined: "Nature-based solutions aim to help societies address a variety of environmental, social, and economic challenges in sustainable ways. They are actions inspired by, supported by, or copied from nature; both using and enhancing existing solutions to challenges, as well as exploring more novel solutions, for example, mimicking how non-human organisms and communities cope with environmental extremes".

2.3 Laws and regulations for stormwater management

Stormwater management is dependent on several different regulations that set specially formulated requirements in different situations (Boverket, 2023c). In this chapter, a short review of the EU's water directive, with a supplemented flood directive will be presented. Furthermore, a review of the effecting Swedish laws as the Environmental Code, (EC), the Public Water Services Act, (LAV) and the Swedish planning and building act (PBA) from a stormwater perspective will follow.

2.3.1 EU Directives

To reach an equal water management between countries, the members of the European union (EU) have set up the water directive (Vattenmyndigheterna, n.d.). The EU's water directive has then been supplemented, with for example the flood directive. All supplemented legislation has the same purpose, to protect and manage our water environments. For clarification, a "directive" is a form of legislation that lays out a requirement for member states of the European Union (European Union, n.d.). Nonetheless, each nation must create its own laws to achieve these objectives. Directives themselves are not directly legally binding but the national laws created to implement them are legally binding. In contrast with for example EU regulations, which are directly applicable and legally binding in all EU member states from the moment they are enacted. Regulations are laws that apply uniformly across all member states without requiring any national implementing legislation.

The Water Directive

The Water Directive is a framework directive for water management (Vattenmyndigheterna, n.d.). This directive has been established to ensure ecologically sustainable management, protection of the water resource and that the quality of the Union's water resources is improved (2000/60/EG, 2000). The provisions of the directive have been mainly applied in Swedish legislation through the provisions on environmental quality in chapter five of the Environmental Code (SFS 1998:808, 1998), the Water management regulation (SFS 2004:660, 2004), the laws on water delegates (SFS 2017:872, 2017) and authority regulations (Söderasp et al., 2023). The goals are reached by the implementation of the action plans, which is specified in the management plans.

The action plans are the focus of the water directives systematics. Under Swedish legislation, the water management regulation (SFS 2004:660, 2004) and chapter five of the Environmental Code (SFS 1998:808, 1998), contain measures that implement the requirements for the action programs.

The flood directive

Flood risk assessment and management is intended to be facilitated by the flood directive, which aims to lessen the negative impact of floods on human health, the environment, cultural heritage, and economic activity within the union (Söderasp et al., 2023). There is a strong relationship between the flood directive and the water directive since the work with the assessment and management of flood risks is closely linked to the management of water bodies. In the Swedish law, the directive is being employed through regulations in the regulation on flood risks (2009:956, 2009) in the Swedish agency for community protection and preparedness regulations (MSBFS 2013:1, 2013). This is then managed and applied at the county boards planning for managing flood risks (Söderasp et al., 2023). The task of determining the potential locations of floods actions is undertaken by the member states through methodically mapping flood risks, and creation risk management strategies for those locations (MSB, n.d.).

2.3.2 Laws in Sweden

The laws that regulate stormwater management, set requirements for water quality, and state the responsibilities for the stormwater are the Public Water Services Act and the Swedish Environmental Code (EC) (Boverket, 2023c). The Swedish planning and building act (PBA) then provide the municipality with the planning instruments needed for management.

The Public Water Services Act, (LAV)

The establishment of an operational area for water, sewage, or stormwater by the municipality is governed by the Public Water Services Act (LAV) (Boverket, 2015). When stormwater needs to be diverted within an existing or planned integrated development due to concerns about human health or the environment in general, area regulation for stormwater must be defined. This means that specific rules, guidelines, or policies regarding the management and control of stormwater in a particular area need to be established. This could involve defining how stormwater is collected, treated, and discharged to prevent flooding, pollution, and other related issues within that area.

LAV states that it is the owner of the general utility facility that oversees setting up the water services that are included in the region of operation (SFS 2006:412, 2006). This stakeholder is usually called “Water Utility Manager” and can be the municipality or a municipal company that is obliged to take care of the stormwater within the area of operation. The water utility manager holds the task of ensuring that rainfall, that is drained from public places and neighbourhood land, is handled by the public sewage system. In situations where the LAV is not applicable, when the land is not public, it is the individual property owners' duty to manage stormwater (Boverket, 2023b).

The Environmental Code, (EC)

The Environmental Code was implemented with the purpose to promote sustainable development, which means that current and future generations can live in a healthy and

good environment (SFS 1998:808, 1998). With the EU's water directive from the year 2000, a common regulatory framework has been established, and applies to all water districts in Europe. The Environmental Code affects all types of measures, regardless of whether they are a part of a person's daily activities or of business-related activities (Naturvårdsverket, n.d.). Furthermore, all EU-directives that are within the environmental-divisions are being incorporated within the environmental code. For water-related subjects, including stormwater management, pipeline network maintenance, sewage treatment plant operations, raw water withdrawal and transfer, and protection of water sources, are covered by the Environmental Code (Svenskt Vatten, 2022).

A fundamental part of the Environmental Code's framework is the Environmental Quality standards. It is stated in the Environmental Code under chapter five in paragraph one that "The government may, for certain geographical areas or for the whole country, issue regulations on the quality of land, water, air or the environment in general, if it is necessary to permanently protect human health or the environment or to remedy damage or inconvenience to people or the environment (Environmental quality standards)" (SFS 1998:808, 1998). Environmental quality standards, or EQS, are rules regarding the general state of the land, water, and air quality (Boverket, 2024). It is furthermore stated in the EC under chapter five in paragraph two what the EQS shall state, which can be summarised to either permanently preserve the environment or human health, or to address any harm or inconvenience to either of these areas. Ordinances and regulations determine the EQS, and is decided by the government, or by other authorities delegated to the task by the government.

The Swedish planning and building act, (PBA)

The Swedish planning and building act (PBA) is the framework for physical planning and is used as an instrument for the control of land and water use in the municipality (SFS 2010:900, 2010). Important to highlight is that there are no specific provisions on stormwater in the PBL (Söderasp et al., 2023). In Boverket, which is a Swedish authority responsible for issues related to housing and urban planning, these building standards can be found. The building standards possess guidelines in addition to a general recommendation about the wastewater control (BFS 2011:6, 2011). The management of stormwater is instead often included as part of the application of the regulations on sewage and flooding or the law's provisions on water management.

According to the PBA, planning and examination should focus on using land and water areas for the purpose or purposes for which they are most suitable, taking into consideration the needs, location, and nature of the region (SFS 2010:900, 2010). In terms of location, considerations of the soil's sensitivity to impact, ecological conditions, and the effects upon the ground below the ground surface (Söderasp et al., 2023). The provisions on management of land and water areas shall be used, and sections from the environmental code. Furthermore, land may be claimed for development only if the land from a general point of view is suitable for the purpose (SFS 2010:900, 2010). The aspects that should be addressed in this matter is the strive for a sustainable and good housekeeping with the ground, water, and environment condition.

PBA outlines that planning for stormwater must consider municipal and regional conditions, natural and cultural assets, environmental and climatic considerations, and planning in accordance with the act. (SFS 2010:900, 2010). The preparatory work to the current provision mentions that by hardening the soil surface through urban development counteracts the possibility of maintaining a good water balance (Söderasp et al., 2023). It is therefore mentioned that municipalities with support from the planning determination, can set aside areas for construction of facilities that are needed for local treatment of stormwater. The municipality is obligated to show that a stormwater investigation has been performed and will work as a guide for how the stormwater will be managed within a plan through planning regulations or directly in a building permit case (SFS 2010:900, 2010). Additionally, in advance notice if the action is to be taken outside an area with a detailed plan.

2.4 Stormwater management today

Stormwater affects the whole society and the responsibility for content, size, and direction within a certain catchment area lies upon both municipalities, property owners and operators (SOU 2014:50, 2014). Work towards a more long-term management of stormwater involves strategic planning, development, and management of green and blue infrastructure, as well as water resources. This is accomplished through various types of management plans, policies, and tools at the national, regional, and local levels (Naturvårdverket, n.d.). This section provides a brief overview of how it is performed in Sweden, also an illustration of the structure is provided in Figure 1. In the figure, those circles shown in white are not legally binding, while those in blue are legally binding

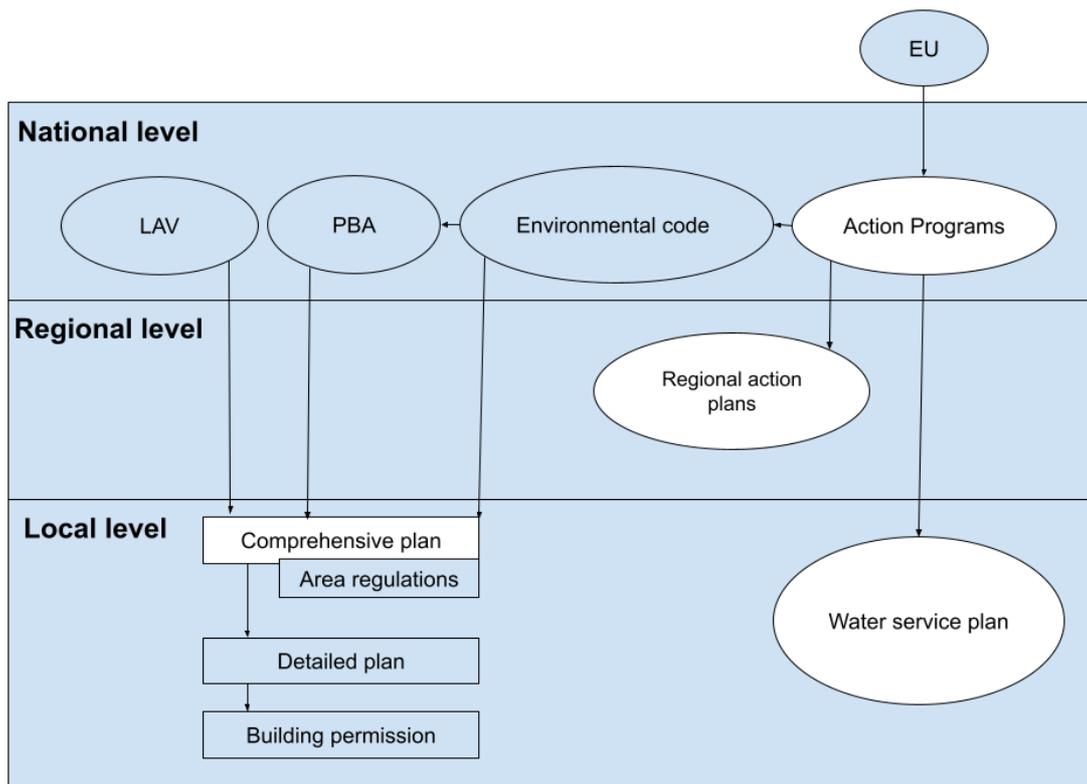


Figure 1: The stormwater management structure in Sweden. Based on the literature found and described in the sections below

2.4.1 National management level

Regulation on authorities' climate adaptation work (SFS 2018:1428, 2018) are governing authorities' work with climate adaptation. According to the regulation authorities must, initiate, support and evaluate the work with climate adaptation within their area of responsibility. The water authority has the responsibility to draw up action programs (2021/22:MJU5, 2021). There are five water districts in Sweden, which are separated based on catchment areas, illustrated in Figure 2.

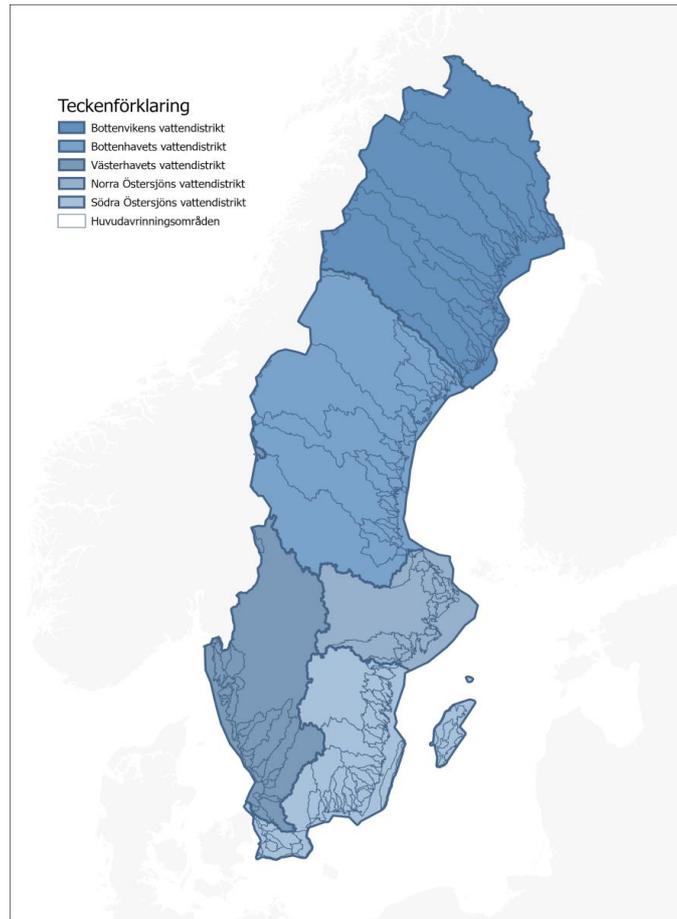


Figure 2: The Five water districts in Sweden (Lise Svensson/Boverket, 2024).

A county board recognized as the water authority oversees establishing and enforcing action programs and follow-up actions, as well as classifying the state of specified water bodies (Naturvårdverket, n.d.). The plans contain information about the laws from the Environmental Code (SFS 1998:808, 1998) that must be followed and what measures authorities or municipalities need to adopt. It must also be stated which authorities or municipalities who need to take the necessary measures and when the measures need to be implemented (Naturvårdverket, n.d.). The national authorities' action plans might therefore look different due the large differences in responsibility. Furthermore, the measures must be subject to impact analyses, the effect must be analysed in relation to frameworks of EU and that funding for the measures must be proposed. An action program's material needs to be updated at least once per action cycle, or once every six years. Each district's management plans, environmental quality standards, and action plans are decided at the conclusion of a six-year cycle.

Furthermore, the Planning and Building Act designates county administration boards as the entities responsible for defending and coordinating state interests during the planning phase (Boverket, 2023d). The county administration boards can be viewed as the state's extended arm in the various regions, and within their respective purviews, the central government authorities are obligated to provide the county administrative boards with the data they need for this purpose.

2.4.2 Regional management level

From the action program, the county administration boards must follow up at least 12 of the suggested actions (Naturvårdverket, n.d.). The county administration boards have prioritized and established orientations in their regional action plans that, in many ways, represent the circumstances and regional issues of the counties. The binding regional plan is planned in a non-judicial manner (Söderasp et al., 2023). The essential characteristics for the use of land and water areas, as well as the rules for the placement of buildings and other structures that are important to the county, must be stated in the regional plan. The intention is for the plan to provide guidance for municipal authority's decisions on general plans, detailed plans, and area regulations. The significance of the region should be given substantial weight when drafting the different plans, even if the regional plan is merely indicative. In other words, the regional water supply plan is a planning document that is not legally binding.

2.4.3 Local management level

According to the Swedish environmental goals, all municipalities should integrate a sustainable stormwater management in their planning of new buildings or in the case of significant changes to existing buildings by 2023 (Sveriges miljömål, 2023). Furthermore, From the previously mentioned action program, the municipality must follow up on at least 8 of the of the suggested actions (Naturvårdverket, n.d.). From 1 January 2023, but with application from 1 January 2024, new regulations apply with the requirement that each municipality must have an up-to-date water service plan (SFS 2006:412, 2006). The water service plan must contain the municipality's long-term planning of how public water services must be provided. A water service plan must also contain the municipality's assessment of what measures are needed for the public water facilities to function and increase the load due to torrential rain. The municipal council decides on the adoption and amendment of the water service plan and must test it at least every four years.

The municipal comprehensive plan is one of the most crucial instruments for strategic planning in the municipality (Naturvårdverket, n.d.). Although the comprehensive plan is not legally enforceable, it is a valuable tool for providing direction for more in-depth planning. The general plan's positions serve as a reference for the municipality when making choices about area regulations, detailed plans, building permits, and other permit examinations. As a basis for the comprehensive and detailed planning, the municipalities can choose to produce plans over the water and sewage, policies, programs, and tutorials (Havs och vatten myndigheten, 2020). A municipal plan over the water and sewage is a governing document which describes how the supply is to be organized throughout the municipality, both inside and outside the municipal activity area.

However, on a local level, the responsibility for handling stormwater looks a little bit different depending on where the water is in the landscape (Naturvårdverket, n.d.). Stormwater management is the municipality's duty if it flows through what is considered public land. This is accomplished using the general stormwater facility of the water utility manager. The water main's accountability starts at the point of connection to the public facility and doesn't stop until the water has undergone purification or treatment. When stormwater flows on privately owned land, however, the responsibility falls on the property owner. The owner of the area is responsible for handling the stormwater, so it does not create nuisance to the environment. What conditions apply to the property will

determine which option is best. If just leading the water out onto the property is not feasible, then the stormwater may need to be directed to a delay magazine or an infiltration facility. In today's system solutions, house foundation drainage must not be diverted to the wastewater line.

2.5 The planning process for stormwater

All municipalities must illustrate in their detailed planning how stormwater management will be addressed (Boverket, 2023b). Furthermore, with planning regulations, the municipality can create the conditions needed to implement a certain stormwater solution. To plan an area in detail, the municipality must clarify whether the planning area is part of an operational area for stormwater or if a new operational area must be formed. The requirements then for plan regulations may vary depending on whether the plan area has an operational area for stormwater in accordance with the Public Water Services Act or not. An overview of the stormwater planning procedure will be provided in this chapter, where it is divided into the detailed planning process, followed by design and pre-design, which is then leaning into the phase of construction and management. The procedure is illustrated in Figure 3.

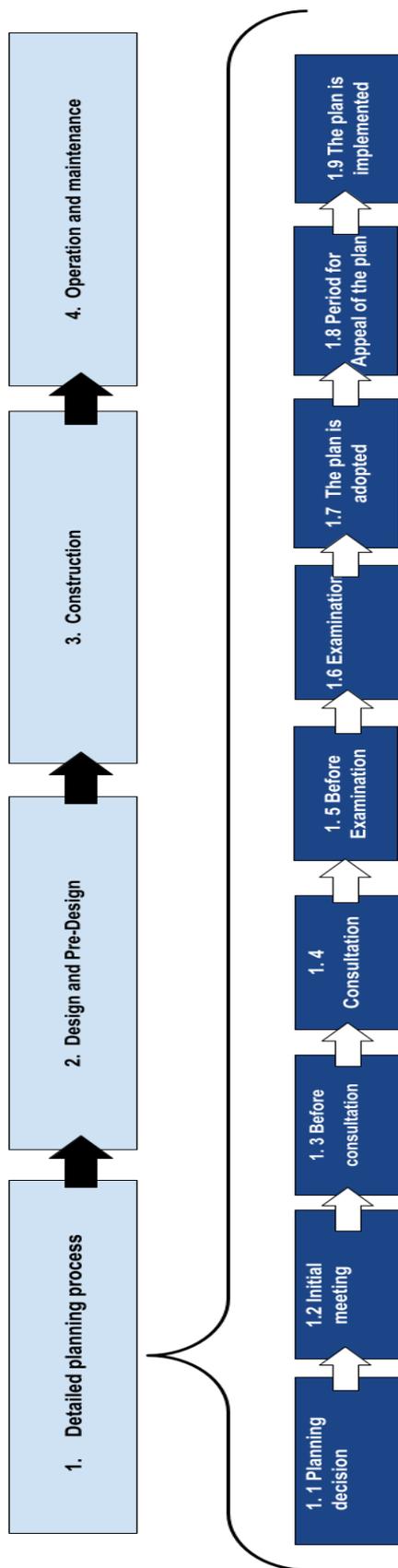


Figure 3: An overview of the stormwater planning procedure.

1. The detailed planning processes.

The various parts of the detailed plan consist of plan regulations, a plan description, an implementation description, and a property plan (Svenskt Vatten P105, 2011). Plan regulations set clear standards for the area's design, such as the minimum amount of hard surface, the requisite delay volume, and level of streets and ground surface. The purpose of the detailed plan is outlined in the plan description, along with an explanation of its contents, which may include geological and geotechnical conditions. Furthermore, the implementation description lists the tasks required to carry out the plan. If stormwater is to be diverted across one or more surrounding properties, a property plan may be required. The property plan specifies which properties are to participate in the community facilities and the spaces to be used for the facilities. Below is a description of the workflow that results in these documents which together creates the detailed plan.

1.1 Planning decision

The department for urban development within the municipality gives an opinion on the existing detailed plan, if necessary after coordination with other units (Göteborgs Stad, n.d.-b). The planning notification objective is to provide a transparent communication to all those who propose to implement a measure requiring extensive preparation, regardless of the municipality's intention to begin planning work or not (Boverket, 2023a). During the work of producing a detailed plan, there must be maps of the area and a list of properties (Boverket, 2020). The property list must include information on which properties are affected by the detailed plan.

1.2 Initial meeting

When a need has been identified for a new detailed plan of an area, the planning can be initiated (Boverket, 2020). Other options can be that a private property owner, that wants to proceed with a change, can search for a planning notification. The municipal council then takes a decision upon the planning notification, which then is the starting point for municipal management departments to start working with a new detailed plan. A typical first step in the process involves gathering input from the municipality's administrations, among other sources, at an initial meeting (Göteborgs Stad, n.d.-b). While an overview preliminary study that answers fundamental issues should be conducted, a thorough stormwater investigation is typically not conducted at this point.

1.3 Before consultation

Following the initial meeting, the planning coordinator are directed by the City Planning Administration to conduct the necessary investigations for the planning project (Göteborgs Stad, n.d.-b). The County Administrative Board's examination criteria are one of the factors that regulates the stormwater and cloudburst investigations. Whether the plan is feasible or not is now being investigated. A summary of the stormwater and cloudburst investigations is to be used in the plan description. It is during this early step, that the municipality can choose to take in external experiences, for example consultants, for the investigations.

1.4 Consultation

After a proposal for a detailed plan has been drafted, a consultation is conducted to gather feedback from the general public, relevant authorities and organizations, and other interested parties (Boverket, 2020). The stormwater investigation now includes

recommendations for stormwater management inside the planning area, providing the essential steps to accomplish sustainable stormwater management (Göteborgs Stad, n.d.-b).

1.5 Before Examination

The investigation can be finished or expanded at this point if there have been significant modifications to the detailed plan, or if it was decided that it was necessary to split the investigation and just conduct the study prior to the consultations (Boverket, 2020).

1.6 Examination

Following revisions, the detailed plan proposal is made available for inspection. The public impacted by the plan has another chance bring up their opinions during the period of appeal. The municipality compiles the written opinions from the consultation in an consultation report (Boverket, 2020). The views from the consultation must also be included in the review report if these have not been compiled before. When the review statement is complete, the municipality must as soon as possible send the statement or information about where it is available to those who have not had their views satisfied.

1.7 The plan is adopted

When the period for examination has expired, the municipal council adopts the detailed plan (Boverket, 2020). The municipality is required to inform all parties involved and post the decision on its notice board upon adoption of the detailed plan.

1.8 Period for appeal of the plan

If one of the involved parties are not satisfied with the detailed plan, there is a period of appeal where the plan can be questioned up in court (Boverket, 2020). Time of this period is up to three weeks, with starting point when the municipality informs on its notice board upon adoption of the detailed plan.

1.9 The plan is implemented

Once the appeal period has passed and no one has filed an appeal, the detailed plan becomes enforceable and takes effect. If the detailed plan is appealed, it becomes enforceable once the court makes a decision that hasn't been challenged.

2. Design and pre-design.

Planning is required for suggested facilities on public land after the investigation is finished (Göteborgs Stad, n.d.-b). Before putting the full strategy into action, a preliminary design might need to be completed. If pre-planning is carried out, the storm water facility and the proposal from the storm water investigation must be considered. Designing a stormwater facility is based on the stormwater investigation and any preliminary design that has been done.

3. Construction management

The project is now reaching the construction phase. In the event of a need to deviate from the design the responsible construction manager needs to make sure that the functions for delay or purification are not impaired (Göteborgs Stad, n.d.-b).

4. Operation and maintenance

The last step in the processes is handing over the finished project into operation. An operational instruction needs to be prepared before giving it to the operating workers (Göteborgs Stad, n.d.-b).

2.6 Stormwater Solutions

To address the issues with urban stormwater there is a need for sustainable urban stormwater technologies. Using nature-based solutions (NBS) is one feasible mitigation technique (Akther et al., 2018). The NBS idea complements and expands upon other closely related ideas, like blue and green infrastructure. Names for green-blue infrastructure approaches vary across the globe, for example low impact development (LID) in USA, sustainable urban drainage systems (SUDS) in UK or landscape-based stormwater management in Denmark (Qiao et al., 2019). These are all interconnected system of naturally occurring and artificially created landscape elements, such as green spaces and water bodies, that serve a variety of purposes, including flood control, water storage for irrigation and industrial use, and wetland areas for wildlife habitat or water purification (Ghofrani et al., 2017). Based on different hydrological processes, three groups of technologies can be pointed out: onsite control, process control and downstream control (Liu et al., 2019). The following paragraphs presents the different groups and examples of sustainable urban stormwater technologies, ending with Table 1 that lists the benefits and drawbacks of the various stormwater solutions.

2.6.1 Onsite control

Technologies within “Onsite control” are using doable, small-scale measures to retain as much stormwater locally as feasible (Liu et al., 2019). Within this category, stormwater is primarily retained on site by infiltration, evapotranspiration, or reuse, without typically releasing runoff further downstream. "Onsite control" has a beneficial impact on local water balance, water quality, and flood mitigation.

Green roofs

A green roof is a multi-layered construction with a planted upper surface on the primary framework of the roof. In addition, green roofs can reduce stormwater flow from building surfaces by capturing and holding onto precipitation, which lowers the amount of flow into metropolitan rivers and stormwater infrastructure (Oberndorfer et al., 2007). The water is then released back into the atmosphere through evapotranspiration (European Commission, 2015). Moreover, additional advantages of green roofs might be emphasized, both economic and environmentally. For example, they can help to sequester carbon, conserve energy, and reduce heat island effects (Akther et al., 2018). Green roofs also benefit to cool the buildings, improve air quality, extend the life of base roof materials, improve biodiversity, raise aesthetic value of the building, and lastly improve water quality.

The design of the green roof is the primary effect of their hydrological performance. There are two categories of green roofs: extensive and intensive. Extensive green roofs consist of a 150 mm-thick covering of grasses and plants, primarily belonging to the Sedum genus. Intensively vegetated roofs offer a greater variety of usable plant species and deeper topsoil layers (>150 mm) (Akther et al., 2018). In general, large-particle, lightweight, engineered materials like expanded shale, pumice, or gravel are used to build green roofs base. Avoiding a significant increase in the primary roof's structural load is the motivation for choosing lightweight materials.

Furthermore, choice of material depends also on the local availability, cost of materials, and the climate.

Permeable pavement

Permeable pavement helps reduce the water flow rates and peak flows by providing attenuation storage, and provides urban spaces with economic, social and environmental benefits (Kazemi & Hill, 2015). The construction not only lowers flow rates but also contributes to the removal of heavy metals, oil, grease, sediments, and some nutrients from the stormwater. Permeable pavements and porous pavements are the two categories of pervious pavements. Both designs let precipitation seep through the surface and can therefore lessen the stormwater flow. They are usually used in parking lots and on less-travelled roads. The primary distinction between the two types of pavement is that whereas permeable pavement features impermeable surfaces placed on top of permeable medium with some empty space, porous pavement allows rainfall to permeate over its surface (Woods et al., 2015).

There are various permeable materials available, the best one to choose will depend on the anticipated traffic volume, the requirement for infiltration, and the material's aesthetic appeal (Alam et al., 2019). A permeable pavement's performance is influenced by several variables, including the type of pavement, its thickness, and the porosity of the bedding material underneath.

2.6.2 Process control

The second group called “Process control” reduces floods by increasing the concentration time, through slowing the stormwater downstream (Liu et al., 2019). Through infiltration, these technologies can also enhance local water balance and water quality (García-Serrana et al., 2016).

Vegetated Swales

Swales are vegetated, wide, shallow, linear depressions that transfer stormwater runoff from impermeable regions to permeable soils that allows water to infiltrate (Kõiv-Vainik et al., 2022). Apart from their primary function of transporting stormwater, they additionally help to treat and reduce it by the processes of sedimentation, filtration by plants and vegetation, and infiltration through soil (Gavrić et al., 2019).

A minimum base width of 0.5 m and a maximum depth of 400–600 mm is recommended (Woods et al., 2015). There should be no more than 6% longitudinal slope. The swale's length ought to be at least as long as the road it faces. Native plant species, such as grasses and herbaceous species, should be chosen as the vegetation, which should be kept between 75 and 150 mm in height. There are several types of swales: standard, dry and with check-berms. In the use of dry swales, the infiltration capacity is optimised through an under drainpipe at the bottom with a specific filter material. To increase the infiltration rate, the swale could be combined with filter strips and check-berms inserted on a regular basis. The size of the swales and different rain intensity affects the performance (Revitt et al., 2017). For example, the swale generally produces no runoff with smaller rain event but for larger events the swale instead helps to delay the runoff peaks.

Buffer strips and filter strips

The purpose of buffer and vegetated filter strips is to reduce non-point source pollution by creating gently sloping areas of land next to water channels, such as streams and ditches (Kõiv-Vainik et al., 2022). To clarify, buffer and vegetated filter strips is green spaces alongside to parking lots or roadways. They are used to absorb rainwater runoff from impermeable surfaces. Furthermore, they can be used to filter particulate matter and associated pollutants from stormwater prior to its entry into the adjacent receiving water (Deletic & Fletcher, 2006). There are several intricate processes that take place in buffer strips and swales, including biological, physical, and hydraulic (M. Barrett et al., 2004).

The design of the buffer and filter strips are generally uniformly graded, gently sloping, and should be vegetated with smaller plants, covered by a grass mixture. They are mostly located between hard-surfaced areas and a receiving watercourse.

2.6.3 Downstream control

The utilization of larger scale facilities for temporary detention and gradual discharge to the recipients or downstream urban drainage systems is the third group of technologies known as "Downstream control" or controlled discharge (Liu et al., 2019). Through sedimentation, downstream detention improves water quality and helps minimize floods.

Constructed wetland.

Constructed wetlands, or treatment wetlands, are permanently damp places that use natural processes to treat and decrease runoff water (Woods et al., 2015). Due to their increased recreational appeal and ability to create green spaces, constructed wetlands are more frequently utilized for stormwater management in urban development (Dotro et al., 2017). Their primary goals are to store urban runoff for a longer time and enhance stormwater quality through a series of physical, biological, and chemical processes.

Based on the kind of vegetation and hydrology, there are multiple classifications for constructed wetlands (Dotro et al., 2017). For example, submerged and emergent plant wetlands are one classification based on vegetation type. Moreover, the flow path can also be used to distinguish between two main types of constructed wetlands. These two are subsurface flow constructed wetlands (SF CWs) and free water surface constructed wetlands (FWS CWs). (Stefanakis, 2019). FWS systems are designed with a water column 10–50 cm above the substrate layer, which is typically soil. Subsurface flow CWs are typically designed with gravel beds and can be of horizontal flow (HF) or vertical flow (VF). To avoid dead zones and algae growth, which can inhibit the removal process, CWs should be designed with smooth edges (Ventura et al., 2019).

Rain Garden / Bioretention system

A "Bioretention system" or "Rain garden" is made up of relatively small, excavated spaces in urban areas that are backfilled with a special substrate (Roy-Poirier et al., 2010). Bioretention systems can reduce stormwater volumes through infiltration and evapotranspiration, by capturing rainwater runoff to be filtered through a prepared soil medium (Ishimatsu et al., 2017). Bioretention is a technique that depends on ecological interactions within a natural environment to remove pollutants and retain stormwater. The

technology is similar to wetlands, but with the difference that it is intended to empty in a matter of hours and is dependent on terrestrial wooded ecosystems. For example, when the planting soil's pore space capacity is surpassed, stormwater collects at the soil's surface. The collected water can then be dewatered using a filter design, an underdrain design, or a combination of the two techniques. Infiltration into the subsoil or by the roots of vegetation is one way to achieve this.

Furthermore, it can be used in different types of environments and has a high tolerance to changing hydrologic regimes (Roy-Poirier et al., 2010). High tolerance to changing hydrologic regimes refers to withstand fluctuations in water availability, such as periods of drought or flooding, and still thrive. As for the design, it usually consists of a mixture of sand, organic matter, and high-permeability soil, the substrate is 0.7 to 1 m thick and is covered in a layer of mulch (Davis et al., 2009). Natural terrestrial flora that is resilient to environmental pressures is usually employed. The systems generally permit runoff to pool or pond on top of the substrate for a maximum of 15 to 30 cm (Roy-Poirier et al., 2010).

Table 1: Different Stormwater solutions pros and cons.

	Pros	Cons
<p>On site control</p> <p><u>Green roofs</u></p>  <p>(Malmberg, 2019)</p>	<ul style="list-style-type: none"> • Reduce stormwater flow from building surfaces (Oberndorfer et al., 2007). • Help to sequester carbon, conserve energy, and reduce heat island effects (Akther et al., 2018). • Benefit to cool the buildings, improve air quality, extend the life of base roof materials, improve biodiversity, raise aesthetic value of the building. • improve water quality 	<ul style="list-style-type: none"> • Cost of installation (Vijayaraghavan, 2016) • Extra load on roofs • High Maintenance Less capacity to delay the water during the winter (Godecke, 2016)
<p><u>Permeable pavement</u></p>  <p>(Sluijsmans, 2020)</p>	<ul style="list-style-type: none"> • Help reduce the water flow rates and peak flows. • Contribute to the removal of pollutants from the stormwater (Kazemi & Hill, 2015). 	<ul style="list-style-type: none"> • Higher Installation costs (Rehan et al., 2018) • Not suitable for all roads (Drake et al., 2013) • Clogging may result from winter road maintenance

Process control

Vegetated swales



(SDOT Photos, 2020)

- Treat and transport the stormwater (Gavrić et al., 2019)
- Reduces the stormwater
- Impractical in areas with very flat grades
- Steep topography (M. E. Barrett et al., 1998)
- Wet/ or poorly drained soils
- Not effective and may erode

Buffer strips and filter strips



(Codepem, 2008)

- Absorb stormwater from impermeable surfaces (Deletic & Fletcher, 2006).
- Filter particulate matter and associated pollutants from stormwater
- The longer and steeper the slope, the less effective grass strips are at reducing pollution (Blanco-Canqui & Lal, 2008).
- If the flow is concentrated, the filter strips may not hold up.

Downstream control

Constructed wetland



(NC Wetlands, 2018)

- Treat and decrease runoff water (Woods et al., 2015).
- Store urban runoff for a longer time (Dotro et al., 2017).
- Take up a lot of space (Dotro et al., 2017)
- Sensitive to changes in water level due to drought or dry out the plants.

Rain Garden / Bioretention system



(TJ Gehling, 2016)

- Reduce stormwater volumes through infiltration and evapotranspiration (Ishimatsu et al., 2017).
- Easy to implement due to its small size.
- Used in different types of environments.
- High tolerance to changing hydrologic regime.
- Issues with drainage (Ishimatsu et al., 2017).

2.7 Barriers

When implementing stormwater solutions in urban areas, and especially sustainable stormwater solutions, there are some challenges and barriers faced in the implementation. The last decade, the interest for sustainable stormwater solutions, particularly green-blue infrastructure, has increased significantly (Heidari et al., 2023). Even though the interest for green blue infrastructure has increased, the level of implementation is behind. Some of the barriers that has been pointed out in literature can be divided into different categories. According to Heidari et al., (2023) these categories can be sorted to: socio-cultural, financial, institutional and governance, legislative and regulatory, technical and biophysical. These categories are used in this chapter when investigating the different barriers.

Socio-cultural

The socio-cultural barriers are also declared as cognitive barriers in the literature (Dhakal & Chevalier, 2017), but in this paragraph it is referred to as a socio-cultural one. One of the main socio-cultural barriers that has been pointed out in the literature is the lack of knowledge or awareness for green-blue solutions (Heidari et al., 2023). Such barriers were detected not only within the communities where the installations would occur but also among the engineers, planners and other public sector workers that would be involved in the implementation work for green-blue solutions. Another barrier that Dhakal & Chevalier (2017) highlights is a reluctance towards changing from grey infrastructure to green blue infrastructure from the public. This is based on the historically absence of data when it comes to green-blue solutions (Nylen & Kiparsky, 2015). The reluctance among the public is also based on the fact that unawareness occurs about how the grey system is environmentally unsuitable and how green-blue solutions manage stormwater in a sustainable way.

Financial

One of the major barriers that is pointed out according to O'Donnell et al., (2017) is the funding and cost that is related to green-blue stormwater solutions. But the capital cost for a green-blue solution compared to grey infrastructure is in general lower. Which indicates that the barrier is rather a lack of long term funding for maintenance than the lack of funding for the implementation (Qiao et al., 2019). The funding is planned for building the solutions but not for the maintenance of them. Which is a crucial parameter since it does not matter if a sustainable stormwater solution is being built if it lacks maintenance. To keep a stormwater solution sustainable a long-term maintenance must be planned.

Institutional and governance

Some of the major barriers that Sweden is facing when it comes to governance factors are the local politicians priorities (Qiao et al., 2019). This is mainly caused by the fact that financial support, standards and priority given to sustainable stormwater management is decided at the local level. Designating that the local government politicians are choosing and prioritizing between the different services, such as schools, social welfare etc, where sustainable stormwater solutions are often not highly prioritized.

Legislative and Regulatory

Depending on where you are, there will be different legislative and regulatory barriers. The main challenge for some places is that they are lacking any guidelines at all (Heidari et al., 2023). In Sweden, there is no clear national directive for a sustainable stormwater management, instead the responsibility falls on each individual municipality (Viklander et al., 2019). In some cases, there may be a clear guidance for how sustainable stormwater management should take place according to the municipality, but as there is no requirement, it may be missing in some cases. This may lead to problems as there is no clear, uniformly developed strategy for how to act. The barrier is in general not the physical maintenance but rather the structure of who's responsibility it is (O'Donnell et al., 2017). This could be the cause of not having clear national directives.

Technical

Technical barriers may not be considered as one of the major barriers, but since it is an infrastructure practice it will face some technical challenges as well (Heidari et al., 2023). Some of the technical barriers that are highlighted by Liu & Jensen (2018) is that it is difficult to report advantages of green-blue solutions that have nothing to do with monetary value. Another barrier is the lack of space, especially when it comes to the implementation that is in conflict with already existing infrastructure. Heidari et al., (2023) points out the lack of knowledge or an insufficient technical knowledge about green-blue infrastructure among practitioners as a recurring barrier within this category.

Biophysical

One major barrier that has been pointed out when it comes to the theme of biophysical, is the dearth of sufficient land availability for building of green-blue solutions (Heidari et al., 2023). In addition to that, stormwater solutions above ground compete for space together with new buildings, which are usually prioritized on undeveloped land as they generate a clear financial gain compared to stormwater constructions. Another barrier for the implementation of blue green solutions is when the stormwater management comes in too late in the planning process for an area (Cettner et al., 2014). Stormwater management needs to be included earlier in the planning process so that there is an opportunity to set aside space for green-blue solutions, instead of ending up with grey solutions underground.

3. Method

This chapter will describe the methodology for performing a thorough literature review as well as the structure of the work associated with this research project. Consequently, the work is based on an interview study, which is presented in this section. At the end, there will also be a presentation on the ethical aspects for this research.

3.1 Research design

For this master thesis the research design consisted of a literature search and a qualitative investigation using an interpretive methodology for interviews. Clark et al., (2021) defines a qualitative study as one in which words and themes are prioritized over quantifiable data analysis. An interpretive philosophy of knowledge, which stresses how people interpret social reality and act based on these interpretations, is what distinguishes qualitative research methodologies. This strategy is not the same as quantitative research methods, which are typically more concerned with quantifying and generalizing findings. An inductive method between theory and research is another way to characterize a qualitative research study, which demonstrates how social reality is ever-changing.

3.2 Literature study

This master thesis was based upon a comprehensive literature study, which where the first step of the method. To locate appropriate literature sources, the search engine Google Scholar and the database Scopus were employed. First step in the literature study were to gain knowledge of the planning process and the problems surrounding stormwater management. The process of conducting literature research involved methodically going over many theories found in scientific papers, journals, and websites. A literature search was therefore conducted, by using key words associated within the stormwater management context.

The used keywords were mainly within blue-green stormwater management-related terms like stormwater, green-blue solutions, green infrastructure, management, flooding, risk, barriers, sustainable environment, and urban design. Publications with high citation scores was mainly chosen, due to higher relevance within the field, but also used to find other related sources through the snowball-effect. This means that every new discovery builds upon earlier discoveries, the snowball-effect is thereby increasing the breadth and depth of gained knowledge. Moreover, literature was also handed out from the company Norconsult as for example stormwater investigations, to gain knowledge of how the process is performed from a consultant point of view. Examining pertinent water manuals, such as Svenskt Vatten publications, was another crucial step in gathering information. All important and relevant knowledge that was gained during this session was put under the background section in the report.

3.3 Interview study

The data gathering approach used in this study is qualitative interviewing. Given its flexibility and ability to capture settings and behaviours in a manner distinct from that of a quantitative analysis, the interview approach is well-suited for the research field of the study. According to Clark et al., (2021) the qualitative method indicates that the process

is dynamic and adaptable. While the researcher looks for in-depth and varied responses, a qualitative method also strives to promote spontaneity. According to Clark et al. (2021) one of the main types of qualitative interviews is a so-called semi-structured interview.

The semi-structured interview is one of the primary forms of qualitative interviews, according to Clark et al., (2021). In a semi-structured interview, the researchers have an interview guide, which is a list of questions to be answered during the interview. Open-ended questions allow the respondent to provide the most honest response possible. It is not necessary to ask the questions exactly as they are outlined in the guide, in fact direct questions should be avoided.

Other researchers like Kvale & Brinkmann (2014), agree with the approach. By using open and non-directive questions, the researcher can encourage the participant to express themselves freely and reflect on their own experiences. In certain situations, additional questions that arise during the interview can be asked. Even yet, it is crucial that all the guide's questions are to be answered and that the tone and objectives of each interview match up with one another. This will make it easier to compare the interviews when doing the data analysis in the future. Kvale & Brinkmann (2014) also states that during the interview itself, it is important to be flexible and responsive to the participants' answers. To truly grasp the participant's viewpoint and experiences, it is important to be able to improvise and follow up on thought-provoking responses.

3.4 The selection process

To find and select the right respondents for the interviews, stakeholders involved in various stages of the planning process was identified. This approach ensured that the interviews covered all stages of the planning process for stormwater. Four groups were displayed from the planning process and are illustrated in Figure 4. Section 3.4.1 provides a detailed description of the different groups considered.

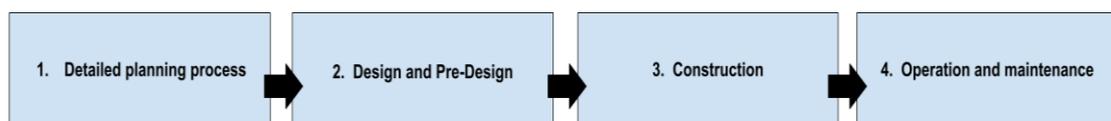


Figure 4: The different stages in the planning process from detailed plan to operation and maintenance.

Beside the four different groups from the planning process, stakeholders from both big and small municipalities were considered in the selection process. A bigger municipality in this thesis is defined through a population larger than 200 000. This aspect is important to consider as it is interesting to see if the problematics might vary.

Furthermore, to reach the right stakeholders in the various stages of the planning process, personal communication with supervisors at Norconsult and Chalmers was used as guidance. Once an initial group of people had been contacted, the snowball method was

applied to the selection process. Snowball sampling is based on people in the first sample recommending or contacting new people who are suitable for the study (Clark et al., 2021). This is particularly useful as it is easier to find a small number of people in the beginning and then apply the snowball method, so that we can reach a broader range of individuals who are highly relevant to our research topic. Since the interviews should cover the whole planning process for stormwater, all the way from detailed plan to operation and maintenance, people working in both municipalities and as consultants were interviewed.

3.4.1 Respondent Description

Under this section, there is a description of the different respondents, more specifically their expertise and why they were chosen to participate.

The respondents were divided into the different stages in the planning process. The interview section was carried out by dividing up the respondents into four different groups, based on where in the planning process they were active. The first group (Group 1) consisted of people involved in the detailed plan, the second group (Group 2) consisted of people involved in the designing and pre-design step, the third group (Group 3) were people involved in the construction step and the last group (Group 4) consisted of people from the operation and maintenance. All the groups consisted of people at a varied age and at different places of their careers. This is important to consider as it creates a broader perspective.

Furthermore, since some respondents are involved in multiple stages of the process, Table 2 has been created to clarify their specific roles according to at what stage in the planning process they are active. A green marker indicates full involvement of the respondent in that stage, while a lighter green marker illustrates partial involvement. In cases where a marker is absent, it means the respondent's involvement occurs even earlier in the planning process, such as working on the comprehensive plan.

Table 2: This table provides information on which respondents were interviewed and clarifies their roles, including whether they operate in smaller or larger municipalities or if they are private consultants. The green checkmarks illustrate involvement in that stage and group 1-4 is the different stages in the planning process.

Respondent	Role	Group 1	Group 2	Group 3	Group 4
Cloudburst specialist, but former project manager within stormwater	Bigger municipality	✓	✓	✓	
Project Engineer in the later steps	Bigger Municipality		✓	✓	

Planning architect at Norconsult	Consultant	✓		
Landscape architect at Norconsult	Consultant	✓	✓	✓
Project leader at the operation & maintenance department	Bigger Municipality			✓
Maintenance technician in the operation & maintenance department	Bigger Municipality			✓
Senior Consult at Norconsult	Consultant	✓		
Consultant at Sigma	Consultant	✓		
Water and Wastewater Engineer	Smaller municipality	✓	✓	✓
Architect at Fojab	Consultant	✓	✓	
Strategic Process Leader infrastructure	Smaller Municipality	✓		
Gothenburg Region - regional planner in water and sanitation and climate adaptation	Municipal Association			
Project Engineer in the earlier steps	Bigger Municipality	✓		

Group 1 consisted of people active in the beginning of the planning process for stormwater, which was both consultants and people working for the municipality. The majority of the respondents in this group had an education as an engineer, with a focus on environment- and civil engineering. In addition to engineers, this group also included a planning architect and a landscape architect.

Group 2 was covered by people operative in the designing step of the planning process. These are people working for the municipality as project engineers, who are responsible for both the designing step and the construction phase. Involved in this group was also the as landscape architects, which works with the illustration of the stormwater solutions.

Group 3 consisted of people active in the construction phase. This group was covered by fewer respondents and consisted of people within the municipality, who were active in the design stage as well. Furthermore, the landscape architect was also involved in this stage.

Group 4 consisted of people active within the last step in the planning process for stormwater, which is the operation and maintenance step. The respondents here also consisted of people from the municipality.

3.5 Interview implementation

Meetings in person with the respondents were the main method used to conduct the interviews. When there was a shortage of availability, the interviews were conducted digitally using the communication tool Teams. The person being interviewed was given a short explanation of who we were and why this study was done before the interview started. The respondents were informed that the interviews would be conducted in an anonymous manner and that any information they disclosed would be used exclusively for the objectives of the research. Information about possibly using citations was also discussed, but with the important notification that the respondent will have the opportunity to read and approve it before publication. In line with the plan from previously mentioned (Kvale & Brinkmann, 2014), the interviewee was asked if it was okay to record the interview and offered the floor to any questions before it started.

During the interview, questions were asked according to the script, which were answered in the best possible way during recording. The respondents were given the time they needed to think and reflect before answering. Furthermore, the structure of the interview was performed with one that was the speaker, and another one that was there for notes and follow up on thought-provoking ideas. It is seen to be advantageous that someone controls the respondent's communication since it makes maintaining a consistent theme in the conversation simpler and makes it safer for the subject to only hear inquiries from one source. By giving one person the administrative tasks, a better quality of the interview can be reached.

Furthermore, according to Kvale & Brinkmann, (2014) when the interview was conducted, the respondent may experience some anxiousness and emptiness. It is therefore imperative that a follow-up is included. The respondent was therefore given the

opportunity to share their thoughts and describe their experience at the end of the interview. When the recording is turned off, the respondent was given another opportunity to fill in with thoughts and reflections. This is also motivated in Kvale & Brinkmann, (2014) where they state that the respondent feels more at ease sharing more details once the tape recorder has been turned off.

3.6 Structure of the interview questions

To structure the interview question script effectively, the design was using the thesis research question as a basis for what each block aimed to gain. The presentation of the interview blocks are provided below. Followed by a presentation of the connection between each research question and the interview blocks. The interview questions can be found in the Appendix A.

Each block is here provided:

1. **Background Information:** This block gathers basic information and background details about the respondent.
2. **Communication and Materials:** This section focuses on the respondent's experiences and opinions regarding communication and materials related to the subject.
3. **Sustainable Stormwater Solutions:** This block addresses the respondent's knowledge and perspectives on sustainable stormwater solutions.
4. **Other/Identifying Barriers:** This final section allows for more open-ended responses, aiming to identify potential barriers based on the respondent's role and experiences.

Research Question 1:

The interview blocks are structured to gain insights into the planning and decision-making process for stormwater solutions in Sweden. This includes collecting background information (Block 1) and exploring communication methods and materials related to stormwater planning (Block 2).

Research Question 2:

The challenges and barriers faced by stakeholders in implementing sustainable stormwater solutions are addressed through questions in the "Other/Identifying Barriers" block (Block 4). This block allows for open-ended responses to identify various challenges based on the respondent's role and experiences.

Research Question 3:

Overcoming challenges and barriers and promoting sustainable stormwater solutions is directly addressed in the interview questions within the "Other/Identifying Barriers"

block (Block 4). Additionally, strategies for overcoming these challenges are explored in this section.

Research Question 4:

The parameters considered when selecting a stormwater solution are examined in the interview questions within the "Sustainable Stormwater Solutions" block (Block 3). This block specifically focuses on understanding the respondent's perspectives on crucial parameters for selecting stormwater solutions.

Research Question 5:

The definition of a sustainable stormwater solution from the perspective of different stakeholders is explored in the interview questions within the "Sustainable Stormwater Solutions" block (Block 3). This block aims to capture diverse insights into how stakeholders define sustainability in the context of stormwater solutions.

This structure ensures a thorough and organized approach to collecting and analysing the data. To collect comprehensive answers from respondents, the questions were customized based on the respondent's role and the specific information they could provide. However, the different blocks were always included, and the core questions remained consistent and were always asked.

3.7 Method of Analysis

As an important part of the method, the analysis of the provided information from the interviews were of high importance. According to Clark et al. (2021) three steps make up the analytic process for a qualitative study: managing the raw data, making meaning of the data, and ultimately interpreting the data. These three procedures were followed in the analysis of the interview study and is further illustrated in Figure 5.

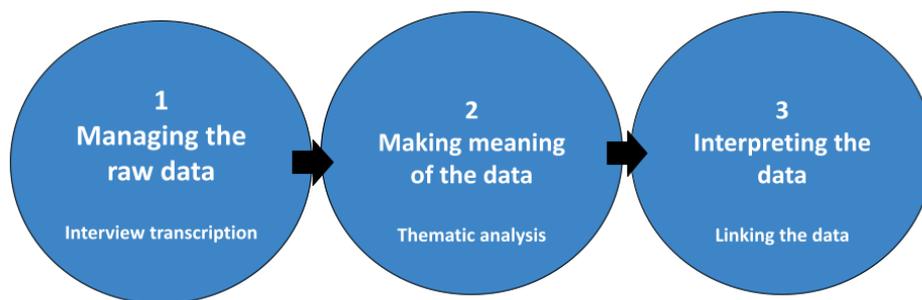


Figure 5: Analytic process for the qualitative study.

An interview transcription was performed to manage the raw data. Most of the interviews had been taped and then transcribed by hand close in time of the interview. By this method a reduction in misunderstandings were possible. It also led to a catch-up of important quotes that came up during the interviews.

Making meaning of the data included the method of thematic analysis. The task of a thematic analysis was to identify categories that were of interest. In the process of analysis, the data were coded by comparing the interviews to find similarities, after which the themes are discovered and examined. Thematic analysis utilized for this paper is described by Clark et al. (2021) and follows described pathway below:

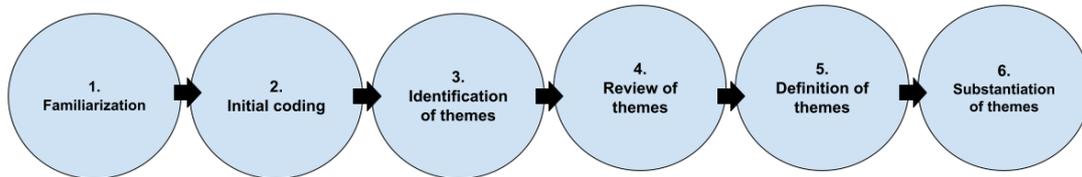


Figure 6: Thematic analysis utilized for this paper.

1. Familiarization
Involves recording, transcribing and putting down relevant notes.
2. Initial coding
Summarize the notes and refine them into codes. Initial coding consisted of underlining words and summarizing bits of the interview into single sentences.
3. Identification of themes
Finding themes requires contrasting and comparing the presently accessible codes. They are composed in part of the theoretical ideas related to the topic and the evolving codes.
4. Review of themes
Review of themes means that different themes are now combined into larger compositions where there may also be sub-themes to clarify the analysis.
5. Definition of themes
Moreover, the "definition of themes" step should clarify whether and how certain themes connect to one another.
6. Substantiation of themes
Lastly, a document that demonstrates the codes in detail, making the analysis relevant to the topic.

Lastly, Interpreting the data involved linking the data analysis to the thesis research questions and the background. It should be noted that the themes identified in the method later became the various barriers, the different definitions of the sustainable stormwater solutions, the parameters, and the identified strategies. These will be further elaborated

upon in the results section, providing insights into the diverse challenges and potential approaches highlighted throughout the analysis.

3.8 Ethical aspects

The research is partly based on an interview study with respondents operating within the stormwater planning process. When interviewing people, there are several ethical aspects to consider in order to protect their integrity. Kvale & Brinkmann's (2014) ethical guidelines have been used as a basis for the interview process. The ethical guidelines highlight the importance of informed consent, confidentiality, consequences and the role of the researcher. Informed consent means that the respondent is informed about the purpose of the survey in which they participate, but also that the persons in question participate of their own free will. Before each interview, the respondent was therefore introduced to the purpose. Since no compensation was given for appearing at the interview, participation was considered to be of free will. Confidentiality in research refers to the agreements that exist for handling the data created during the interview (Kaiser 2012). Which in practice usually means that the data that could identify the specific participant in the survey will not be revealed. In order to protect the individual's privacy and security, all interviews in the report were handled anonymously.

In addition to this, the research group has a duty of confidentiality and only uses the material from the interviews for research purposes. From an ethical perspective, it is also important to consider the consequences of the qualitative study, as the respondent should not be harmed by the interview. Which means that the sum of the potential benefits of participating in the study should outweigh the potential risks that may arise. In order to avoid harm to the person in question who participates in the interviews, anonymity is therefore applied in the report.

Lastly, the researcher's involvement in the study is considered, specifically focusing on their moral integrity and capacity for empathy. This is due to the fact that the researcher's integrity is emphasized during interviews, as all knowledge flows through the researcher (Kvale & Brinkmann, 2014).

4. Result

In this chapter, the results will be presented. It is structured around the research question for this thesis and provides a comprehensive overview of the information gathered from the interviews and literature search.

4.1 What is the planning and decision-making process for the implementation of stormwater solutions in Sweden?

The planning and decision-making process collected from the literature and described in the background has been confirmed throughout the interviews by the different respondents. Furthermore, Table 3 is included to illustrate the stakeholders identified through both interviews and literature review in the process.

Table 3: illustrates the stakeholders identified in stormwater management

 City Planning Office	 Building permit
	 Planning unit
 Water and Sewer Authority or equivalent	 Stormwater specialist
	 Project Engineer
	 Operation and Maintenance
 Architect	 Landscape Architect
	 Architect
 Consultants	 Water and wastewater Engineer
	 Environmental specialist
	 Planning Architect
 Other developer	
 Street Department or equivalent	
 Park unit	
 Environmental Management	



In Figure 7, an enhanced illustration of the stormwater planning procedure is presented. Notably, stakeholders, as elucidated in Table 3, have been incorporated at various stages throughout the process, providing a comprehensive overview of their involvement.

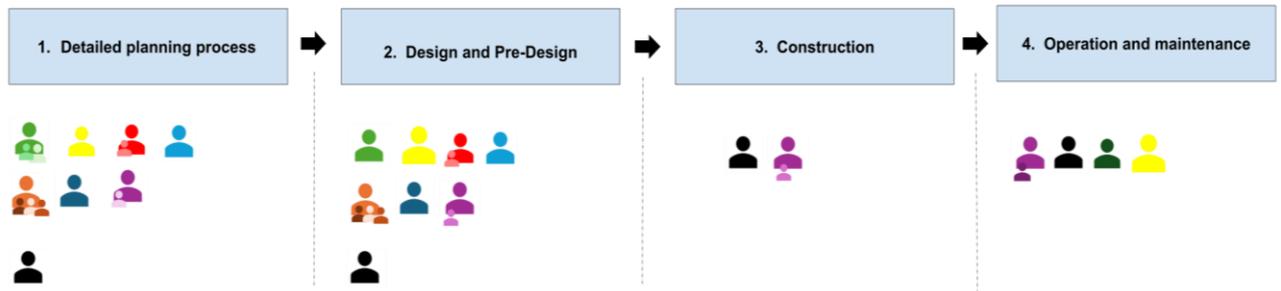


Figure 7: An illustration of the stormwater planning process with the different stakeholders involved in each step. The figure also involves stakeholders that have not been interviewed in this study.

The engagement of several stakeholders during the planning process is depicted in Figure 7. Table 4 which is included below, goes into further detail on each stakeholder's responsibilities and goals. Table 4 also involves stakeholder that has not been interviewed in this study, this is illustrated with a green marker next to the stakeholder. Interesting outcomes from this illustration is that there is more participation shown in the early phases. The earlier stages include planning and developing the detailed plan and design step, as Figure 7 illustrates. Another notably discovery is that the extent to which the stakeholders are involved varies according to the project and municipality.

Table 3: Explains the different stakeholder's contribution to the stormwater managed process. The table also involves stakeholder that has not been interviewed in this study. This is illustrated with a green marker next to the stakeholder.

Stakeholders	Description		
City planning office or equivalent	A municipal administration that participates in considering stormwater when selecting new development areas. Engages from the start, coordinates, and invites to the initial meeting. Ensures that a stormwater investigation is conducted. Building permit and the planning unit is a part of the city planning office.	Building permit	A building permit within stormwater management is an official approval from local authorities that ensures a construction project complies with regulations to manage stormwater runoff. It involves reviewing site plans to incorporate necessary infrastructure.
		Planning unit	A planning unit is a municipal department responsible for integrating stormwater management into urban development plans. It reviews and approves development proposals, ensuring compliance with regulations, and coordinates efforts to manage stormwater effectively throughout the planning process.
Water and Sewer Authority or equivalent	A municipal administration responsible for water and sewage issues. Serves as the main operator for water and sewage systems. Participates in nearly the entire stormwater planning process. Includes various departments within the administration that are involved at different stages. Stormwater specialist, project engineers and operation and maintenance teams are a part of Water and Sewer Authority.	Stormwater specialist	A stormwater specialist is an expert tasked with managing and mitigating the impacts of stormwater runoff. Their role involves implementing best practices for stormwater management and coordinating with various stakeholders to address water quality and quantity issues.
		Project Engineer	Oversees the planning, design, and implementation of water and sewer infrastructure projects. They ensure compliance with regulations, manage budgets, and coordinate with contractors and stakeholders to deliver efficient and sustainable solutions for water and sewage systems.
		Operation and Maintenance	Involves the ongoing management and upkeep of water and sewage systems.

Architect	Architects in stormwater management design structures and landscapes to control runoff, incorporating features like green infrastructure. They can be a part of the municipality's administrations but also privately owned companies. Is usually involved during step one and two of the stormwater planning process.	Landscape Architect	Landscape Architects in stormwater management design outdoor spaces to manage runoff, integrating for example green infrastructure
		Architect	Architects in stormwater management design structures and landscapes to control runoff.
Consultant	A Consultant in stormwater management offers specialized expertise in planning, designing, and implementing effective stormwater solutions. They can be a part of the municipality, or private companies leased. Water and Wastewater, environmental specialist and planning architect are three types of consultants. They are usually involved during step one and two of the stormwater planning process.	Water and Wastewater engineer	In stormwater management, a Water and Wastewater Engineer designs systems to control runoff and mitigate its impact, ensuring environmental protection and infrastructure resilience.
		Environmental specialist	In stormwater management, an Environmental Specialist assesses and mitigates the environmental impact of runoff and infrastructure projects.
		Planning Architect	Hired to develop a detailed plan. A planning architect leads the assignment and conducts all investigations, including stormwater and sewerage investigations. Coordinates the process carefully to ensure that all investigations are included, and all information is incorporated into the planning documents. Then coordinates with the county administrative board or other authorities and stakeholders
Street Department or equivalent	A municipal administration responsible for the operation, maintenance, and development of streets, roads, and public spaces. Participates from the starting block in the stormwater process and acts in consideration of its area. Responsible for facilities solely draining road areas. Is usually involved during step one and two of the stormwater planning process.		

Park Unit	A municipal administration that oversees the management, maintenance, and development of public parks and green spaces. Is usually involved during step one and two of the stormwater planning process.
Environmental Management	A supervisory authority in accordance with the Environmental Code. Engages from the start but is intended to act as a supervisory authority throughout the process. Is usually involved during step one and two of the stormwater planning process but works as a consultant in environmental issues.
Property Management Office or equivalent	Is responsible for overseeing and maintaining the municipality's or organization's real estate assets. Engages from the start and contributes to managing stormwater on properties and other areas under their responsibility. They are typically involved in steps one and two of the stormwater planning process and serve as a supervisory authority during operation and maintenance.
Other Developer	Refer to entities or individuals, aside from the main municipal authorities or agencies, who are involved in the planning, design, or implementation of stormwater management initiatives. This might include private developers, engineering firms, environmental consultants, community organizations, or other stakeholders who contribute to stormwater management efforts in various capacities. Depending on the role of the developer, they can come in during various stages of the planning process.

In the earlier stages of the planning and decision-making process, during the detailed planning phase it is important to coordinate and collect accurate investigations. Several respondents emphasize the importance of the right order. It is during that step that the groundwork for the rest of the process is laid. However, it is highlighted throughout the interviews that a flexible detailed plan is desirable, this due the many years a detailed plan is current.

“...In the detailed planning stage, the investigations are more general, which is always a challenge. Usually, one desires quite flexible detailed plans because things tend to change rather quickly. There needs to be a certain level of flexibility. “

- *Planning Architect.*
(Author's translation)

Moreover, a good communication during the different stages and the right type of knowledge for stormwater management is of importance according to several of the respondents. It is usually played out through a start-up meeting, where external consultants are informed and instructed over what needs to be done.

“...We receive a request when the client has a problem that they want us to investigate. Sometimes, they may have already sent us material, but if not, we usually have a meeting to discuss their issues and what assistance they need, as well as the type of material they require. Once we have a clear understanding of the scope of the task, we assemble a project team that meets the client's needs for expertise. Then, we proceed with the task and have periodic check-ins with the client.”

- *Senior Consultant at
Norconsult*
(Author's translation)

An approval of the detailed plan indicates that the design step can begin. A predesign during the detail planning stage can have been performed according to some of the respondents, and that can be seen as positive for the later steps. However, this is not always the case and there seems to be a conflict between how much a detailed plan should involve or how flexible it should be.

"...It's a balancing act of how far one can go. I think it's a bit tricky. There's a slight conflict in wanting flexible, general plans. But in doing so, one might lose certain aspects."

- *Planning Architect.*
(Author's translation)

Another interesting outcome from the interview is that the desirable stormwater planning procedure is not always the case. According to some of the respondents sometimes the design step can occur at the same time as the detailed plan. To illustrate this even further, Figure 8 is provided.

“...But the issue occurring now is that I want to separate the planning process that illustrate how it should proceed. Currently, the design work can happen simultaneously with the detailed planning, which is quite common.”

- *Landscape Architect
(Author’s translation)*

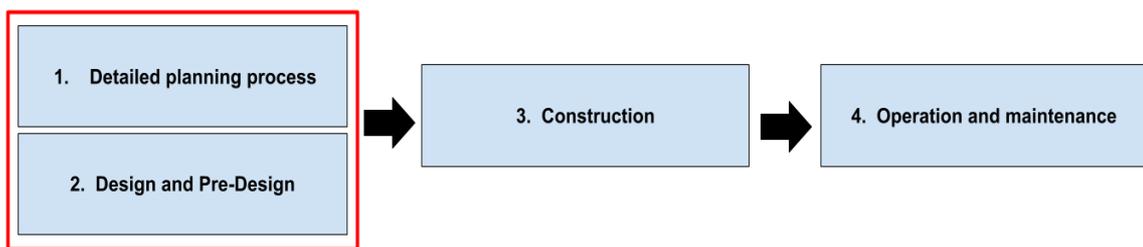


Figure 8: An overview of the stormwater planning procedure where the design and pre-design step is performed during the detailed planning process.

The problem that arises according to the respondents is the lack of investigations when the two steps are performed at the same time. There seems to be a general belief that the desire to build and build quickly is one of the reasons why this work path has evolved.

“...For construction companies, the aim is to progress as quickly as possible. The detailed planning process can take quite some time. As soon as it's completed, the goal is to start constructing the building.”

- *Landscape Architect
(Author’s translation)*

4.2 What are the main challenges and barriers faced by stakeholders (i.e. municipalities and consultants) in the implementation of sustainable stormwater solutions?

Through the conducted interviews it became clear that there are several barriers and challenges to the implementation of sustainable stormwater solutions. Based on the interview study, different themes were gathered to be able to sort out all the received answers. By these themes several barriers were created, based on both previously literature and new detections. Which will be presented in this section.

Furthermore, figure 9 is provided to illustrate the different challenges and barriers mentioned by the respondents. The colour blue illustrates the main challenges and barriers

faced by stakeholders, while grey indicates the barriers that were confirmed to exist. The number of respondents who share the same opinion can also be observed in Figure 9.

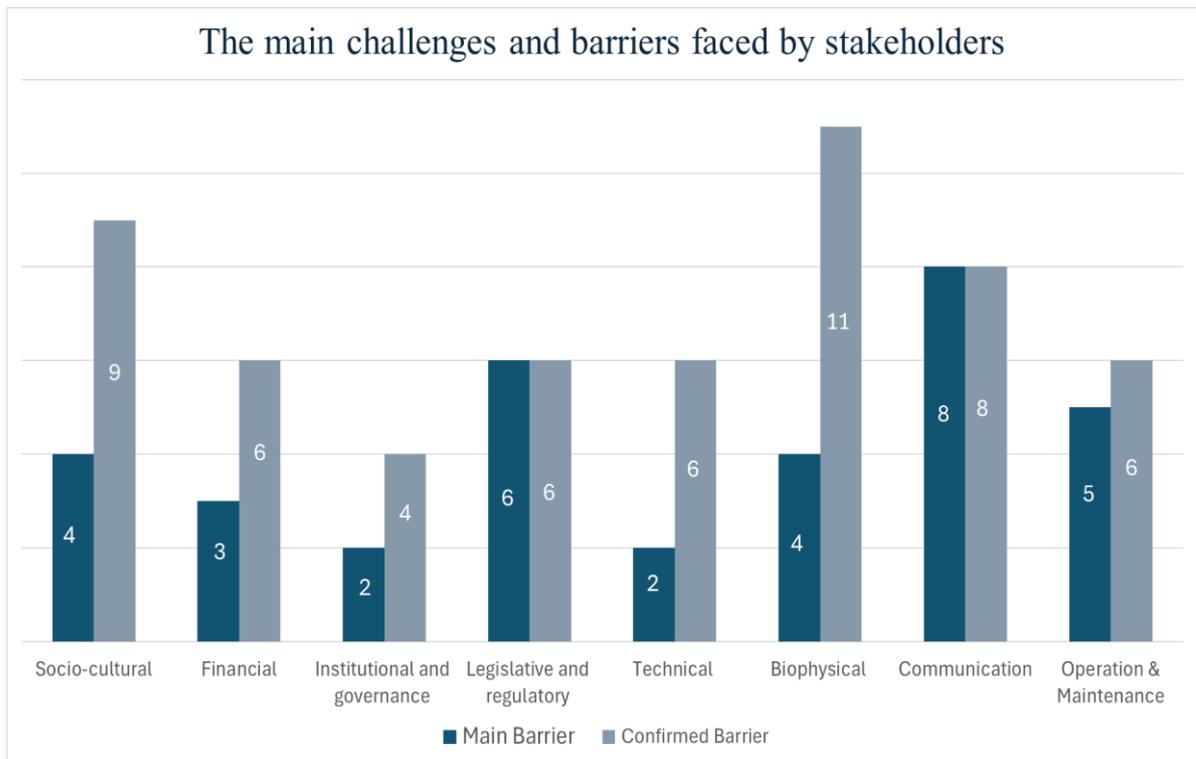


Figure 9: A diagram that illustrates in blue which are the main challenges and barriers faced by stakeholders based on the answers gotten from the different respondents. In grey an illustration of confirmed barriers is added as well.

It becomes evident from Figure 9 that there is a distinction between the perceived main barrier and the confirmed barrier. The largest differences can be seen under biophysical where almost all the respondent confirmed that the lack of space is present during the stormwater management process. However, not all the respondents meant it as a main barrier when the question was asked directly. The same outcome can be seen under socio-cultural, and technical but with a smaller difference. In conclusion, the major barriers were identified based on Figure 9. These were derived from both the blue bars, representing main barriers, and the grey bars, representing confirmed barriers. Based on this analysis, it can be concluded that socio-cultural, legislative and regulatory, biophysical, communication, and operation and maintenance factors are considered the major barriers to the implementation of sustainable stormwater solutions.

Socio-Cultural

One barrier that has been exposed from a lot of the respondents is the lack of knowledge. Many refer to a significant lack of competence within the industry. This is specifically pointed out in contexts related to both the detailed planning process and a lack of knowledge within the organizations. Several respondents experience the absence of the right expertise in the detailed planning process. Respondents argue that this lack of

competence often leads to stormwater not being a prioritized issue in a detailed plan, with other matters taking precedence, resulting in limited space for managing stormwater.

"...It becomes difficult for the client to consider everything and make the necessary trade-offs and prioritizations. Sometimes, they may not have the right expertise to do so, those who are involved in the detailed planning side."

- *Senior Consultant at
Norconsult
(Author's translation)*

The consultant suggests that it becomes challenging for those involved in detailed planning to make the right choices and priorities. This means that it can be difficult for, for example, a sustainable stormwater solution to secure the necessary space, as multiple parties lay claim to the land. This requires multiple considerations and prioritizations, which are not easy, given the lack of knowledge about the importance of a stormwater solution for an area.

Another respondent highlights the lack of knowledge about sustainable stormwater solutions during the construction phase, due to a lack of prior experience. People have become proficient in building concrete pipelines as that is what they do most of the time, but there is a lack of previous experience and knowledge about how effective sustainable stormwater solutions can be. The respondent also points out that due to a significant lack of experience with green-blue solutions, there is uncertainty about their maintenance frequency.

The landscape architect highlights that the lack of competence not only exists within the various administrations in the municipalities but can also exist among project managers in companies lacking competence and understanding of stormwater.

"(...) The customer has not understood themselves the significant problems with stormwater in the area, which is based on ignorance."

- *Landscape
Architect
(Author's translation)*

When the client does not understand the problems that arise if stormwater is not managed correctly and given the necessary space for handling, the consequences can be disastrous. The respondent claims that this lack of knowledge can then become problematic in their work, as they are significantly affected by it.

Financial

Another barrier that has been pointed out from the interviews is the financial problem that can occur. This is not one of the major barriers, but it has been highlighted by some of the respondents as an important factor for the choice of stormwater solution. One of the respondents highlights the economic issues that exist in relation to stormwater solutions

and how it may not provide as clear of an economic benefit as a building might have done in the same location.

“...The economic benefit is the environment, no one receives it back in dollars. Instead, we receive it back in the form of the environment.”

- Project engineer in the earlier steps
Bigger Municipality
(Author’s translation)

By this, the respondent means that since a stormwater solution does not generate direct revenue, there is caution in investing in such matters. This also partly emphasizes the architect, as the respondent emphasizes that the economic aspect plays a role in projects, where in many cases, choices are made to cut back on things or, in some cases, opt for short-term solutions. It can be difficult to get the necessary support to invest in robust initiatives that will benefit in the long run.

One of the respondents, who works in a larger municipality, also mentions financing as a problem. Especially as a problem when transitioning from comprehensive plans to detailed plans. This is because it is challenging to move from large-scale issues addressed in the comprehensive plan and incorporate them into a smaller scaled detailed plan. The respondent explains that to include important aspects from the comprehensive plan, for instance important aspects of managing stormwater, into the detailed plan, planning programs can be helpful. However, the issue with planning programs is the lack of clear financing for them. This results in it becoming a significant cost issue for the municipality, which significantly hampers the ability to structure things correctly when funding is lacking.

Institutional and governance

One thing that has been revealed through the interviews is that some of the barriers to the implementation of sustainable stormwater solutions are rooted in the lack of support from the government. In order to succeed in stormwater management, it is necessary for politicians to allocate resources in the municipalities.

“...That certain resources are allocated or that politicians in some way set goals for a certain portion of the budget to be allocated to this type of project. However, this is something that needs to come from above.”

- Cloudburst specialist, but former project manager within stormwater,
Bigger municipality
(Author’s translation)

One of the respondents points out that there is pressure in some municipalities during new development projects to maximize the area with buildings, as there is a desire to build as much as possible. This results in stormwater not being given any space, and solutions must then be implemented underground. The respondent argues that this contributes to

the lack of opportunity to achieve sustainable stormwater solutions due to the significant influence of politics and economics. Another issue highlighted by the same respondent is how priorities within municipalities in Sweden can vary significantly.

” ... in a national context, there are varying priorities among municipalities, depending on factors such as the amount of land available, the political stance, and the responsible county administrative board. The county administrative board has chosen to interpret the EQS in different ways, leading to differences in the strictness of enforcement from one case administrator to another.”

- Gothenburg Region
(Author's translation)

The respondent believes this affects the municipalities' work on stormwater issues significantly, as some municipalities work extensively on environmental quality standards and sustainability related to stormwater, while others do not prioritize this as much due to varying levels of demand. The planning architect also addresses this problem as they lack a national directive on what should be included in orders. The respondent calls for this as it would have facilitated the work to become more structured. However, it is currently the responsibility of each municipality to ensure that it is done correctly, and priorities vary greatly from municipality to municipality.

Legislative and Regulatory

A recurring challenge that the respondents have highlighted is the issue surrounding legislation. This problem has been expressed by respondents who work within municipalities as well as by those who work as consultants. Respondents who work in smaller municipalities express a lack of clarity in the legislation when it comes to the allocation of responsibilities and the requirements that can be imposed on property owners. The current legislation lacks clarity in this regard. This leaves a very limited space for municipalities to apply sustainable stormwater solutions.

” ... public space constitutes 30% of the city, while private property area accounts for 70% of the city. It is not possible to implement sustainable stormwater management in Gothenburg on public space alone, as it is insufficient. More land is needed to work with, presenting a significant challenge as it is not feasible to impose clear requirements on property owners.”

- Cloudburst specialist, but former project manager within stormwater, Bigger municipality
(Author's translation)

This respondent emphasizes the importance of the difficulty in working with sustainable stormwater solutions due to having limited land to work with as a municipality when no requirements can be imposed on property owners. The lack of clarity in the legislation that several express contributes to different municipalities interpreting the laws differently according to our respondents.

One of the consultants highlights that the legislation is unclear and that nothing is happening, as the work to improve the legislation is progressing slowly. However, clear legislation would have significantly eased the situation. This lack of clarity in the legislation, according to the consultant, affects the officials within the municipality as they become uncertain about how stormwater should be handled when it is not clearly stated in the legislation.

“...And these three major laws (PBA, the Environmental Code, and LAV), it is not always the case that they refer to stormwater in the same way, which creates a certain ambiguity.”

- *Senior Consultant at
Norconsult
(Author’s translation)*

Another important aspect that the consultant raises is that stormwater can be difficult to define as it is described differently in various legislations. This contributes to uncertainty about how it should be managed in different stages. A respondent from a larger municipality also highlights this issue, emphasizing the importance of understanding when each law applies, which proves challenging due to the lack of clarity.

In addition to the ambiguity that exists within the legislation, another interesting factor is mentioned as to why there are challenges in the legal field. One of the respondents explains that stormwater is not considered one of the general considerations that must be investigated according to the Planning and Building Act, as some other issues are, such as agricultural land. It only states that consideration should be given to stormwater, but it is not at the same level.

Technical

Another barrier, mentioned by a few respondents, but not by the majority, is the technical challenges associated with sustainable stormwater solutions. Despite being less frequently cited, it is considered an important issue.

One of the consultants highlights that there is a certain uncertainty surrounding sustainable stormwater solutions in some municipalities. This is partly due to a lack of understanding on how to implement such solutions in the municipality, but also a significant uncertainty when it comes to maintenance. This uncertainty is partially rooted in a lack of knowledge about above-ground solutions, according to the respondent.

Similar to the consultant, the landscape architect points out that there is often a significant lack of detailed information from the client. This may be related to the consultant's highlighted uncertainty surrounding sustainable stormwater solutions. If the client does

not have sufficient knowledge about these solutions, the information provided may be inadequate, which can impact the respondent's work in various ways.

Another aspect related to the technical side is the absence of key performance indicators for stormwater, according to a respondent working in a larger municipality. The respondent explains that they typically use the guideline that 5% of the area is needed to purify a site. This is, however, something that has been determined within the specific municipality and there is no such national standard in place.

Biophysical

Another barrier that several of the respondent's express concerns about is space. When it comes to the implementation of sustainable stormwater solutions, both consultants and individuals working within municipalities agree that space is required for successful implementation. One of the respondents who works in a smaller municipality highlights space as one of the most important factors for succeeding in the implementation of sustainable stormwater solutions.

” ...in detailed plans, the challenge lies in the necessity of accommodating space for stormwater management facilities. The transition is made from the traditional practice of simply directing stormwater into a pipe and out into a receiving body of water, which does not require any space.”

- *Strategic Process Leader,
Smaller Municipality
(Author's translation)*

This, the respondent argues, is the basis for the challenge they face. People must understand that in order to build sustainable open stormwater solutions, there must be space for the stormwater. The issue is that stormwater competes for this space against other interests. Another respondent who works in a larger municipality also emphasizes the competition for space with other interests as a major challenge. This respondent suggests that stormwater is a relatively new issue in the competition for space, which may be one of the reasons why it is not allocated as much space in planning as other aspects of urban development.

One of the consultants explains that the conditions set in the detailed plan are crucial for determining how much space is allocated for stormwater management in surface solutions at a later stage. According to the respondent, having space in the early stages is of utmost importance to have any chance of doing something in the end. Another consultant also highlights the importance of space in succeeding with open stormwater solutions. The respondent emphasizes the need for early planning to create space for these solutions.

“...if the place does not exist, then it does not exist.”

- *Landscape architect
(Author's translation)*

Another important aspect mentioned in the challenge of space is access. Respondents from operations stress the importance of their limited involvement in planning, which often results in problems when they need to operate and maintain stormwater facilities that are difficult to access. They claim that they are rarely involved in the planning of a stormwater facility, which contributes to access becoming a significant problem when they need to reach and maintain the facility with their large vehicles.

” ...They are sitting and planning very exciting things in the city, from their point of view, but then they forget to ask how we want it. And when we finally come in, there is no space, and then it doesn't work, we can't operate this. And there is no other place because then it is too late in the process.”

- *Operation & Maintenance,
Bigger municipality
(Author's translation)*

The respondents also mention the challenge of multiple parties wanting to be in the same place, which is not feasible, but operations & maintenance are at the bottom and rarely have a say early on.

Communication

One of the primary barriers identified by the majority of respondents is the significant challenge of communication. It does not matter if one is active in the earlier or later stages, communication is seen as a barrier throughout the planning process. When it comes to the planning process related to stormwater, it is common to have a silo mentality according to several respondents. What the respondents mean is that individuals work separately on what they are responsible for and then pass it on to the next without follow-up. One of the respondents who is active during the design stage in a larger municipality highlights the lack of communication with those in the earlier stage.

”... I believe that in my unit we are not good at seeking expert help. We receive a project, and then someone realizes that it is not working. And then we ignore it, we don't bring in these stormwater experts and brainstorm what we can do instead.”

- *Project engineer in the later steps
Bigger Municipality
(Author's translation)*

With this, the respondent emphasizes that those in the department are usually more generalists or project managers who have not been involved from the beginning and therefore lack understanding of why something should be done. They might not see the need or purpose of the facility, which leads them to consider it unimportant, even though it may be important. However, they are not good at involving those who were involved in the planning stage before, leading to some information being lost along the way. The respondent explains that it is not part of their routine to invite those from the earlier stage

into their work, even though it might have facilitated the work to some extent. There is uncertainty about how to seek help from individuals in the earlier stage, with the respondent emphasizing that it is easy to feel burdensome when asking for help.

The landscape architect highlights similar problems, as they point out the communication issues that exist between stakeholders in projects. In some cases, involvement in the early planning stages does not guarantee continued participation. The construction company might later choose a different designer and builder, leaving the initial participant completely out of the loop, as explained by the respondent. There is then no communication at all afterward. This lack of communication in the later stages leads to the respondent having no knowledge at all about what values remain in the project, other than what is left on the building permit. The respondent reminds that there is not much about stormwater management on the building permit. This respondent also emphasizes that it is up to the client how involved they should be in the projects and cites that it is up to the client to demand involvement since they are the ones paying in the end.

Another important factor contributing to communication being considered a major barrier, according to respondents, is how the material created is communicated. Several respondents argue that sometimes the reports created are very technical, making it difficult for outsiders to understand what is actually meant.

Operation & Maintenance

When reaching the last step in the planning process some of the respondents highlighted that barriers could appear when handing the project over to operation and maintenance. To maintain and operate a stormwater solution, space is required for personnel and work vehicles to arrive. However, this is something that is not always considered in projects, which can lead to solutions being denied maintenance. If a stormwater solution is not being looked after, there is a high risk of functionality loss and regrowth.

"...It has happened many times that something is built, and then the operations and maintenance team finds it too difficult to maintain. This results in a project that is never handed over for operation and maintenance."

- Project engineer in the later steps
Bigger Municipality
(Author's translation)

One of the reasons behind that a solution can be denied down in the operation and maintenance section is the difficulties in ability to access the area. From the interviews it was pointed out that the size of the work vehicle is often a problem, as its large size often is forgotten. Another problem that was highlighted is solutions that are placed close to or on different roads and roundabouts. To reach and maintain these stormwater solutions, there is a need to either stop the traffic or risk to put the personnel in danger.

"...Access is one of the biggest issues we face. Our vehicle is almost 11 meters long and quite heavy. Moreover, it must be able to get reasonably

close. It's not always understood by everyone. The work environment is one of the major challenges with access."

- *Operation & Maintenance,
Bigger municipality
(Author's translation)*

The team in the operation and maintenance department always have a say in the matter if they believe that the solution is possible to maintain or not. What happens then is that they issue a statement back to the project leaders which is obligated to handle the problem. However, what now is happening is that a new process begins for handling the issue, and it can take years before the problem has been handled. This results in that the already constructed stormwater solutions are not being maintained during that period.

"...They usually don't get back to us. We just provide an opinion, and then it's another process. It can take several years before they realize that if you place the storage tank here instead, it can be operated."

- *Operation & Maintenance,
Bigger municipality
(Author's translation)*

4.3 How can these challenges and barriers be overcome in order to promote the implementation of sustainable stormwater solutions? What strategies can be applied?

According to the results that have been conducted from the respondents, there are some strategies to apply to be able to overcome the challenges and barriers that sustainable stormwater solutions are facing. This section will present all the strategies suggested by the respondents to overcome the identified barriers. At the end of this section, Table 4 will illustrate the strategies mentioned, where they can be implemented, and which barriers they address.

Strategical documents in the municipalities

The planning architect, accustomed to close collaboration with municipalities, states that a key strategy for implementing more sustainable stormwater solutions in detailed plans is the existence of strategically aligned documents with political backing. This is to facilitate the work of the project manager. Moreover, when external project managers are brought in by the municipality, having clear strategic documents on how stormwater should be managed makes the process more efficient.

"...However, a more comprehensive document that explains how we should handle stormwater issues, that is needed. It is very reassuring to have that to rely on in a detailed plan."

- *Planning Architect.
(Author's translation)*

A water and wastewater action plan could serve as an example of such a guiding document from the municipality. This is something that one of the respondents from a smaller municipality emphasized as crucial in their work on stormwater. Having such a document to rely on when planning for water in the city, including stormwater, is essential.

Dedicate and prioritize resources

To enable municipalities to invest in structured documents related to stormwater, respondents highlight the need for municipalities to dedicate and prioritize resources. A former project manager within stormwater in a larger municipality underscores this as a crucial strategy for success. Improving collaboration between departments within the municipality to enhance work processes is necessary. The respondent suggests that prioritizing resources is essential to achieve this. Another respondent from a smaller municipality emphasizes the importance of dedicating a role with a strategic focus within the municipality, such as a municipal strategist. Without this, there is a risk of getting stuck with urgent tasks or short-term deadlines, hindering long-term strategic planning. Having a position with a strategic focus, according to the respondent, contributes to the municipality's ability to focus on water and wastewater issues and develop strategic documents.

Assign a collaboration group at the municipality

Another important solution to enhance municipal work is to establish a collaboration group for stakeholders within the municipality. A senior consultant sees a need for increased competence within municipalities to implement more stormwater solutions.

” ...There are many who may need a certain increase in competence within the municipality. And that includes everything from the planning side to water and sewage, environment, parks, to traffic, and building permits.”

- *Senior Consultant at
Norconsult
(Author's translation)*

The respondent stresses the importance of an increased knowledge, as a greater understanding of stormwater and what can happen if it is not handled correctly is needed. If not handled correctly it can lead to a very large costs at a later stage. Lack of understanding could lead to the abandonment of sustainable solutions in the planning process. Therefore, having a collaboration group within the municipality to discuss water-related issues, not just stormwater, would be beneficial for knowledge enhancement across the organization.

Financial coordination within the municipality

A respondent from a larger municipality suggests improving financial coordination to overcome economic barriers related to stormwater management. Instead of allocating funds to specific departments, the respondent proposes a shared financial pool to optimize

solutions consistently. The respondent believes that a shared economy could enhance overall work efficiency.

Visualization

One important strategy to apply for the ones operating with stormwater investigations is to be better at visualization in their work. Most of the respondents said that this is an important solution for making it easier for people outside the stormwater departments to understand the solutions and their purpose. One of the respondents that works as a consultant highlights the importance of making it understandable. This is because those who ultimately make decisions about funding are politicians, and in practice, it can be any individual, who may not have expertise in stormwater management. Therefore, it is crucial to use visualization to make it easily understandable. Another respondent highlights the importance of having graphical material in their work and how much it can simplify things for those who will read the material later. Additionally, the respondent also believes that including some map material is beneficial so that all relevant parties understand where the water is coming from.

Another respondent who works in a smaller municipality argues that visualization is very important in their work. However, the respondent also highlights that it does not necessarily require complicated tools to achieve a good visual result. Simple tools that visualize possibilities and challenges in a clear way are sufficient. Another respondent also emphasizes that most illustrations can be created using a simple program like PowerPoint.

”.. I use PowerPoint extensively to create illustrations because if one cannot present it in a way that is understandable to those who lack comprehension due to not being a water expert, they will not grasp it.”

- Project engineer in the later steps
Bigger Municipality
(Author´s translation)

Therefore, one of the solutions for better understanding the material produced is to include good illustrations. According to the respondent, people tend to retain more information when it is explained through a picture rather than a 50-page long report.

Communication improvements

A strategy that should be implemented to counteract the communication problems that have been confirmed through the stormwater planning process is to create a team of all expertise according to one of the respondents. This is to more easily involve people who have been involved previously in the process so that they can help those in the later stage understand the purpose of their solution. Another respondent highlights the importance of how crucial communication is to achieve good cooperation between the parties involved. This is especially crucial when there may be insufficient information to rely on

in certain tasks. Furthermore, it is important to maintain clear communication throughout the project in order to continue working.

Involve operation & maintenance

An important factor in the work of implementing sustainable stormwater solutions that has emerged during the interviews is to consider the operational aspect in the early stages of the planning process as well. Initiating a dialogue early on with those involved in the operation and maintenance team is something that some of the respondents highlight as a key point for improvement. By including the operation and maintenance team in an earlier stage, they have the opportunity to provide feedback on the technical solutions proposed in the initial investigations. This is an important aspect as it is crucial to build facilities that can actually be operated in the end.

Involve the operational aspect in stormwater investigations

To involve operation and maintenance in the early stages is also something highlighted from the consultant's perspective. Incorporating it as a routine in the work with stormwater investigations would contribute to a better end product. It would also lead to an increase in competence on the consultant's side and they would gain a better understanding of the entire process linked to stormwater. The operational aspect in the reports can then also contribute to providing a stronger argument for implementing specific stormwater solutions.

Experience feedback

Several of the respondents highlight the importance of maintaining a common thread throughout the planning process, and that it can sometimes be a challenge. Based on the interviews, it has been revealed that feedback from experience is something that most could improve on in their work. One of the respondents, who works in the consulting industry, mentions that it should be part of their assignment but in many cases, it is not done. This is not primarily due to lack of time, but rather because they move on to the next assignment and forget about the previous one. Feedback from experience would not only benefit the relationship with the client, by asking if the outcome met the client's expectations and if they were satisfied with the delivery. It would also benefit the work with technical feedback. By asking for example, what happened with the solution, how does it function in relation to the adopted detailed plan? Feedback from experience can be done through direct contact or by sending out a form where there is an opportunity to request feedback.

Handover template

Another proposed solution to improve the planning process is to have a clear form of handover template in the various stages. This template could be some kind of checklist, making it easier for the person handing over to ensure that everything important is included. This template should include the decisions adopted in the work stage one has been involved in, as well as a clear allocation of responsibilities for the process.

Design of the stormwater investigation

To facilitate the process, several suggestions have emerged on how a stormwater investigation should be structured to enhance understanding among multiple

stakeholders. One respondent emphasizes the need for simplicity and conciseness. This entails clearly outlining in the report the specific issues affecting the area and identifying feasible alternative solutions.

Clearer legislation

A significant portion of the respondents highlight a crucial solution to many of the challenges in the implementation of sustainable stormwater management solutions, which is the need for clearer legislation. It needs to be more explicit that those involved in the planning process know which law to apply and what requirements they can impose. Therefore, there is a need for coordination among the various laws. This is emphasized by a respondent working in a smaller municipality, which cites that many of the current laws governing stormwater management overlap. Another respondent, also working in a smaller municipality, emphasizes the importance of a legal change to make it easier to impose requirements within neighbourhood land. Thus, to access a larger area for implementing measures.

” ...If a law is implemented stating that everyone is responsible for managing their stormwater in a different way, even within properties, then there will be a lot more land available to implement measures.”

- *Strategic Process Leader,
Smaller Municipality
(Author’s translation)*

Good financial foresight

One important factor in overcoming the obstacles related to finances is to have good financial foresight, according to one of the respondents working in a smaller municipality. By having good financial foresight, one enables the necessary funds to be obtained at an early stage. Since stormwater often generates benefits beyond pure economic gain, it may be a good suggestion to conduct cost-benefit analyses with a societal perspective, as suggested by the respondent, to increase the likelihood of securing the required investment.

Decision making tools

To more easily secure decisions during the planning process for stormwater management, one of the respondents emphasizes the importance of using decision-making tools. One suggestion for such a tool is VIS, which the respondent believes is a tool that can facilitate collaboration among relevant stakeholders to come together and make wise and well-founded decisions. The VIS tool was developed to highlight stormwater issues and provide a broader perspective on their impact in cities. This evidence-based dialogue tool aims to inspire, emphasize, and enhance the potential added value and role of stormwater solutions in urban environments. It facilitates dialogue by weighting various social, economic, and environmental values, including climate considerations. There is a belief that if more of those involved in the process understand why certain decisions are made, there is a greater chance that they will not change in later stages, which can be common when it comes to planning sustainable stormwater solutions.

”... In this way, I believe that VIS can contribute to raising awareness and making wiser societal investments, simply put.”

- Architect at Fojab
(Author's translation)

Working more within catchment areas

Having focus on the various catchment areas instead of municipality borders is one strategy to use, according to the respondent. As water travels across the many locations and neighbouring municipalities bring drainage to each other, it is insufficient to manage the stormwater within the bounds.

“The issue of MKN and the purification question is also very difficult to solve on a narrow small detailed plan area. And could have been better resolved if one looked at the entire catchment areas.”

- Gothenburg Region
(Author's translation)

By instead working in catchment areas, one gains a greater overview of the area and its challenges, which would lead to more space being available for sustainable stormwater solutions. However, this proposal is something that would need to be implemented at an early stage, such as at a comprehensive planning level according to the respondent. This is because it will result in many detailed plans being interconnected, and not everyone may consider stormwater as it should be on the plan, since it is handled in a common detailed plan.

Summary of the strategies

The strategies are summarized in Table 4 below, within that table it is possible to see on which level the strategies or solutions are applicable. If the strategies are applicable on a local level, it means that they can both be implemented in municipalities and by consultants. The table also shows which barrier from the previous chapter that the strategy or solution is overcoming.

Table 4: Strategies to overcome the barriers connected to the implementation of sustainable stormwater solutions. The table also includes on which level the strategies are applicable and which barrier the strategies overcome.

Strategy	Which level the strategy or solution is applicable in	Barrier that the solution overcomes
<i>Strategical documents in the municipalities</i>	Local (municipal level)	Institutional & governance
<i>Dedicate and prioritize resources</i>	Local (municipal level)	Institutional & governance
<i>Assign a collaboration group at the municipality</i>	Local (municipal level)	Socio-cultural or technical (overcomes the lack of

		knowledge that exist within the municipalities)
<i>Financial coordination within the municipality:</i>	Local (municipal level)	Lack of finance
<i>Visualization</i>	Local (applicable by both consultants and on a municipal level)	Communication
<i>Communication improvements</i>	Local (applicable by both consultants and on a municipal level)	Communication, to prevent silo effect for example
<i>Involve operation & maintenance</i>	Local (applicable by both consultants and on a municipal level)	Operation & maintenance
<i>Involve the operational aspect in stormwater investigations</i>	Local (applicable by both consultants and on a municipal level)	Operation & maintenance
<i>Experience feedback</i>	Local (applicable by both consultants and on a municipal level)	Technical
<i>Handover template</i>	Local (applicable by both consultants and on a municipal level)	Technical
<i>Design of the stormwater investigation</i>	Local (applicable by both consultants and on a municipal level)	Communication
<i>National directive</i>	National	Legislative & regulatory
<i>Clearer legislation</i>	National	Legislative & regulatory
<i>Good financial foresight</i>	Local (applicable by both consultants and on a municipal level)	Financial
<i>Decision making tools</i>	Local and regional	Communication and technical
<i>Working more within catchment areas</i>	Regional	Institutional & Governance

The table shows clearly that there are a lot of strategies to implement on a local level. But these strategies are spread within being both applicable on a municipal level and on consultants. The strategies for a national and regional level are fewer, but they are harder to implement since they concern bigger areas.

4. 4 Which are the most crucial parameters when selecting a stormwater solution?

It is established from the literature and background information that various solutions serve various purposes. However, from the interview study the different respondents answered quite differently when it came to which are the most crucial parameters to consider when selecting a stormwater solution. When the question was asked to the respondent a variety of answers came back, which is summarized in Figure 10 .To find similarities between the answers and the respondents' roles, each bar has been divided into which respondents answered what. It is however difficult to draw any similarity factor between the different answers and roles of the respondents.

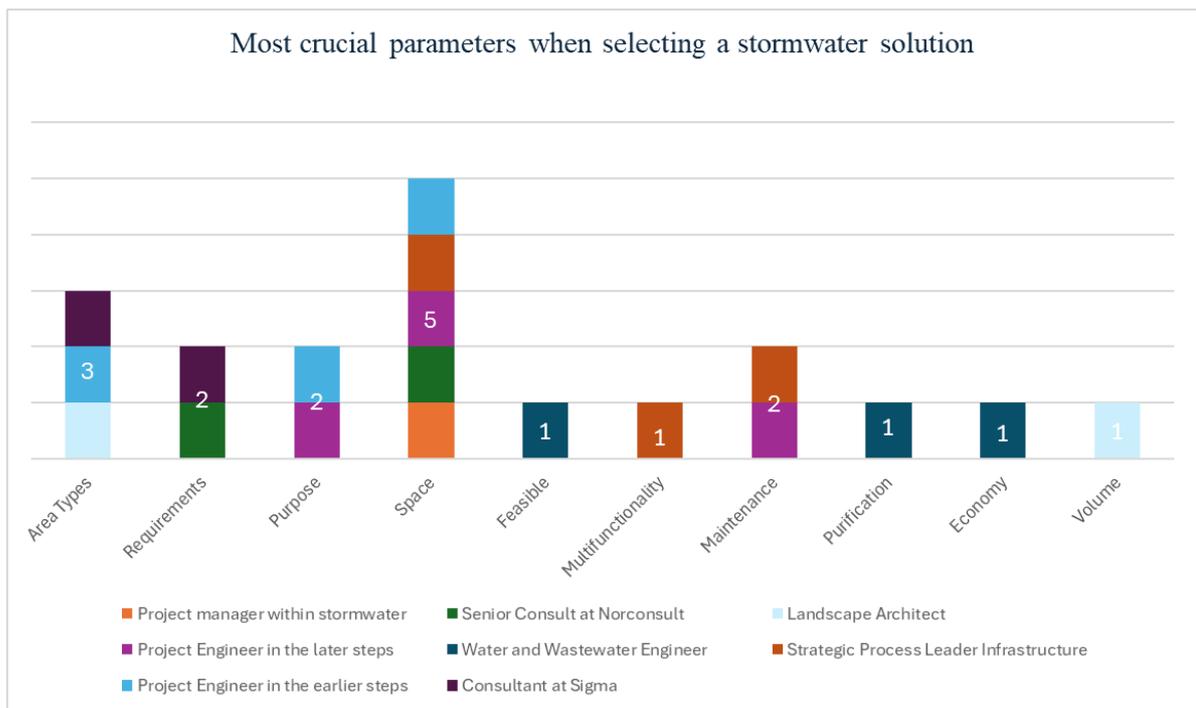


Figure 10: A diagram that illustrates which are the most crucial parameters to consider based on the answers gotten from the different respondents. How many respondents share the same opinion is indicated through a label on the bar.

From the diagram it becomes clear that space is one of the main parameters that the respondents believe can be seen as crucial. When the respondents refer to space, they share the opinion that usually a space is already given when selecting a solution, which limits the choice of solution.

“Depending on the available surface area, if there's space, one can choose something that might occupy more space. If the space is limited, it might require some kind of underground solution.”

- Project engineer in the later steps
Bigger Municipality
(Author's translation)

In projects where the involvement of stormwater solutions comes in early, a larger variety of parameters can be taken into consideration when space has been given. Important to highlight is also where the space is given since it is important to put a stormwater solution in a low point or where the flow of stormwater gathers. This also goes in hand with one other shared opinion among the respondent, which is that area types are crucial when selecting a solution. Area types refers to the variety of conditions that each place brings. The specific type of stormwater solution that is selected is influenced by these various conditions.

“...I would say area types are one of the absolute biggest factors. It's different if you're going to build in a small residential area compared to building in an industrial area. Then, you'll have completely different solutions. How large are the areas that drain? What flows can we expect? What infiltration opportunities are there currently? What are the groundwater levels like?”

Consultant at Sigma
(Author's translation)

Furthermore, the importance of operation and maintenance were also stated to be crucial when selecting a stormwater solution. The main reason behind this argument is that it is important to make sure that there is an access to maintain the area. If the solution is not properly maintained, there is a high risk of functionality loss.

"...The maintenance aspect is really important. We have a lot of stormwater ponds that have been built but not maintained. They probably served their purpose, but now trees are growing in them, and they look ugly. It's very disappointing when you've invested resources and money into something that isn't managed. So, I think it's crucial that it's managed."

- *Strategic Process*
Leader,
Smaller Municipality
(Author's translation)

Another crucial parameter is the requirements that need to be fulfilled, therefore the selection of a stormwater solutions is bound to the fulfilment of, for example the environmental quality standards or flow requirements.

"...The requirements that govern, such as flow requirements, delay requirements. It could be that the pipeline network may not be able to handle increased flow. In that case, flow cannot be increased."

*Consultant at Sigma
(Author's translation)*

The purpose often plays a vital role according to some of the respondents. If the purpose for example is purification or delay, it will affect which solution to prefer according to the respondents. Moreover, parameters like volume, economy, purification, multifunctionality and feasibility were mentioned as well when searching for the most crucial parameter. However, it is stated by looking at the variety of answers collected from the interviews, that the answer for this research question is depending on the situation for each project and that there is not just one parameter to point out as most crucial.

4.5 What is a sustainable stormwater solution?

The definition of a sustainable stormwater solution varies among the respondents. It seems to not exist one general belief, instead there were many different factors that played a vital role. In Table 5 all the different factors that the respondents mentioned and believed to be important when defining a sustainable stormwater solution is presented.

Table 5: This table shows the different factors that the respondents mentioned and believed to be important when defining a sustainable stormwater solution, together with an explanation.

Themes gathered:	Explanation:
Open stormwater solutions	Open stormwater solutions, such as open ditches or open ponds. They can be green but also made of concrete and stone. Not buried pipes underground.
Site-specific	A sustainable stormwater solution is very site-specific and variable. A sustainable stormwater solution might be completely different in some places compared to others. There may be different infiltration possibilities, flows, and conditions.
Economically, socially, and ecologically	Sustainability is usually translated as being economically, socially, and ecologically sustainable. When comparing traditional stormwater solutions, which typically involve underground pipes, there aren't many social or ecological values to be gained. There needs to be a focus on finances, as resources must be managed carefully. But there is a need to implement solutions that work ecologically, so that exploitation doesn't harm the conditions for wildlife and nature. The social aspect is also important to consider, where social, economic, and ecological needs can be combined to build a sustainable stormwater solution.

Stormwater as a resource	A sustainable stormwater solution is defined as a solution that utilizes water as a resource in the city. This means that we should not only solve water issues but also contribute to urban development in several ways. We must both conserve resources and utilize the land in the city. Incorporating greenery, plants, and trees, promoting biodiversity, and enhancing social aspects can lead to happier and more satisfied people.
Multifunctional space	Stormwater solutions need to deliver multiple benefits and not just focus on water. That one can combine social needs with ecological ones in the city. For example, incorporating greenery, plants, and trees, promoting biodiversity, and enhancing social aspects can lead to happier and more satisfied people.
A solution that lasts for a long time and maintains the required function	Choosing a solution that endures for a significant duration and benefits the environment is important. There are many stormwater solutions that are underground, allowing space for other purposes and ensuring durability. These can also be seen as sustainable. Stormwater management should function over a long time, as the goal is for it to last and maintain the required function.
Improving water quality and meeting environmental quality standards.	A solution that considers the environment, ensuring it doesn't worsen water quality but improves it. Sustainability means not degrading anything and meeting environmental quality standards for water. Currently, large amounts of stormwater are discharged without any treatment, especially in existing developments. We mustn't compromise the ability to achieve environmental quality standards when selecting a sustainable stormwater solution.
Delay of stormwater	The objective is to avoid the risk of flooding. Therefore, the delay of stormwater is an aspect to consider when choosing a solution. It is important that the facilities mitigate the risk of flooding or damage. This is a significant aspect of a sustainable stormwater solution.
Easy to maintain	That the solution should be accessible and easy to maintain is of utmost importance. If there is no one maintaining the stormwater solutions, there is a high probability that they will lose their function and become overgrown. Regardless of how good the solution may be, it is not sustainable if it is not maintained.
Nature-based solutions	A sustainable stormwater solution can be said to be encompassed within the framework of nature-based solutions. With nature-based solutions, the purification issue is also addressed, which is important from many aspects. Many other values, such as heat and biodiversity, are incorporated with nature-based solutions.

To further illustrate how the different respondents answered, Figure 11 is provided. By looking at the figure it becomes clear that no definitions stand particularly out from the other. Most respondents believe that a solution that takes economically, socially, and ecologically aspects into consideration is the right definition for a sustainable stormwater solution.

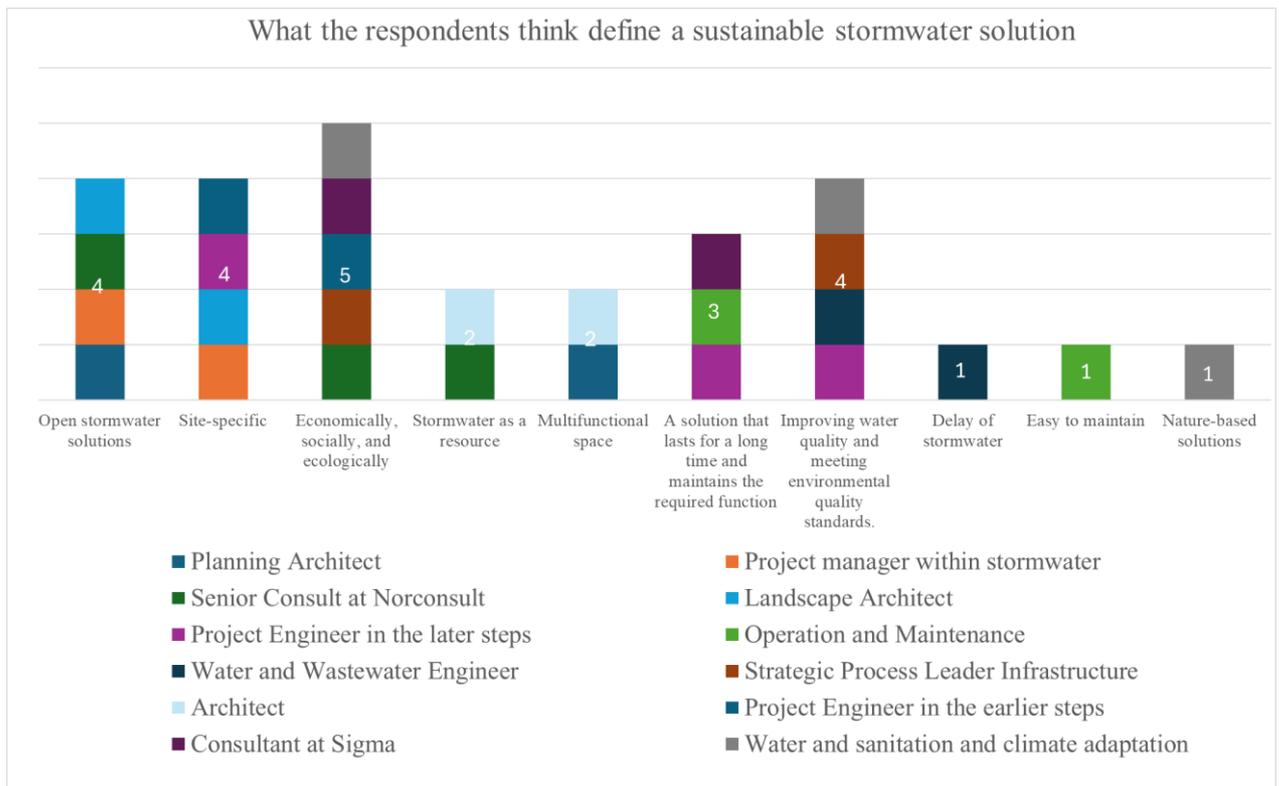


Figure 11: The horizontal axis displays the factors identified from the interviews. The bars are divided based on which respondents have answered which factors, and the label on each bar indicates the total number of responses for each factor.

Additionally, there is a relationship between the responses and the backgrounds and current roles of the various respondents. For instance, the responses are a little skewed when considering the various responsibilities that the respondents play. For instance, the operation and maintenance team emphasize the significance of maintenance for a sustainable stormwater solution. The emphasis on the technical aspects of a stormwater solution, such as the significance of enhancing water quality, is another obvious slant in the responses provided by respondents that deal with these kinds of questions.

5. Discussion

As the results have been gathered and interpreted, the discussion is structured similarly. This section will analyse the outcomes and compare them with the background information provided in earlier chapters. The discussion aims to highlight the significance of the findings and their implications within the context of the research question.

5.1 What is the planning and decision-making process for the implementation of stormwater solutions in Sweden?

The aim for this question was to investigate how the planning and decision-making process looked like for the implementation of stormwater solutions in Sweden. Through a qualitative analysis with interviews and a comprehensive literature search the planning and decision-making process could be established.

5.1.1 Two scenarios of the planning and decision-making process

The literature and the respondents concurred that the general planning processes resembled those presented in the results. All involved respondent agreed upon Figure 3, which also correlates with information gathered from the references Boverket (2020) and Göteborg stad (n.d.-b). However, as it turned out, the planning and decision-making process have a possibility to look different. The reason for differences is the pressure from the will to build fast according to some of the respondents, which may have the effect that the designing step is performed at the same time as the development of the detailed plan. This created problems for the design step, as needed investigations have not yet been established or developed for them to start their work properly. This could result in errors in the later steps, or simply that the solution is not right for the location due to rash decisions. If the design work begins before the plan is finalized, there is a risk that the final plan may require changes to the design to comply with its requirements. This can lead to additional work and costs.

Unlike the general planning procedure, which begins with an authorized detailed plan before moving on to the design phase, all required investigations have been completed and approved by the involved parties and the County Administrative Board. For this reason, this approach is better. This alternative approach to the planning process was not identified in the literature prior to the investigation, instead it emerged through the interviews. The reason behind this is difficult to determine, probably due to that it is not a desirable way of the planning and decision-making process, and it is done due to the time saving aspects.

5.1.2 Identification of stakeholders

The progress of various stakeholders is a significant finding of the planning and decision-making process. The objective was to locate responders in order to complete the process, which was accomplished and depicted in a figure. The conclusion that can be drawn was that many diverse stakeholders with a range of interests are participating in the general planning process. Their participation can also vary based on the project, if it is large or small areas, industries or residentials, developed or undeveloped land. It was therefore

difficult to find a general participation description as it is not clear who is responsible for what and how much they operate during the different stages.

5.1.3 Conflict during the detailed planning

Another important finding from one of the interviews is that there seems to be a conflict during the detailed planning phase, that waiting flexible, general plans might lead to losing certain aspects. As the detailed plan is current over a long period of time, it is not advantageous to be specific. However, it is important to include the stormwater issue at the beginning, so it doesn't get lost. Flexible detailed plans can offer several advantages when it comes to stormwater management. By allowing flexibility in design, plans can be tailored to integrate innovative and more sustainable stormwater solutions that also is up to date. On the other hand, flexible detailed plans may also pose disadvantages for stormwater management.

If there are no clear guidelines or requirements, developers may prioritize economic over environmental considerations when designing properties. This could result in the use of traditional, non-sustainable stormwater management methods. The respondent also emphasizes how difficult it is finding that ideal balance, and that it may vary depending on the project. However, as it is said in the result by the respondents, a good communication during the different stages and the right type of knowledge for stormwater management can be the answer to this problem.

5.2 What are the main challenges and barriers faced by stakeholders (i.e. municipalities and consultants) in the implementation of sustainable stormwater solutions?

The result from the interviews aligned with the barriers that have been found in the literature. But the result also indicated some more important factors that have not been mentioned in the literature about the implementation of sustainable stormwater solutions. These barriers have been defined as “communication” and “operation and maintenance”. Both of these barriers have been confirmed by the respondents as major barriers to the implementation of sustainable stormwater solutions, therefore we have chosen to highlight them as separate barriers. This differs from what we found in the literature, as communication and operation were often included under different themes but never as the biggest problems.

5.2.1 Legislative and regulatory as a defined barrier

One of the main barriers that the respondents emphasized were the legislations, which is related to the legislation and regulatory from the literature chapter. From the literature both Viklander (2019) and O'Donnell et al. (2017) highlights the biggest barrier within legislative and regulatory to be the lack of a clear national directive for a sustainable stormwater management in Sweden. This was also pointed out by one of the respondents as a barrier and the respondent also highlighted that the legislation is lacking information about the division of responsibilities between the private property owners and public space. That unclearness makes it hard to implement sustainable stormwater solutions according to the respondents. More aspects about the difficulties within legislation have

been discovered from the interviews compared from the literature. The things that the respondents highlighted as the big challenges were for instance that the absence of clarity in the legislation concerning stormwater management is leading to challenges. This uncertainty affects officials within municipalities, who are unsure about how to handle stormwater when it is not clearly defined in the laws. Additionally, the varying definitions of stormwater in different legislations add to the confusion, making it challenging to manage effectively. These ambiguities surrounding the laws are likely one of the reasons why so many other barriers have been revealed in the report. Much of the lack of knowledge, for example, that exists in the planning process related to stormwater would probably not have been as significant if there had been a clearer legal directive.

Another interesting factor that was exposed in the result regarding legislation was that stormwater is not considered as one of the general considerations that must be investigated according to the Planning and Building Act. This is probably one of the reasons why stormwater does not get as much space in the detail plan as other questions.

5.2.2 Communication a barrier due to the number of stakeholders involved

As the results showed in the first research question, there are many actors involved in the planning process for stormwater. With so many different stakeholders involved in the process, it is not surprising that communication is considered one of the biggest challenges according to the respondents. It is common to have a silo mentality throughout the process, and when one is finished, they simply pass it on without any idea of what actually happens in the end. To improve communication between the involved stakeholders in the process, some form of routine implementation is needed to involve the relevant parties more. However, this can also be difficult, as one of the respondent's highlights, it is ultimately up to the client how much actual contact one has. But on the other hand, this feedback does not always have to involve more than a brief conversation, which in the long run does not cost much. This lack of communication between the relevant stakeholder in the planning process may be a reason why sustainable stormwater solutions disappear along the way, as one does not know what values remain in the project when it is built, as they have only passed on what they proposed as a solution without any follow-up.

5.2.3 Other barriers detected that have a significant role

Beside the communication and legislative barrier that was considered as the main barrier by the respondents, the majority also confirmed socio-cultural and biophysical as barriers. The result indicated that there is a significant lack of knowledge throughout the planning process for stormwater. This lack of knowledge exists in the earlier stages such as the detail planning stage but also in the later stages such as the construction phase. Which indicates that there is a need for more competence throughout the whole process about sustainable stormwater solution. This knowledge gap regarding the knowledge for green-blue stormwater solutions was also confirmed by Heidari et al. (2023). But something else that was pointed out by Dhakal & Chevalier (2017) regarding the knowledge gap was that it exists a reluctance to move from traditional grey solutions underground to more sustainable blue-green solutions. Our results on the other hand rather indicated that people have a strive towards sustainable stormwater solutions but that it is the knowledge about stormwater that is lacking throughout the process, which leads to the fact that sustainable stormwater solutions easily can get lost along the way.

Many of the barriers confirmed by the respondents can be linked to institutional and governance issues. However, this barrier has not been confirmed by a significant number of respondents. This particular barrier may warrant more attention, considering that many of the barrier's stem from the priorities set by the politicians within the municipality. If the politicians in the municipality lack knowledge about stormwater and its sustainable solutions, it is not surprising that they do not allocate significant funding to it. When stormwater management is low on the list of priorities, it is not unexpected that there is no room left to implement sustainable stormwater solutions. An important factor for the implementation of sustainable stormwater solutions is space which the respondents also have confirmed. And to have the opportunity to implement sustainable stormwater solutions, it is essential that the space is available from the beginning and is anchored in the plan map. Therefore, having support from politicians is crucial in securing the necessary space for implementation.

5.3 How can these challenges and barriers be overcome in order to promote the implementation of sustainable stormwater solutions? What strategies can be applied?

The aim with our study was not only to investigate which barriers that existed within the planning process for sustainable stormwater solutions but also to examine which strategies that were suitable to overcome the confirmed barriers. From the respondents we have been able to conduct several strategies to implement on both a municipal level and as a consult. Some of the proposed strategies can also be applicable on a national and regional level.

5.3.1 Strategies for enhancing legislation and national directives in the stormwater planning process

One of the things that the majority of the respondents requested was a clearer legislation to address many of the challenges that arise throughout the entire planning process. As the laws relevant to stormwater are not synchronized and there is no clear definition for stormwater. However, this change requires some work because if one law is amended, the others need to be reviewed as well, but this is something that the respondents believe is about time to address. This change is something that planning architects at the beginning of the planning process demand, as well as municipalities and consultants who are active later in the process. This strategy, however, is difficult to influence as an individual, as it is a national issue that needs to be elevated. But the more pressure and demands that the individual actor requests this, the greater the chance that a national change will occur. Another suggestion proposed as more of a national strategy is to implement national directives. This is lacking in today's society and is something that would have particularly facilitated the early stages of the planning process. The national directives that the respondents refer to are directives that concern what should be included in a stormwater investigation. This is to make it clearer what, for example, a planning architect should be able to demand in terms of requirements for a stormwater investigation included in the detailed planning process.

As previously mentioned, a large proportion of respondents expressed a demand for changes in legislation and national directives. However, as long as the legislation stays the same the work around stormwater would facilitate if the municipalities have clear strategic documents linked to their water management and how they will handle stormwater within the municipality. It has been shown to not only be advantageous for external parties conducting investigations for the municipality, but also a significant internal benefit within the municipality as these documents can lead to an increase in competence for those involved within the municipality. This can almost be seen as a standard for municipalities to work towards, yet it is not a certainty for everyone to have a water management action plan to rely on, for example. This could be due to the fact that those within the municipality are governed by what the politicians want them to prioritize and allocate resources to. If approval is not obtained from the municipality's politicians to dedicate resources to developing strategic water-related documents, it will be difficult to implement in practice. Convincing politicians can sometimes be more challenging in larger municipalities compared to smaller ones, as there is a longer path to reach the politicians in a larger municipality. In a smaller municipality, it is much closer to the politicians, making it easier to explain why there is a need to invest in this.

5.3.2 Communication and visualization strategies in stormwater investigations

Besides the strategies that were suitable at a national level, strategies that are applicable at a local level have also been discovered through the interviews. This local level may involve a strategy or solution that is applicable at the municipal level, but it can also be applicable in the work of consultants. One of the biggest barriers according to the respondents was communication issues. To overcome this barrier, respondents have highlighted visualization and communication improvements as applicable solutions. Several respondents emphasized the importance of visualization in stormwater investigations, and that it is something that should be focused on more. Visualization is considered important to utilize more extensively because it can have such a significant impact, but it does not necessarily require advanced tools to visualize water. It can involve programs like PowerPoint to make a solution clearer.

The key is that by using figures and focusing more on visualization, it can be made more understandable for people who are not well-versed in water matters. This is particularly important as there are many different stakeholders involved in the stormwater investigation, and to better understand why the proposed solutions have been suggested, it is crucial to have explanatory images. By utilizing visualization to a greater extent in the work, one can not only facilitate the communication problem between different actors but also contribute to counteracting the lack of knowledge that exists throughout the planning process. This is achieved by simplifying the work done by explaining it with clear images as well, which helps more individuals gain an understanding. This is something that has been highlighted by several respondents as important, as it has been shown that it is not always easy for an external to read the lengthy reports that a stormwater investigation may sometimes entail.

As communication is highlighted as something extremely important to focus more on, several alternatives have been proposed, including to reduce the silo mentality that has unfortunately become more common throughout the process. One suggestion that has been put forward is to create a team of all expertise. This is to facilitate communication

between the different stages in the planning process. As it stands today, there is not much communication between the stages, with many handling their own tasks even though the work would often benefit from perhaps checking in an extra time with those in the earlier stage on how they thought about a solution, for example. To make this communication path shorter, it is therefore suggested to create a team of experts at the beginning of projects. Another similar strategy has been proposed, but it was more focused on helping municipalities to achieve an internal competence enhancement. One of the respondents raised the idea that there should be a collaboration group within the municipality as there is a need for a general competence enhancement there. This proposal would mean addressing issues that may otherwise be postponed and opening up for discussion between the different administrations, so that ultimately a common strategy can be agreed upon by more people. The more individuals involved in the work, the greater the likelihood that the municipality will actually follow through with what has been agreed upon.

5.3.3 Incorporating operation and maintenance early in stormwater planning

Another interesting discovery that emerged from the interviews was the minimal involvement of operations and maintenance in the planning process. In several cases, they only become involved in the final stages of a stormwater project, which results in them not having the opportunity to provide input on the solution. It has been revealed from the interviews that many of the stormwater solutions would actually benefit from involving operations and maintenance in the planning stage. If operations are involved earlier, even if only for a brief discussion, it can lead to the creation of facilities that can be maintained effectively and not just built without consideration for maintenance, thus losing the purpose of the facility. It is also considered beneficial for consultants, for example, to incorporate the operational aspect in stormwater assessments. Since that ensures the proposed solutions can be implemented effectively by considering maintenance requirements early on.

5. 4 Which are the most crucial parameters when selecting a stormwater solution?

In our investigation into the most crucial parameters for selecting stormwater solutions, we found a wide range of opinions among respondents. This difference raises important questions about whether there can be a universally crucial parameter or if it inherently depends on the specific context of each stormwater project.

5.4.1 Stakeholders diverse background affecting the results

One significant factor contributing to the varied responses is the diverse backgrounds of the stakeholders involved. Each stakeholder brings a unique perspective based on their education, experience, field of expertise and current job role. For instance, landscape architects may prioritize parameters that they need to do their job, for example volume to create their drawings. Meanwhile engineers might focus more on functionality and choose purification, feasibility or following the requirements. Furthermore, roles within the municipality administrations also mentioned economy and operation and maintenance as an important factor. These varying priorities result from the unique objectives and

difficulties linked with every field, giving rise to a wide range of viewpoints regarding what defines a crucial parameter.

There is much that points to the fact that different professional responsibilities demand attention to various aspects of stormwater solutions. Interestingly, our data did not reveal a clear pattern based on job roles, which suggests that while job-specific priorities exist, they may not be as distinctly divided as expected. This could be due to the limited size of respondents, indicating that a more extensive group of respondents participating might help to identify more definitive trends.

5.4.2 Space as a highlighted parameter

To further elaborate the respondents' answers, one key parameter to consider according to the respondent seems to be space, as that is a crucial parameter that decided what stormwater solution will be implemented at the end. Often, by the time the design and pre-design stages are reached, space constraints have already been established, leaving no alternative options. This likely explains why space emerged as the most frequently cited crucial parameter. Additionally, the density of urban landscapes, particularly in already developed areas, means there is limited available space for implementing stormwater solutions. From the background, solutions that can be combined with buildings and other infrastructure elements like roads and parking lots would be easily motivated when space is limited. This is confirmed by all the respondents that highlighted space as an important parameter. From the background, a type of solution that fits in this category is for example green roofs. According to Liu et al., (2019) the function of green roofs is using doable, small-scale measures to retain as much stormwater locally as feasible. Green roofs were also specifically mentioned by the project engineer operating in the later steps.

However, when space is given, a possibility of implementing larger stormwater solutions can be possible according to the respondents. No specifically solution were mentioned by the respondents in this matter. But from the background the implementation of constructed wetland can be an alternative according to the references Dotro et al. (2017) and Woods et al. (2015).

5.4.3 Other highlighted parameters

Another key parameter that stands out is the type of area, where the specific conditions and characteristics significantly influence the most suitable stormwater solution. These conditions can include factors such as infiltration capacity, peak flow rates, and other stormwater-related attributes. It seems reasonable to let each area guide the choice of solution. However, this parameter is somewhat vague and does not directly answer the question, instead highlighting that each project is unique.

However, it seems fair as parameters to consider needs to include the capacity to handle large rainfall events, ensuring that solutions can manage rare but intense storms, and daily operational effectiveness in managing everyday runoff and water quality. Additionally, the integration with existing infrastructure is critical to minimize disruption and ensure compatibility with current systems. Economic viability must balance initial costs with long-term maintenance and operational expenses, while environmental and social impacts aim to reduce negative environmental effects and gain community support. Given these

diverse requirements, it's understandable why stakeholders may prioritize different parameters.

5.4.4 The parameter depends on the specific context of each stormwater project

It is interesting to note that every parameter needs to be carefully weighed, considering both the purpose of the solution and the conditions or space available in the area. One interview respondent emphasized the importance of asking, "What is the purpose of the solution?" This perspective provides a valuable starting point for determining the most appropriate stormwater solution. As the respondent spoke about that sometimes even not the best solution is implemented due to many different reasons.

The urban landscape is dense and characterized by a constant tension between development and preservation. This delicate balance is likely to remain in flux, driven by the continual desire for improvement and expansion. In summary the most crucial parameters according to this study are space and area types. However, reaching the requirements, having operation and maintenance in mind and what is the purpose of the solutions for every new project, seems nevertheless important. Furthermore, purification, the economic aspects, if it is feasible and having to be multifunctional is also motivated to be crucial. The fact remains that the crucial parameters will ultimately depend on the unique and multifaceted challenges of each new project. Therefore, the answer to this research question may simply be that it depends on the specific context of each stormwater project.

5.5 What is a sustainable stormwater solution?

Sustainability is defined in the background referred according to Brundtland Commission (1987), as a development that meets the needs of the present without compromising the ability of future generations to meet their own needs. In the context of stormwater management, it counts in many different factors and requires a holistic perspective that takes both economic, social and environmental considerations. From the literature referring to Naturvårdverket (2023), the definition of a sustainable stormwater solution refers to the reduction of polluted stormwater discharge into surface and groundwater, as well as reduced risk of flooding that can pose threats to the environment, properties, and community functions. The solutions aim to foster urban ecosystems and facilitate cities' adaptation to a changing climate. When conducting an in-depth analysis of the meaning of these large and comprehensive phrases one may wonder, does everyone share the same belief? The simple answer to this should be yes, however as the interviews revealed different definitions, the answer to this research question took a more complex turn.

5.5.1 Difference between nature-based solution and open stormwater solution

The wide range of responses from different participants was surprising. Each perspective, when considered in the context of sustainability, appeared valid and justified. In other words, all the varied definitions seemed reasonable and well-supported as definitions of sustainable stormwater solutions. To begin with, one respondent defined a sustainable stormwater solution as a nature-based solution, which aligns with the literature discussed in the background section. Using nature-based solutions addresses the environmentally aspects as purification and biodiversity values, but also social values as recreation and human well-being. Given that the definition of nature-based solutions aims to help

societies address a variety of environmental, social, and economic challenges in sustainable ways, it is appropriate to define a sustainable stormwater solution accordingly.

It is interesting to note that only one respondent mentioned nature-based solutions, while more respondents referred to open stormwater solutions when asked. The different answers might be because people have different jobs and backgrounds. However, even highly knowledgeable specialists and consultants tended to respond with open stormwater solutions. Which may indicate that a nature-based solution is not always the best and most sustainable solution. When the respondent meant open stormwater solution, they referred to a solution that can be green but also made of concrete and stone, which is the difference from the nature-based solution. It seems fair to define a sustainable stormwater solution as open, and not buried pipes underground. There are numerous beneficial aspects that can be highlighted, making it reasonable to define sustainable stormwater solutions as open, just as it can be justified and appropriate to define nature-based solutions in a similar manner. Open stormwater solutions however may lack significant environmental benefits. As nature-based solutions prioritize sustainability by leveraging natural processes. The choice between them may depend on project objectives and stakeholder priorities, However, it's worth noting that nature-based solutions offer the potential for greater long-term sustainability when considered.

5.5.2 Many factors that influence sustainable stormwater solutions

When discussing sustainable stormwater solutions, clarity in understanding each person's perspective is crucial, as this study demonstrates that even experts can hold differing opinions on the matter. Furthermore, it was highlighted from the interviews that the objective of a sustainable stormwater solution is to avoid the risk of flooding, which is also an aspect brought up as a part in the definition of a sustainable stormwater solution from the background, according to Naturvårdverket (2023). Interestingly, only one respondent pointed it out. More cited that a sustainable stormwater solution indicates improving water quality and meeting environmental quality standards which is just as justified. The interesting issue that arises here is: Why don't all the respondents provide the same response? The reason behind this may be that there are different purposes in the definition and that a sustainable stormwater solution is site-specific. This may relate to the discussion about nature-based versus open stormwater solutions, especially when considering whether the goal is to slow down stormwater, purifying it, or achieve both, which ultimately depends on the particular site.

5.5.3 Economic, social and ecological perspectives

From the background, a sustainable stormwater solution is defined according to the European Commission (2015) as a solution that considers economic, social, and ecological perspectives. This definition was the most frequently cited during the interviews. However, some talked more about the economic aspects of it, and others had a more environmentally focus. Even rarer where the social aspects, which according to some is hard to even measure. Despite a common goal of sustainability, stakeholders have different interpretations of what sustainable stormwater solutions are. These differences in definitions inevitably lead to varied outcomes. When everyone defines sustainability differently, it's not surprising that the results can be inconsistent.

5.5.4 Different definitions of sustainable stormwater solutions

It is spoken about from institutions and journals that sustainability has become something of a buzzword, adding another layer of complexity. Municipalities often include the directive to implement sustainable stormwater solutions in their guidelines. However, these directives need to be clearer about what they mean by sustainability rather than just using the term as a catchphrase. The results clearly show that there are many factors that influence sustainable stormwater solutions, making the concept complex and difficult to define in a few sentences. Moreover, the term "sustainability" is often used without a precise definition, which can lead to misunderstandings and misaligned expectations. For instance, what one municipality considers a sustainable solution might focus primarily on environmental impact, while another might emphasize economic viability or social benefits. This lack of a unified definition can result in projects that, while labelled sustainable, vary greatly in their approaches and outcomes.

In conclusion, while the goal of sustainability is universally acknowledged, the definition of sustainable stormwater solutions varies widely among stakeholders. This variability leads to inconsistent results and highlights the need for clearer, more specific guidelines. Municipalities and other governing bodies must articulate what they mean by sustainability and provide detailed criteria to ensure that all parties are working towards the same objectives. Only through a more precise and unified understanding of sustainability can truly effective and consistent stormwater management solutions be achieved.

5.6 Method discussion

After conducting a qualitative analysis based on interviews, we were able to reach significant results. However, there are still some potential sources of error that need to be mentioned. Firstly, it is important to consider that stakeholder selection might be a source of error. If the sample of stakeholders interviewed is not representative of the broader population involved in stormwater management, the findings may be skewed. For instance, having more participants from the municipality or from consultancy firms might lead to different answers. We tried to mitigate this by ensuring an equal division of stakeholders, and we believe we succeeded in this effort.

Another source of error could be that stakeholders may provide desirable answers or may not fully disclose challenges due to fear of consequences or a desire to present their organization positively. This can lead to an incomplete or inaccurate understanding of the barriers. Although we cannot fully control this, we did not observe any indications of such issues during the interviews. It is however important to keep this in mind when analysing the results.

Additionally, because the interviews were conducted live with spontaneous questions and answers, there might have been some reliance on the interviewees' memory. People might rely on their memory to recall past experiences and decisions, which can be inaccurate or selective, leading to potential errors in the data. This is important to consider since our examples and definitions of sustainable stormwater solutions are based on these responses. To reduce this memory reliance, an improvement may be sending the questions to the interviewees afterwards for further reflection. Although sending questions in

advance might hinder spontaneous responses, which we wanted to capture, we did provide an outline of the interview topics ahead of time to help them prepare and reduce memory-related errors.

Another source of error is the number of stakeholders interviewed, which can always be questioned. A larger number of stakeholders might provide a more in-depth result and reveal more correlations between job roles or barriers. In this case, much of the result relies on individual perspectives. However, the individuals interviewed were carefully selected and well-educated in this subject, lending reliability to their responses.

Lastly, the qualitative nature of the study relies heavily on the researcher's interpretation of interview data. Different researchers might interpret the same data differently, affecting the consistency and objectivity of the findings. To avoid this, we analysed the results separately and then compared our themes afterwards. This approach promoted discussion and led to deeper analysis.

In summary, while we took steps to mitigate potential sources of error early in the process, they are still important to highlight and consider when reading the thesis.

6. Conclusion

This study aimed to investigate barriers hindering the implementation of sustainable stormwater solutions and promote their adoption. By identifying and understanding these barriers, including those previously unrecognized, the research sought to provide insights into the planning and decision-making processes involved in stormwater management. The findings of the study, derived from interviews with various stakeholders, mirrored established barriers identified in prior research. However, they also unveiled previously overlooked factors, such as communication or operation and maintenance, which emerged as significant barrier of the investigation.

Notably, respondents highlighted legislative ambiguities as a prominent barrier, suggesting that a strategy of clearer legal directives could solve several other challenges. A lack of knowledge observed in the planning process might have been mitigated with more explicit legal guidance. Furthermore, the general planning processes resemble those described in existing literature, but this investigation reveals that variations exist, particularly concerning simultaneous design and detailed planning phases. While this approach holds potential advantages in terms of time efficiency, it introduces challenges during the design phase, where inadequate investigations hinder proper development.

For overcoming these barriers found, various solutions were proposed, with enhanced visualization and early involvement of operations and maintenance emerging as particularly promising strategies. These approaches not only facilitate communication among stakeholders but also address knowledge gaps in the planning process. It is also considered beneficial for consultants, for example, to incorporate the operational aspect in stormwater assessments, as it ensures that proposed solutions can be implemented effectively. Lastly, the use of strategical documents in the municipality can address issues related to institutional and governance barriers. Having a document like this to reference during stormwater management planning is crucial. It has been demonstrated to enhance the efficiency of the process while also fostering increased knowledge, understanding, and awareness of stormwater issues.

The diverse perspectives emphasized by participants underscored the multifaceted nature of sustainability, with each offering valuable insights. Ultimately, the effectiveness of crucial parameters depends on the unique challenges of individual projects. In conclusion, while sustainability in the context of stormwater is universally supported, its definition varies among stakeholders, leading to different approaches and outcomes. A more precise and unified understanding of sustainability is essential for consistently effective stormwater management solutions.

6.1 Suggestion to further research

Following the conclusion of the analysis and discussion, suggestions for further study within this context were discussed. Three further research ideas were proposed:

1. Interviewing a broader range of stakeholders can provide a more comprehensive perspective on the issue at hand. By involving a diverse set of participants, including individuals from different job roles or backgrounds, the study can

uncover additional insights and potentially reveal patterns in how various factors influence decision-making processes. For example, by examining whether job roles or backgrounds affect the considerations cited by stakeholders, researchers can gain a deeper understanding of the complexities involved in stormwater management.

2. Expanding the scope of research to include an examination of comprehensive plans could lead to valuable insights and open up new pathways for exploration. By considering a broader context, researchers may identify additional barriers that have not been previously recognized or addressed. For instance, analysing comprehensive plans may reveal more underlying barriers.
3. Building on existing research into decision-making tools, is an opportunity to explore further into this area during the interviews. While the current study briefly touches upon stakeholders' perceptions of such tools, a more extensive focus on decision-making tools could provide valuable insights into their effectiveness and potential barriers to their adoption. By exploring stakeholders' experiences and perspectives in greater detail, researchers can uncover nuances and challenges associated with the use of decision-making tools in the context of stormwater management.

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Appendix A

Block 1 – Background information

- What do you work with today?
- What is your background? Education, previous work experience, etc.
- Which stage of the planning process are you involved in? (show the figure and let them point to the stage they are involved in)
- Do you get involved in earlier or later stages as well? So that you are involved in multiple steps during the planning process?

Block 2 – Communication and Material

- Can you explain in more detail what you do in your work?
- Let's see if it fits: (What does a typical workflow look like for you? (Do you use any specific tools to help in your work, like MIKE, GIS, or similar?))
- What type of materials are you provided with? Where do you get your information from?
- How do you perceive the materials you are provided with? Are there any challenges with the type of materials you receive?
(Do you notice any differences between the materials you get internally compared to materials from an external consultant?)
- What type of materials do you pass on to the next stage in the process? (reports, maps, models, etc.)
- Who do you pass the materials on to?
- What type of communication do you provide? (when the materials are to be passed on to the next stage)
- What do you think is a challenge at the beginning of the process versus a later stage when it comes to implementing stormwater solutions? (Especially sustainable stormwater solutions)

Block 3 – Sustainable stormwater solutions

- How do you define a sustainable stormwater solution?
- Is working with sustainable stormwater solutions something you actively pursue? (open stormwater solutions instead of traditional underground ones)
- How do you work with the various dimensions of sustainability? That is, social, economic, and ecological?
- What are the most important parameters in your opinion when choosing a stormwater solution?

Block 4 – Other/ Identifying Barrier

- Considering what we have talked about earlier, what do you think are the biggest obstacles to the implementation of sustainable stormwater solutions?
- Do you have any suggestions for strategies that can be used to overcome these obstacles?

- Do you have any thoughts on how this can be improved? Any suggestions for solutions?
- Looking at your projects in general, what do you always need to keep track of when it comes to laws and regulations? Considering that when it comes to stormwater, it is not always clear who should do what.
- Looking at the entire planning process up to operation and maintenance, are there any additional challenges that have not been mentioned earlier?
- (Would a greater use of various tools/aids during the planning process contribute to an improved work process?)

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