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Nature-based solutions for urban stormwater management: Experiences in Malmö and Copenhagen

A case study analysis on the decision-making process

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Abstract

Nature-based Solutions (NBS) are one of the approaches to the regeneration of urban areas. These solutions are copied from, inspired by, or supported by nature. The solutions, ideally, result in multiple benefits to the society and environment. The examples of NBS measures for stormwater management are, including but not limited to, natural swale, retention ponds, and green roofs. Such measures have been successfully applied in Malmö, Sweden since the 1990s and recently been executed in the municipality of Copenhagen, Denmark. This research aimed to understand the transition from policy to the actual practice of integrating NBS measures into the stormwater management plans of the municipality of Malmö and the municipality of Copenhagen. It studied decision-making and planning processes for the integration at the city level of these two cities and the reasons behind their successful implementation by reviewing the literature and interviewing 14 stormwater management and climate adaptation professionals from both cities. The data gained from the studies were organised and analysed for better understanding three key issues: the initiation of integrating NBS, the process of integration, and how this process can be leveraged. The results point to the collaboration from various sectors and political support as the key social innovations which lead to the successful implementation of the NBS measures to the urban stormwater management plans. The suggested leverage points and strategies for scaling up the integration process include focusing on communication and knowledge transfer which could lead to the shift in the mindset of stakeholders towards stormwater management.

Keywords: Nature-Based Solutions, Green Infrastructure, Sustainable Urban Water Management, System Leverage Points

Executive Summary

More than half of the world's population is now living and having their asset in the urban environment. This number is increasing, despite that cities are highly vulnerable to climate change and environmental hazards, for example, flood, drought, or food security. These demographic challenges combined with the current mismanagement of the urban environment, unsustainable land use, and potentially more severe and frequent events of natural and human-induced hazards are encouraging decision makers to pay greater attention to building resiliency and mitigation strategies for the urban environment.

Nature-Based Solutions (NBS) is an emerging approach meaning the measures that could address *multiple challenges* with *nature-based ideas* and *utilise natural elements* to archive the goals while considering societal factors. The multiple challenges that NBS could address also include the resiliency building and mitigation strategy to the urban environment. This thesis focuses on the implementation process of using NBS for stormwater management in two cities: Malmö, Sweden, and Copenhagen, Denmark due to their similar geographical characteristics but different history in urban stormwater management. Both cities have successfully applied NBS to their stormwater solutions.

This research aimed to understand the successful transition from policy to the actual practice of integrating NBS measures into the stormwater management plan by asking three following research questions:

1. *Why did the municipality of Malmö and Copenhagen decide to integrate NBS into their stormwater management projects?*
2. *How did they implement the NBS?*
3. *How can the integration of NBS be scaled up?*

To answer these questions, the data collection process of this thesis included reviewing the literature and interviewing 14 stormwater management and climate adaptation professionals from both cities. The interviewees were researchers, municipality staff who are working on the climate adaptation or cloudburst[1] management plan, and staff from the water utility companies. The data gained from the studies were organised and analysed through the seven factors influencing the urban decision-making approach (Ddamba et al., 2015). Then, the results were used to form two casual loop diagrams for each city to provide detailed recommendations for the effective system interventions to support the scaling up of NBS integration in those cities by using the 12 places to intervene in a system (Meadows, 2009) as a framework.

When the rain falls in the natural landscape, stormwater would, slowly, drip off the trees' canopies, and run through the foliage at ground level to the natural water storage area such as puddles, ponds, and swamps. These processes allow nature itself to manage the stormwater through infiltration and evapotranspiration. In contrast, the impermeable surfaces in the urban area cannot slow down water velocity or allow them to infiltrate as in nature, which results in higher percentage of runoff. The increasing of runoff rate is one of the stormwater management issues in the urban area. The sustainable urban stormwater management approach seeks to mimic the natural process and the NBS for stormwater management would be the solutions

[1] Cloudburst is a heavy rain which the precipitation level is higher than 15 mm within 30 minutes (City of Copenhagen, 2014)

that could provide multibenefits, and use natural elements to slow down stormwater, provide the temporary storage, or allow the rainwater to infiltrate into the ground. The example of NBS for urban stormwater management could be rain gardens, green roofs, natural swales, city park, wetlands, or, even, urban trees.

Since the stormwater management facilities are part of cities' infrastructure and planning, they are governed by the city management system and influenced by the urban planning discipline's perspectives towards the role of nature in the city. The development of these two issues was examined throughout literature review. The urban governance has shifted from top-down technocratic and sectoral practice into a more horizontal democratic and collaborative approach (Kaika, 2005; Malekpour et al., 2015). Also, the perspectives towards the role of nature in the city have shifted from zoning and having them as recreation or decorative objects to integrating them and seeks to utilise multi aspect of the ecosystem services into the urban area (Scott et al., 2016). For the decision-making process in urban governance, it varies in different municipalities due to the seven factors influencing urban decision-making approach (Ddamba et al., 2015): Data, Institutional Embeddedness, Administrative Structure, Funding (Public/Private), Spatial Scale, Duration of the project, and Stakeholders. The decision-making process still bases on the intuition of decision makers due to the incapability of the decision-aid tools (Ddamba et al., 2015; van Stigt et al., 2015).

Why did the municipality of Malmö and Copenhagen decide to integrate NBS into their stormwater management projects?

Malmö has been using NBS measures since the 1980's. The NBS were parts of the city development plan at the community scale. The reasons for the municipality's interest in integrating NBS as their stormwater infrastructure were the multifunctionality of NBS and the ability to reduce stress from the conventional system at a cheaper cost. These reasons had also driven the initiations of NBS integration in Copenhagen. It is also remarkable that the cloudburst events which recently happened in the respective cities had also driven these cities to seek for innovative solutions for managing stormwater. The key differences between the two municipalities at the initiation phase were timing and initiator. The perspective towards having

the nature area in the city during the first time NBS were considered in Malmö stormwater management regime was to zone a huge area for nature, while the perspective at the initiation period in Copenhagen was to integrate. These different perspectives reflected in the different scales, functions, and locations of the implemented projects in both cities. While the initiator in Malmö is the head of the water utility company in Malmö, the initiatives in Copenhagen raised from the steering groups formed by the municipality, researchers and the water utility company in Copenhagen. The keys to successful initiation for the implementation of NBS as the stormwater solutions from the two cities are the ambitious and hardworking leader and the creation of the constructive and aligned-dialogue towards proactive actions within and between organisations.

How did they implement the NBS?

The implementation process in Malmö and Copenhagen are quite similar. The municipality plans are governed by national legislation. The stormwater management plans are initiated by the municipality, and it is the responsibility of the city's water company to address the technical aspect of the management, while the city planning departments are making the development plan which they always include the environmental dimension into their plans. In both municipalities, the water companies are in charge of the design, construct, operate and maintain the technical elements of the proposed solutions, while the city's planning and maintenance departments of the municipality, are in charge of design, construct, operate and maintain the recreational and nature elements of the solutions. The input from researchers and research programmes are taken into account under the decision of the planning departments. Both of the municipality oblige to have the public consultation process, but the depth of public involvement can vary from a different level and local authorities of the plan.

Even though both cities implementation processes seem to be similar, there are several details which differentiate these processes. Malmö adopted NBS as part of their stormwater solutions since the 1980s. Therefore the collaborations between administrative bodies were already established as well as the clear responsibilities between them. These establishments made the integration process flows without having any steering group, which is essential for Copenhagen. However, in Copenhagen, the responsibility between different administration bodies are not clear yet. Another noticeable difference between these two cities is the regulation. Copenhagen has a more supportive national legislations which allow HOFOR to use the money directly from their water tariff and enable them to create incentives programmes. The municipality is developing the "biofactor" which will create the legal demand for quantity and quality urban spaces in the city. These legal and policy supports were lacking in the municipality of Malmö.

The main drivers of successful implementation that the two cities shared were: the collaborative culture and there were climate change adaptation plans ready in the two cities which could be a potential to integrate NBS into these measures. Malmö's distinct driver was their experience in implementing NBS and Copenhagen's prominent driver was the establishment of the two official steering groups: the municipality climate unit and VIB programme. The main barriers that the two cities shared were: insufficient supportive data and design solutions, space issues, funding issues and the mindset towards the urban nature among all of the stakeholders. While Malmö's distinct barrier was the unsupportive legislation and policies, Copenhagen was facing the unclear roles and responsibility issues.

How can the integration of NBS be scaled up?

The main actions for scaling up NBS integration are communication and collaboration along with the continual development of innovative solutions and research on the related issues. These scaling up strategies could create the more efficient leverage actions. According to the leverage points and twelve places to intervene in a system by Meadows & Wright (2009), these actions would influence the paradigm shift within the system which would be highly effective intervention to the system and could affect the goals, the rules and other actions within the system. It is also necessary that the communication should be inclusive, committed, aligned, and constructive towards the integration of NBS to the urban stormwater management.

In conclusion, even though the technical issues were a concern towards the integration of NBS to stormwater management, the collaboration and management issues were also prominent. Both of the issues would needed to be holistically developed in order to scale up the integration of NBS. However, the important issue is how to create a constructive dialogue of having nature as the based for the stormwater management solutions. Setting up stormwater management as the major challenge to initiate the integration should not be the only outcome which decision-makers concern. They should set the holistic outcomes for the whole city such as the city with high quality of nature, and resilience to climate change and population growth. In this sense, there could be more innovative solutions and possibilities towards having nature as the base of thinking when considering any of the city challenges, not only stormwater issue.

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Abbreviations

CCAP – Copenhagen Climate Change Adaptation Plan

EU – European Union

HOFOR - Hovedstadsområdets Forsyningsselskab (the Capital Area Utility Company)

ICLEI - International Council for Local Environmental Initiatives

IUCN - International Union for Conservation of Nature

GI – Green Infrastructure

NBS – Nature-Based Solutions

RQ – Research Question

TOR – Term of Reference

UN – United Nation

VIB – Vand I Byer (Water in urban area)

1 Introduction

Nowadays, more than half of the world's population are living in urban environments. These environments also hold most of the human's assets and are the center of the population's economic and institutional activities (Revi et al., 2014). While urban areas are the human's major habitat, they are highly vulnerable to climate change and environmental hazards caused by both humans and non-humans, for example, floods, droughts, or food insecurity. These demographic challenges combined with the current mismanagement of the environment, unsustainable land use, and potentially more severe and frequent events of natural and human-induced hazards had catalysed decision makers to pay attention to building resiliency and mitigation strategies to the urban environment.

Nature-based solution (NBS) is one of the approaches to the resilient urban regeneration. It is a solution, which utilises or is inspired by nature, for addressing any of the main global challenges, including but not limited to, climate change, food security, and social and economic development (IUCN, 2012). However, the solutions could vary according to the local's conditions (EC, 2015). Due to its transdisciplinarity which integrates ecosystems with socio-economic dimensions, it is believed to be able to provide multibenefits to the environment, society, and economy (Potschin, 2015). Even though this concept is new in the academic literature (Potschin, 2015), many European cities had invested in the NBS infrastructures, for examples: Malmö, Sweden; Milan, Italy; Copenhagen, Denmark; and Berlin, Germany.

From the cities given above, this thesis selected two cities for studying their decision-making process of NBS for stormwater management: Malmö and Copenhagen. These cities were vulnerable to stormwater water issues. For example, Malmö faced high-level flooding in 2014 which caused damage costing about a hundred million Swedish Krona and and in Copenhagen a cloudburst event had cost more than 765 million Euros in July 2011 (Georgi et al., 2012). With the climate change phenomenon, it is predicted that the event of rainfall will be more extreme in the coming years, and storm-water management measures will be crucial for these cities.

Both Malmö and Copenhagen already have their mitigation projects and on-going research to address the stormwater issue, including investment in building NBS infrastructure for stormwater management. This thesis studies the decision-making process towards implementation of these NBS projects and looks into the drivers and barrier of the real world practice. At the end, it gives customised recommendations for both cities on how to scale up the integration of NBS to stormwater management. This thesis wishes to provide practical case studies to the academia literature and professionals who are working towards integrating NBS to the cities stormwater management.

1.1 Problem Definition

This section presents the relevance of this thesis, why it is important to understand the decision-making process of NBS for urban stormwater management. The section concerns two main areas: stormwater vulnerability of the cities and NBS research gaps.

1.1.1 Stormwater vulnerability of the cities

Urban population is growing as well as their assets within the urban environment. The dense and high number of people combining with the value of properties and infrastructures make cities vulnerable to urban flood. The vulnerability increases as flooding are the most frequent natural disaster happened in the past decades, and the trend of occurrences is increasing due

to the effect of climate change. The demographic and economic challenges of the cities posted higher cost and level of complexity when dealing with the urban flood, especially if the cities use conventional drainage system which depends mainly on underground pipes (Jha, Bloch, & Lamond, 2012). Another cities' vulnerability factor to flooding would be their high percentage of impermeable surface coverage of the built environment which could not slow down nor allow stormwater to absorb to the ground (Georgi et al., 2012; Jha et al., 2012).

In Europe, the urban population was predicted to reach over 80% of its total population within 2050 (UN, 2012). The climate change would affect the trend of rainfall and precipitation trend would be increasing by 20% in the Northern part of the region (Füssel & Jol, 2012), where the two cities of interest, Malmö and Copenhagen, are located. In the Northern Europe, extreme precipitation days would also increase by one to five days, annually. These extreme events are the cause of flooding in the urban environment, whether it is a flash flood, coastal floods, groundwater flood, or urban drainage flood (Georgi et al., 2012). To be specific on the vulnerability of the chosen cities, four major storm events occurred in Malmö in 2013 had cost more than 900 million Swedish Kroners (HagHigHatafSHar et al., 2014) and the heaviest rainfall in Copenhagen recorded history in July 2011 had cost more than 765 million Euros (Georgi et al., 2012). It is important for these cities to address their stormwater management issues with an alternative approach to maintaining the livability of the cities.

Figure 1-1 Malmö was flooded by a couldburst event in August 2014

Source: http://www.thelocal.se/20140911/record-insurance-bill-after-mlmo-floods

Figure 1-2 The cloudburst event in Copenhagen on the 2nd of July 2011

Source: *http://www.euro.who.int/en/home/sections/news/2011/07/whoeurope-in-copenhagen-working-to-restore-normal-service-after-flood*

1.1.2 NBS research gaps

Since NBS is new in the academia (Potschin, 2015), there are many research gaps within the topic. Many available grey and academia literature suggested various topics for further research as shown in *Table 1-1*. However, literature from *Table 1-1* pointed to three main areas that would be needed to study in order to strengthen NBS related literature and provide best practice case study to the practitioners. These areas are decision-making process, social innovation, and the prove of cost-effectiveness of NBS.

Table 1-1 Research gaps suggested in the literature related to NBS in urban environment

Research gaps suggested in each literature	EC 2015	Directorate I 'Climate Action 2014	Kopperoinen 2015	Brink et al. 2016	Doswald et al. 2014
Evidence of multi-benefits					
Decision-making process					
Business model					
Social innovation					
Cost-effectiveness					
Quantitative research					
Equity/ Power relations					
Traditional knowledge					
Trades-off					
Timescale					

In the area of decision-making process, it was needed to study stakeholders' role and significance of each stakeholder groups in the decision-making process are interested for NBS research. The further study in this area would be useful as guidance for the practical situation. In the area of social innovation, it was needed to study societal perception and institutional framework need to be adjusted to enhance NBS intervention. Thus, there were the need to study on how policy framework could support NBS, what could be barriers, what is needed, who should be in charge, in order to create transformation in the nature-based urban resiliency building area. In the area of cost-effectiveness, there was a need for evidence that NBS intervention is more cost-effectiveness comparing to other alternatives, especially from the implemented case.

As aforementioned, not only that, the evidence of multi-benefits of NBS for urban stormwater management has not been widely studied, there are also several trade-offs when applying NBS measures such as space usage and maintenance cost. It would be beneficial for people who are interest in addressing urban stormwater management issue to understand why the selected municipalities invested in their NBS projects, what are their priorities when they are making these decisions, what are the role of stakeholders, what happened during the design process as well as how could the integration of NBS could be scaled up. Also, both municipalities have started to implement NBS measures for stormwater management which could provide the practical experience for this thesis to study the implementation process including their drivers and barriers.

1.2 Research Aims and Questions

This thesis aims to understand the decision-making process towards implementation of NBS for stormwater management in Malmö and Copenhagen through case study analysis. The

research also wishes to be useful for other cities, who want to integrate NBS, by presenting practical experiences from both cities. Therefore, it is important to examine how these NBS interventions in Malmö and Copenhagen could integrate into the storm-water management plan, why these cities decided to include NBS to its storm-water management plan and invested in the intervention, and the drivers and barriers of the process. Apart from understanding the mentioned issues, this thesis will also provide a policy recommendation for supporting the integration and implementation of nature-based solutions for the two cities.

There are three main research questions in this thesis for examining the mentioned issue in the objectives. The three research questions are:

1. *Why did the municipality of Malmö and Copenhagen decide to integrate NBS into their stormwater management projects?*
2. *How did they implement the NBS?*
3. *How can the integration of NBS be scaled up?*

The first RQs aims to study the initiatives of NBS in the selected cities. It will explore the causes for the cities decision to use NBS for the stormwater management measures as well as the key to their successful initiations. This RQ would provide answers that could be useful for other cities who are preparing to integrate NBS to their cities' infrastructure. The second RQs aims to explore the process of the implementation of NBS, focusing on drivers and barriers of the process that could affect the decision-making. The practical detail this RQ provides would be beneficial for both practitioners and researcher in the relevance fields. The last RQs seeks to find practical solutions which could lead to the increasing of NBS integration in the cities' stormwater management regime. The recommendations derived from this RQs would be beneficial for the practitioners from the two cities as well as others regarded audiences in *Section 1.6*.

1.3 Methodology Overview

This thesis conducts qualitative case-study research in which literature review and interview will be performed for data collection. The literature reviews on; Nature-based solution; sustainable urban water management; sustainable urban planning; urban decision-making process; and methodology, will be conducted for giving the basic understanding of the topic and provide a baseline for the analytical framework. Previous relevant studies on Malmö and Copenhagen will provide basic information on the two cases, following by the interview with the stakeholders from the two cities. The data collected will be analysed and synthesised into customised policy recommendations for enhancing the integration of NBS for the urban stormwater management of the two cities.

1.4 Scope and Limitations

This research aims to understand the decision making and realisation process of integrating NBS to the stormwater management plan of the selected cities. In this thesis, these processes are viewed as systems. Therefore, the scope and boundaries of the system should be defined. This section will identify the geographical and temporal boundaries, the scope of the NBS and the working process that will be studied, as well as the limitations of this research.

The geographical boundaries of this research are due to the selection of the two cities, Malmö and Copenhagen. The rationale for this selection is presented in the problem definition section. Although the focus is on the municipality level, the related EU's directive will be studied as a basis for understanding the policy framework of NBS and urban stormwater management. The

national policy frameworks will be studied from secondary data through research conducted in English due to language limitations.

The temporal boundaries for these two cities are determined by their current integration of NBS to stormwater management, which varies between the cases. Malmö implemented their first NBS for flood management measure in 1989, "Toftanäs Wetland Park" (Stahre, 2008), which is the temporal boundary of this case. The initiation of the 2BG project in 2006 will be the temporal boundary for Copenhagen. However, when asking the participant about their vision, another end of temporal boundary were left opened as "future" to let the participant be as creative as they could.

The definitions of NBS vary between different working groups (Potschin, 2015; Directorate I 'Climate Action, 2014a). Also, in the field of stormwater management, NBS can be called with other terms such as "green infrastructure", "green solutions", or "open solutions". In this thesis, the definition of NBS has developed from the pattern of NBS definitions from the various working groups which require that the solutions should be able to address multiple challenges with nature-based ideas and utilise natural elements to achieve the goals while considering societal factors. More about NBS definition, related terms, and application in stormwater management could be found in *Section 2.1* and *2.2*. The scope of the process which will be studied and analysed started from the transition from the EU and national policies to the making of the stormwater management plan at the municipality level and ended at the decision-making to construct the solutions.

1.5 Ethical Considerations

This research aims to respect and honour all interviewees' identity and perspective. All interviewees were asked for their consensus for recording the interview prior to the conversation. The recorded files were transcribed and sent to the interviewees for their approval to use any recorded data in the paper as well as the disclosure of the transcription in the Appendix. None of the interviewees had expressed a concern for being recorded. However, some of them wanted to remain anonymous. Their concerns are being taken with respect and, therefore, not all of the transcriptions are attached and some of the identities remain anonymous.

1.6 Audience

This thesis is written as a final part of the Erasmus Mundus Masters Course in Environmental Sciences, Policy and Management (MESPOM) at the International Institute for Industrial Environmental Economics (IIIEE) at Lund University in Lund, Sweden. Since the thesis aims to examine the practical aspects of integrating NBS to stormwater management by looking at the whole system, it should be in the interest of practitioners and planners, not only in the sustainable urban water management area but also people who interested in integrated sustainable urban management in general. Since this thesis is looking at the integration process of having nature in the cities as solutions, it would also be interesting for researchers and fellow students whose works focuses on architecture, design, and climate adaptation.

1.7 Disposition

In order to understand the topic of this thesis, related concepts are presented in Chapter 2, Literature Review. There will be an introduction to the term NBS, its application for urban stormwater management, urban planning disciplines, and urban decision-making process which will provide a basic understanding for this thesis.

Chapter 3, Methodology and Research Approach, presents the methodology and analytical framework of the paper. It will explain the rationale and the flow of the research process from data collection to the final strategy recommendation.

Chapter 4, Findings, presents the comprehensive findings from the two cities without any comparison. The chapter will provide the empirical results from the data collection process, literature review and interviews.

Chapter 5, Analysis and Discussion, discusses the three research questions in comparison of the two cities.

Chapter 6, System diagrams and recommendations, provides customised recommendations for the two cities based on a basic casual loop diagram.

Lastly, Chapter 7, Reflection and Conclusions, reveals the personal perspective of the author to this thesis, from the difficulties during the process to the contradictions found among literature from different disciplines and geographical locations, as well as a conclusion of this thesis research.

2 Literature Review

This chapter provides a basic concept of NBS, its application for urban stormwater management, its dialogue within urban planning disciplines, and urban decision-making process as the basic knowledge of general sustainable urban stormwater management and infrastructure governance. The rationale for literature selection will also present in the following sections.

2.1 History of and definition of Nature-Based Solutions

Nature-based Solution (NBS) is the new concept in the resilience building, climate change adaptation and mitigation strategy debates (Potschin, 2015). It is a solution which utilises or is inspired by nature to address main global challenges, including but not limited to, climate change, food security, social and economic development (IUCN, 2012). Due to its transdisciplinarity concept which integrating ecosystems with socio-economic dimension, it is believed to be able to provide multi-benefits to the environment, society, and economy. However, the term is relatively new in the environmental management debates, and definitions are still not harmonised between working groups (Potschin, 2015; Directorate I 'Climate Action, 2014a). Therefore, this section of literature review will go through the history and definitions of the term "Nature-Based Solutions".

As NBS only recently emerges in the academic literature, there's only a limited number of available literature that could be found with this term. However, there are many recent reports of the conferences and workshops related to it. These reports were used for reviewing the history and available definitions of NBS. According to the OpenNESS[2] synthesis paper No.18 (Potschin, 2015), the term "Nature-Based Solution" entered the mainstream scientific literature for the first time in the early 2000s. It was utilised in the context of the solutions to agricultural challenges, which integrate ecology into the practice, such as pest control, farming run-off mitigation and sustainable food production. Around the same period, the concept is also used in the context of land-use planning and water resource management, for example, Kayser and Kunst (2002) discussed the use of wetlands for wastewater treatment in the rural area. The term NBS started to be seen in the academic literature of industrial design in the mid-2000s. However, it is important to note that the concept of "biomimicry" has been used in this field by Janine Benyus as early as 1997. Janine's book, Biomimicry: Innovation Inspired by Nature, described biomimicry as "an approach to innovation that seeks sustainable solutions to human challenges by emulating nature's time-tested patterns and strategies". A good example of biomimicry would be the solar cells which inspire by the leaf's function (Benyus, 1997).

Focusing on the term NBS and its utilisation in the context of resiliency building and the climate change adaptation, it has become more widely used in this area starting from 2009. In 2012, IUCN prioritised NBS in 2013-2016 programme especially in its third programme area "Deploying nature-based solutions to global challenges in climate, food, and development" (IUCN, 2012). The UN Secretary General has mentioned NBS in the context of refining urban planning for the better quality of life (UN, 2013). The European Union also prioritised NBS as one of the priority areas for the EU Research and Innovation Programme (the EU Horizon

[2] Operationalisation of Natural Capital and Ecosystem Services (OpenNESS) is an EU funded project which aims to integrate the concepts of Natural Capital and Ecosystem Services into land, water and urban management by linking these terms to the operational framework that could provide tested, practical and specific solutions. It has many resources related to NBS since the working group believes that it is the mean to connect the Natural Capital and Ecosystem Services concepts into practices.

2020) since 2014 (EC, 2015). Despite the amount of attention NBS has received in the recent years, there is still no consensus definition of the term. This section explored definitions of NBS given by the four working groups; IUCN, BiodivERsA3, the expert group of the EU Horizon 2020, and OpenNESS. This section will compare and contrast these definitions to find their pattern.

IUCN has prioritised NBS in the 2013-2016 programme during the World Conservation Congress 2012 in Jeju, Republic of Korea. It has provided the seven principles for distinguishing NBS intervention from other kinds of intervention;

1. "The intervention delivers an effective solution to a major global challenge using nature."
2. "The intervention provides biodiversity benefits in terms of diverse, well-managed ecosystems."
3. "The intervention is cost-effective relative to other solutions."
4. "The rationale behind the intervention can be easily and compellingly communicated."
5. "The intervention can be measured, verified and replicated."
6. "The intervention respects and reinforces communities' rights over natural resources."
7. "The intervention harnesses both public and private sources of funding" (IUCN 2012)

BiodivERsA' report on the Strategic Foresight workshop 'Nature-Based Solutions in a BiodivERsA context' defines NBS as "the use of nature in tackling challenges such as climate change, food security, water resources, or disaster risk management, encompassing a wider definition of how to conserve and use biodiversity in a sustainable manner. By going beyond the threshold of traditional biodiversity conservation principles, this concept intends to additionally integrate societal factors such as poverty alleviation, socio-economic development and efficient governance principles" (Balian, 2014). BiodivERsA workshop participants also categorised NBS into three types according to the level of engineering, ecosystem services, and stakeholder groups.

Type 1: better using existing ecosystems by minimising the intervention.

Type 2: modifying existing ecosystems to better deliver selected ecosystem services.

Type 3: creating new ecosystems.

The participants noted some trade-offs of NBS that when the numbers of ecosystem service and stakeholder groups are increasing, there will be less capacity to maximise each of the services and satisfy each of the stakeholder groups (Balian, 2014).

The document from the expert group of the EU Horizon 2020 'Nature-Based Solutions & Re-Naturing Cities' defines NBS as the actions inspired by, supported by or copied from the

[3] BiodivERsA is a research consortium which characterise the research landscape and investigate key future research challenges and policy needs for biodiversity and ecosystem services at European level. Since NBS has emerged in the *EU Biodiversity Strategy to 2020*, BiodivERsA also prioritised the concept for the biodiversity research community. (Balian 2014)

nature; both using and enhancing existing solutions to challenges, as well as more innovative solutions. Not only that the concept of NBS intervention comes from nature, but the NBS intervention also used nature's features or system to achieve its goals. It also aims to support the societies to sustainably address multiple challenges such as the environmental, social, and economic challenges. The NBS intervention built upon a healthy natural capital and resilience to change as well as resource efficiency. The intervention also needs to be tailored to the local condition (EC, 2015).

Unlike the above, OpenNESS did not provide its own definition for NBS. However, it has provided definitions for each term in NBS.; Nature, Nature-based and Solutions with some remarks that make the term NBS different from others relevant terms.

> "*Nature* - relates to biodiversity in the aggregate, individual elements of biodiversity (individual species, habitats, ecosystems), and/or ecosystem services."

> "*Nature-based* – refers to ecosystem approaches, ecosystem-based approaches, biomimicry, or direct utilisation of elements of biodiversity."

> "*Solutions* – refers to a specific problem or challenge that for which some recognisable solution or more beneficial outcome exists." This problem-focused term makes NBS distinguished from other relevant terms in the field such as Ecosystem-based Approach or Soft Engineering.

The working group suggests that while there is no clear definition or explanation on how NBS different from other relevant concepts regarding its function, the term NBS could be used as an umbrella term for the ecosystem-based and nature-based approach (Potschin, 2015).

The above definitions share their consideration in the desirable result and the process of NBS intervention. However, each of the definitions is different in the framing, and the weight put on the focus of the benefits or outcome and the process of the interventions. The tables below compare each of the definitions by sectioning them into the desirable results aspect and the intervention process aspect.

Table 2-1 Comparing desirable results from reviewed NBS definitions

Working Groups	**Intervention Process**					
	Planning			Implementation		
	Environment	Society	Economic	Environment	Society	Economic
IUCN	Using nature	Communication/ community rights	Source of funding	Well managed eco-system		
BiodivERsA	Using nature	Societal factors		use/ modify/ creates		
Horizon 2020	inspired by, supported by or copied from nature / existing or innovative solution/ bases on Natural Capital/ resilience/ resource efficiency/ local specific			use nature features		
OpenNESS	Ecosystem-based / direct utilisation of nature feature					

Working Groups	Desirable Results					
	Multi-benefits			Addressing Challenges		
	Environment	Society	Economic	Environment	Society	Economic
IUCN	diverse biodiversity		cost-effective	global challenges		
BiodivERsA				climate change/ food/ water/ disaster		
Horizon 2020				multiple challenges		
OpenNESS				any existing challenges		

Table 2-2 Comparing intervention process from reviewed NBS definitions

In comparison, the NBS definition provided by IUCN is the only definition that mentioned the multi-benefits of NBS intervention. While other working groups frame the desirable outcomes as the ability to address multiple challenges where these challenges were not specified in any particular area but rather giving the wider framing such as global or multiple challenges, which could cover a wider range of challenges. However, BiodivERsA is the only working group that provides more concrete cases of challenges such as climate change adaptation, poverty alleviation, and food security. In the aspect of NBS intervention process, IUCN seems to be the most practical one where the detailed process in planning and implementation is given such as; source of funding, ecosystem management and community rights. While BiodivERsA leaves the planning process more open to the interventions that use nature and integrating societal factors, it is the only working group which provide the definition regarding the implementation process and categorised them into the three types of NBS. In contrast to BiodivERsA, the EU Horizon 2020's expert group focused on the planning process of NBS intervention by giving a variety of the desired processes such as the use of an existing solution or the underlining resource of NBS while they mentioned only the use of nature feature in the implementing process. OpenNESS, however, did not give any concrete example for NBS process but the comprehensive definitions for both planning and implementing stages that the NBS intervention is an eco-system based approach which utilises the nature elements.

The pattern of these definitions could be perceived. All the definitions shared that NBS should be able to address *multiple challenges* with *nature-based ideas* and *utilise natural elements* to archive the goals. Two of them state the importance of integrating socio-economi*c factors* explicitly while the other two mentioned about the factors in a less obvious way. This thesis used the definition developed from the pattern discovered where NBS in this paper includes the measure that can address *multiple challenges* with *nature-based ideas* and *utilise natural elements* to archive the goals while considering societal factors

2.2 Nature-Based Solutions and Sustainable Urban Stormwater Management

This section will provide examples of NBS applications for stormwater management in the urban settings by identifying their nature-inspired concept, natural elements in stormwater management solutions, their benefits, as well as a comparison to traditional stormwater management techniques.

When the rain falls in the natural landscape, stormwater would, slowly drip off the trees' canopies, and run through the foliage at ground level to the natural water storage area such as puddles, ponds, and swamps. These processes allow nature itself to manage the stormwater through infiltration and evapotranspiration. However, the impermeable surfaces in the urban area cannot slow down water velocity or allow them to infiltrate as in nature which results in higher percentage of runoff. The increasing in flow rate is one of the stormwater management issue in the urban area (FISRWG, 1998).

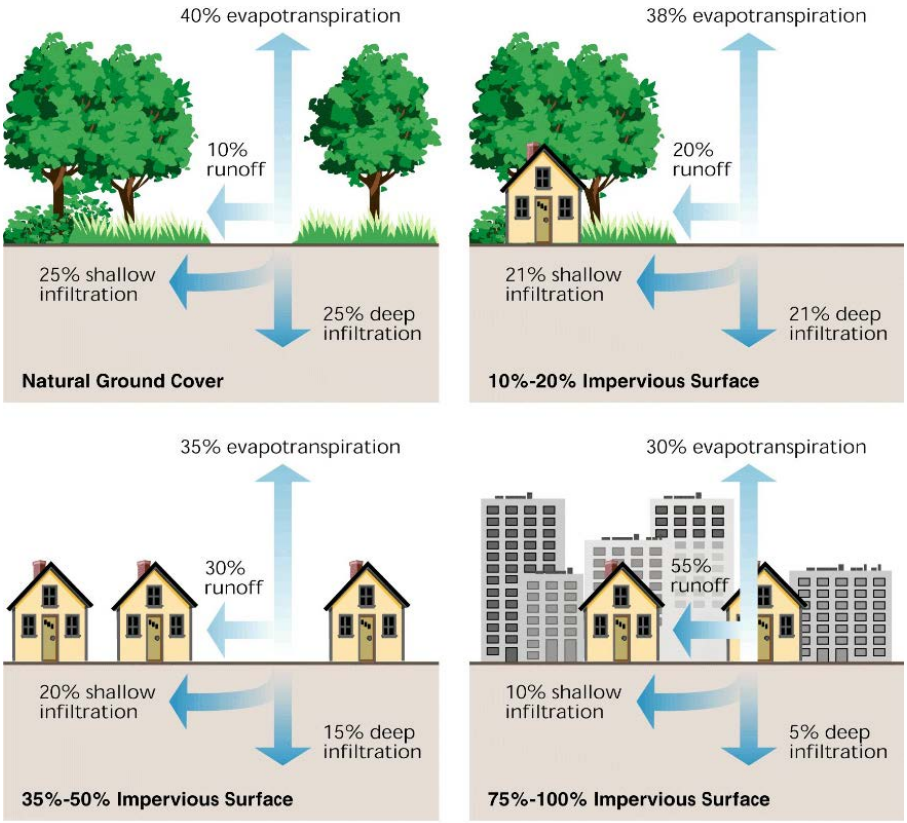

Figure 2-1 the relationship between land cover and surface runoff

Source: FISRWG 1998

In this sense, the NBS for stormwater management would be the solutions that could provide multibenefits, and use natural elements to slow down stormwater, provide the temporary storage or allow the rainwater to infiltrate into the ground. With this definition, the NBS for stormwater management is not a new concept in the field of urban planning or landscape design. These solutions could be called as Green Infrastructure, Blue-Green Infrastructure or open solutions. The integration of NBS to urban stormwater management could also resonate with the concept of sustainable urban stormwater management which aims to use or integrate the open structure to existing ones. The four categories for a sustainable urban stormwater management are source control, onsite control, slow transport, and downstream control (Stahre, 2008).

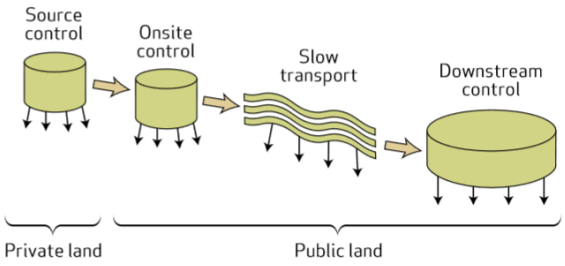

Figure 2-2 The four catagories for a sustainable urban stormwater management

Source: Stahre 2008

The examples of the NBS for urban stormwater could be rain gardens, green roofs, natural swales, city park, wetlands, or, even, urban trees. These solutions could provide multibenefits to the city, apart from stormwater management. The multibenefits are including, but not limited to; improving air quality, managing microclimate, increasing urban biodiversity and therefore the ecosystem service, providing better health of the citizens, increasing urban aesthetic, providing recreational spaces, and increasing surrounded property value (Dhakal & Chevalier, 2016; Maksimović, Kurian, & Ardakanian, 2015). This aspect of multibenefits differentiates NBS from the traditional solutions for stormwater management, in addition to their underlining concept.

Figure 2-3 Examples of NBS for stormwater management in the city

Source: Created by author

The traditional stormwater management solutions were meant to address the problem of flooding by draining the rainwater to the sewage system and the recipient or the wastewater treatment plant as fast as possible by using the pipes and gutter as the solutions (Delleur, 2003; Novotny et al., 2010). These traditional solutions could also be called as "conventional solution", "gray infrastructure" or "the close system". Not only that their underlining concept is opposing the concept of NBS which seeks to detain the rainwater, but the traditional solutions also deliver the stormwater management function only. This approach links to the traditional urban

management approach which is highly centralised and technocratic where the engineer of the city is the one who design and control the whole system (Dhakal & Chevalier, 2016).

The urban stormwater management is a part of the urban environmental system. However, it has not been integrated with other systems (Brown, 2005; Wilkinson et al., 2013) due to the traditional silo-thinking and working mindsets of different departments within the city which routed from sectoral and mono-functional thinking in the traditional infrastructure management (Scott et al., 2016). Especially, when the traditional stormwater infrastructure stays underground and can be constructed and managed by the city's drainage department alone (Stahre, 2008). In this regard, the practitioner who had been practicing with this mindset could feel reluctant to change and result in the barrier of implementing NBS (Dhakal & Chevalier, 2016; Scott et al., 2016). However, there is evidence in a paradigm shift in urban infrastructure governance (Malekpour, Brown, & de Haan, 2015).

There was a paradigm shift in urban infrastructure management from the technocratic and centralised to a more liberal way of thinking (Kaika, 2006), which could be found in the academic literature dated from the 1990s (Malekpour et al., 2015). Habermas's theory of communication action also provides a foundation for collaborative and participation planning since the 1980s (Muller, 1998). The emerging of pluralism within administrative decision making in the Western culture in the 1960s increased the level of transparency, accountability and accessibility from the public among the government (Beierle & Cayford, 2002). In the 1970s, the liability of the managerial perspective in the public sector also aid the flexibility of the governance system and improved its resiliencies (Dominguez et al., 2011). Lastly, the dialogue on sustainability and resilience had become more prominent in the urban strategic planning scene (Malekpour et al., 2015).

The paradigm shift in urban governance regime influences the infrastructure governance which seems to co-evolve with the emerging of the implementation of NBS in the city. This perspective views the multi-functionality of urban infrastructure networks as "the integral parts of the urban fabric and the process of transformation of nature into the city and vice versa" (Kaika, 2005) and requires collaboration and co-evolution with the economic and social institution (Bulkeley, Broto, & Maassen, 2014). This phenomenon also co-evolve with the urban planning and landscape architecture disciplines.

2.3 Nature-Based Solutions and Contemporary Urban Planning Concept

Since the urban stormwater infrastructure and management systems are parts of the urban system (Brown, 2005; Kaika, 2006; Wilkinson et al., 2013). It would be logical to view the NBS for stormwater management as an integrated part of urban and infrastructure planning. This section will look into the development of the western urban planning discipline about having nature area in the city. It will describe how the perspective towards the urban nature had developed from zoning to deepening and having nature as the basis of the urban design.

The idea of having nature in the urban setting from the Western urban planning disciplines could be dated back from the 1890's with the emerging of the Garden City Movement by Ebenezer Howard (1965 (1902)) as a rejection of the rapid industrialisation and the existing supportive urban planning models. This model proposed distinct zonings for housing, work, and recreation with the green areas for leisure and social activities to separate these zones. Howard also required a greenbelt encircling the city for food production activity and limited

urban sprawl (Howard, 1965(1902)). This urban planning concept could be the first time in urban planning discipline which seeks to acknowledge and include the nature in the urban context (Scott et al., 2016). However, the requirement of the low-dense city made this concept gaining less interest from the practitioners and the concept of "functional city" by Le Corbusier (1987 (1924)) emerged.

Le Corbusier proposed for a dense city with high-rise mixed-use buildings which should be functioned and managed as a machine. He viewed nature as the backdrop to the city which needed to be zoned and restricted to a tidy artificial landscape between the buildings, in order to be easily managed (Le Corbusier, 1987 (1924)). This planning concept centered its attention to the technology and ignored the value of nature as well as the human dimension. Thus it received much criticism within the architectural regimes and later become unpopular. The constructed city from this concept failed during the operational phase (Hirt & Zahm, 2012; Newman, 1966). An alternative city planning concept that was emerging during the same period as "the functional city" is "the dispersed city", introduced by another great architecture Frank Lloyd Wright (Wright, 1932). This concept proposed for the "anti-plan" where the city can grow freely into the rural matrix or the nature with the grid of highways. This planning concept consequences in the theoretical justification for the urban sprawl and extensive resource demands for decades (Braun et al., 2012).

The failure in modern urban design concept, the 1970s oil crisis, and the 1980s recession fueled the emerging of the new urban planning concept, "the compact city". The concept seeks to create a "city of short distances" (Scott et al., 2016) which could provide many benefits such as: tackling the urban sprawl (Gilham, 2002), less energy usage for transportation (Banister, 199; Haughton & Hunter, 2003), and more efficient utilisation of urban infrastructure (Burton, 2003). Many planners believed that this concept would bring sustainability to the urban future (Jenks et al., 2000), and the concept was practiced throughout decades. However, "the compact city" is heavily dependent on the traditional form of hard infrastructure and did not address the issue of accessibility or re-connection to nature (Scott et al., 2016). Therefore, practitioners were sought to address other issues in the cities such as water and climate resiliencies, as well as a protection or enhancement of the ecosystem services which could underline the functionality of the city (Wilkinson et al., 2013). This searching pointed out to the "eco-urbanism" which try to address the broader ranges of the environmental issues.

However, the "eco-urbanism" concept has been much focusing on using technologies or hard engineering solutions such as solar technology or smart grid (Sharifi, 2016). Therefore, a more recent practiced which try to integrate the natural process through place-based design and green infrastructure were seen and called as the "re-naturing" of the city (Scott et al., 2016). This concept places nature at the heart of the urban planning and management and views an urban setting as socio-ecological systems (Scott et al., 2016). This deepening of nature into the city also have another route from landscape architecture discourses, dated from 1956.

Ian McHarg, a regional planner, landscape architect and ecological planner, had given the similar idea to NBS in his book "Design with Nature" (1971), which seeks to introduce the place-based design and integrate the natural function of landscape elements at the urban planning scale (McHarg, 1971). Another discourse that emerged in the late 20th century is the "landscape urbanism" which raised from three issue: the aim to address the social and environmental problem caused by industrialisation and modernist planning; an emerging of community-based participatory planning; and the increasing awareness of the environmental issue (Marcinkoski 2016). The landscape urbanism concept proposed a synergy between the environmental and

engineering system within the spatial planning context based on the place-based principle. The concept believes that landscape is changing over time and acknowledge the importance of operation methods. This principle has changed the way nature in the city was limited to city parks or garden: it also engages other infrastructures such as brownfield sites, roads and the needs of the citizens. The landscape urbanism also seeks to integrate landscape or nature elements into the city in the form of green infrastructure. (Waldheim, 2006).

Later, the concept of landscape urbanism developed into "landscape infrastructure" and "ecological urbanism" principles (Marcinkoski 2016). The landscape infrastructure discipline centered on two elements: the regional-scaled ecologically-driven infrastructure and the soft infrastructure system which are multi-functional, adaptive, and subtle. The ecological urbanism focuses on the more inclusive urban design and connection of the urbanisation to its local ecology (Mostafavi & Doherty, 2010). The emerging of landscape architecture discourse within the urban planning discipline, which increasingly focusing on having nature as their base, supports the more integration of NBS in the city. However, the existing structure of the city from the modern era could hindrance the integration of nature.

2.4 Urban Decision-Making Process

From the previous sections, we could see the development of the urban and infrastructure governance as well as the perspective towards "greening" the urban area. The co-evolution of these socio-technical regimes allowed more integration of NBS to the city infrastructure. This co-development also proved the importance of collaboration among stakeholders from different disciplines and roles in governance could affect these changes. However, the integration of NBS would not be able to implement or construct without the approval decision of the project. This chapter will present about the urban decision-making process and the factors that would affect them. It will also introduce the seven factors influencing urban decision-making approach from UrbanData2Design project (Ddamba et al., 2015) which later will be used as an analytical framework for the barriers and drivers to the implementation of NBS measures in the city of Malmö and Copenhagen.

First, it is important to state that there is no standard or general approach in urban decision making (Ddamba et al., 2015). Thus, it is important to look at the local political and institutional context which would highly influence the decision-making approaches. Even cities in the same country could have different decision-making approach due to these differences and the different issues they are facing (Ddamba et al., 2015). In order to make a rational decision, it is important for the decision maker to balance all the interests involved with the project (van Stigt, Driessen, & Spit, 2015). This process would require knowledge from multidiscipline such as environmental sciences, geospatial data, social sciences and economics as well as the local knowledge or data from the local. The rational decision making would also require the knowledge of the interest of all inclusive stakeholders (van Stigt et al., 2015; Wang et al., 2014). Also, there are framework and tools for aiding the decision-making process available such as multi-criteria analysis, cost-benefit analysis, and UNCHS's Tools to Support Participatory Urban Decision Making. However, political support could disrupt these thinking process causing irrational decision made (van Stigt et al., 2015).

Even though rational decision should base on balancing the mentioned knowledge and interests, and there are various tools to support it, but often, the decision makers have to use their intuition or personal knowledge for the process (Ddamba et al., 2015; van Stigt et al., 2015). The dependent on intuition is due to the uncertainty and unaccountability of the tools

or data collection (van Stigt et al., 2015), for example, the computer models can not precisely calculate the value of intangible objects. Also, sometimes, the data from the scientist are not tangible enough to use in the design. These conflicts could be alleviated by the collaboration between scientists, practitioners, designers, and other stakeholders at an earlier phase of a planning process (van Stigt et al., 2015).

As aforementioned, many factors are influencing the decision-making process (van Stigt et al., 2015; Wang et al., 2014). However, in the academic literature, there were a lack of framework or factors regarding decision-making for urban infrastructure or transition in urban planning. Therefore, this thesis has chosen the seven factors influencing urban decision-making approach from UrbanData2Design project (Ddamba et al., 2015) for its analytical framework due to its relevance to the research topic and the framework is up to date. The framework will be used to discuss the process for integrating NBS to the urban stormwater management in Malmö and Copenhagen as well as their barriers and drivers. This framework combines factors from the findings of the European research project 'PROSPECTS' and a UN Habitat report on 'Tools to Support Participatory Urban Decision-making' (Ddamba et al., 2015). The seven factors influencing urban decision-making approach from UrbanData2Design project are:

1. **Data** – Diversity and quantity of data affect how the decision is made.
2. **Institutional Embeddedness** – The urban decision making has been developed from and sensitive to the political and institutional course of the local government.
3. **Administrative Structure** – The responsibility over an issue could vary due to the different structure of city administration, which affect the decision-making process.
4. **Funding** (Public/Private) – The financing structure also affects the decision for implementation in many ways such as time-planning and responsibility over an asset.
5. **Spatial Scale** – The difference in spatial scale of the project can lead to different decision-making approach. For example, a project at the community level can be more inclusive than the project at the regional level.
6. **Duration of the project** – The duration of the project also affects the decision in many ways such as timing for data collection and public participation method.
7. **Stakeholders** – The inclusiveness and mindset of stakeholders also influence decision making, as well as their interest. (Ddamba et al., 2015)

In conclusion for this section and the literature review chapter, infrastructure for stormwater management can be integrated with other urban infrastructures and it could be one of the solutions for "re-naturing" the city by incorporating NBS to the system. To make this happen, it would need a supportive urban management system and governance which the decision-making for the implementation at this level is crucial. The decision-making is complex and has many factors to consider. In order to make a rational decision for the urban area, collaboration and knowledge transfer among the stakeholders are needed.

3 Methodology and Research Approach

This chapter presents a literature review on the methodology for underlining the research design process in *Section 3.3*. Since there are many research methods available, the author started the literature selection based on the research objective which leads to qualitative research method and case study research method. Methodologies and research design in other academic research on the relevant topics are also studied as an example for this thesis.

This thesis aims to understand the practice of the NBS integration process and how to enhance it. As such, qualitative research methods are suitable because they aim to understand a practice, the viewpoint of people acting in the field, as well as, finding reasons for the activities (Flick, 2009). Qualitative research method also allows researchers to understand the complex details of an issue as well as the context in which the research participants addressed the issues (Creswell & Creswell, 2013). The initial study on qualitative research methods included the exploration of various methods such as narrative research, phenomenology, grounded theory, ethnography and case study. A deeper study of these methods pointed out that the narrative research, phenomenology, grounded theory, ethnography methods would be, consecutively, suitable for exploring individual experiences, understanding the essence of a phenomenon, grounding a theory from the data collection or understanding a shared patterns of a culture-sharing group (Creswell & Creswell, 2013). It also suggested that case study research method would be most suitable to achieve the research objective, which is to understand the planning and implementation process of integrating NBS to urban stormwater management in the two selected cases.

3.1 Applying a Case Study Research Approach

Since the case study research method is an emerging qualitative method (Creswell & Creswell, 2013; Yin, 2009), it should be worthwhile to introduce this method to the audience. This section will provide the definition of case study research, the rationale for using this research method, the method process, and characteristic.

"*Case study research is a qualitative approach in which the investigator explores a real-life, contemporary bounded system (a case) or multiple bounded systems (cases) over time, through detailed, in-depth data collection involving multiple sources of information, and reports a case description and cases themes. The unit of analysis in the case study might be multiple cases or a single case.*" (Creswell & Creswell, 2013)

The method is suitable for the research that aims to explore an extensive and in-depth explanation of some process, which does not require the control of behavioral events (Yin, 2009). According to Yin (2009), there are four main applications of case study research method: to explain the casual links in real-life intervention which could be too complex for the survey or experimental methods; to describe the actual interventions and its context; to descriptively explain some certain topics; and to get a deep understanding of the event that has no clear, single set of outcome in the evaluation process (Yin, 2009).

Case study research begins with case selection, identifying the intention of conducting a case study and stating a proposition if there is one. The case(s) selected could be a single or collective case. It could also be within one site or on several sites. However, the selection should be based on a purposeful sampling. Then, the researcher should collect several forms of data from several sources to understand the complexity of the cases, analyse them and conclude with the lesson learned (Creswell & Creswell, 2013). For the analysis, first, the researcher should choose between a holistic analysis which will look at the entire case and an embedded analysis which

look at some specific aspect of the case. This process guides the data collection process. Then, for the multicase analysis, the researcher should analyse each cases based on the theme before doing a cross-case analysis (Creswell & Creswell, 2013).

There are five analysis techniques: Pattern-Matching, comparing pattern from the empirical findings with the proposition; Explanation Building, constructing a set of casual links to explain the case and reflect the proposition; Time-Series Analysis, exploring the "how" and "why" questions about the relationship of the events studied over time; Logic Model, building up a logic model from findings to test the proposition; and Cross-Case Synthesis, building up a word table to compare between cases and reflect the proposition (Yin, 2009). The analysis technique used in this thesis is the synthesis of logic model and systems thinking (See *Section 3.2*). For more details on research design, please see *Section 3.3*.

3.2 Using Systems Thinking

This thesis uses systems thinking as one of its main analytical methods. This idea was inspired by the first interviewees from Malmö Municipality who wished to be anonymous. She used systems analysis to investigate how the organisation could have a higher awareness of urban ecosystem service by using Meadow's 12 system leverage points (Meadows & Wright, 2009). Many of the interviewees also pointed to the systems thinking when giving suggestions for levering the integration of NBS to urban stormwater management. Also, much of the literature reviewed in previous sections often referred to stormwater management infrastructure as a system, a part of the whole urban system (Dhakal & Chevalier, 2016; Maksimović et al., 2015; Stahre, 2008). This section will provide basic concepts of systems thinking, why it is suitable for this thesis and the systems thinking method that will be used in this research.

First, we should look at some related definitions. "System" is a set of elements that interact and interconnected with one another to function as a whole, in a way that there will be a behavioral pattern over time (Maani & Cavana, 2000; Meadows & Wright, 2009). "Systems thinking" is an emerging way of thinking for investigating complexity and change of the system (Maani & Cavana, 2000). There are five main principles of system thinking. First, everything is interconnected in an infinitely complex network of systems and therefore we should look at the system as a whole. Second, everything is also changing, complex and interdependent. Third, both measurable and non-measurable factors should be considered (Anderson & Johnson, 1997; Maani & Cavana, 2000; Meadows & Wright, 2009; Olsson & Sjöstedt, 2004). Fourth, it tries to balance short-term and long-term points of view. Lastly, we are part of the system which could influences us, and we could also have some impact on it, vice versa (Anderson & Johnson, 1997).

Apart from the inspiration from the interviewees and literature mentioned earlier, systems thinking is suitable for this research for another three main reasons. First, this way of thinking allows us to logically and creatively identify causes of problems and new opportunities (Meadows & Wright, 2009). This perspective can lead to new rationale and fresh answers to the third research question on ways to accelerate the integration of NBS. Second, systems thinking has been commonly used for strategy formulation since it highlights: internal contradictions; hidden strategic opportunities; and untapped strategic leverages, which are often ignored or missed by other methodologies (Maani & Cavana, 2000). Third, the system thinking methodology helps in visualizing and communicating the issue (Maani & Cavana, 2000), which will make the analysis part of this research reader-friendly and easy to understand.

There are many methodologies used within systems thinking lens. At first, the activities system analysis method was considered since it explores and enables visualization of the interrelationship between the individuals, the activities, and the contexts (Yamagata-Lynch, 2010). However, due to the fixed structure of its diagram, the time limitation, and the complexity of using NBS for stormwater management regime, this method was not suitable. Thus, this thesis will follow the system thinking and modelling process in Maani & Cavana (2000)'s book where the process is more flexible. This process is divided into five phases: problem structuring, casual loop modeling, dynamic modelling, scenario planning and modelling, and implementation and organisational learning. However, due to the time limitation and objective of this study which seeks to find the system leverage point, it will only go through the first two phases on the steps listed in the following *Table 3-1*. The steps eliminated from the original process do not serve the purposes of this research or are not necessary for answering the research questions.

Table 3-3-1 System thinking steps for data analysis (simplified from Maani & Cavna 2000)

Phases	Steps
1. Problem structuring	1. Identify problems or issues of concern to management 2. Collect preliminary information and data
2. Casual loop modelling	1. Identify main variables 2. Develop casual loop diagram (influence diagram) 3. Identify key leverage points 4. Develop intervention strategy

According to Maani & Cavana (2000), the system leverage point can be identified after the casual loop diagrams are developed. The identification could be done within the framework of the seven factors influencing urban decision-making approach (May et. al. 2007). However, the suggestion developed from this framework alone would not fully answer the third research question, "How can the integration of NBS be scaled up?", Since effectiveness is also a factor of this research question. The leverage points and twelve places to intervene in a system by Meadows & Wright (2009) provide an analytical framework with the aspect of effectiveness for the leverage points identified from the developed diagram.

The twelve places to intervene in a system are as follows. The list is in the order of effectiveness:

1. **Ability of transcending paradigm** – This is the most effective leverage point of the system, meaning that the system could accept that no paradigm is real and is ready to let go its existing mindset.
2. **Paradigm** – This is a highly effective place to intervene in the system since it is the mindset and the source of the system. By changing this, it could affect all of the following factors.
3. **Goals** – By changing the purpose of the system, it could also be leveraged effectively. Like paradigm and other following places, the following factors could be affected when this changes.

4. **Self-Organisation** – It would be quite effective and make the system become resilient if we could leverage the system by strengthening its structure's ability to be added, changed or evolved.
5. **Rules** – Rule of the system is the set of criteria which regulate the system. These could be laws or social norms as well as the rules of nature like gravity.
6. **Information Flows** – This is the accessibility of the actors in the system to the information. This measure could be effective since it could be easier and cheaper to inform the stakeholders rather than build the physical infrastructure.
7. **Reinforcing Feedback Loops** – When the positive or the gain feedback loop is strengthened, the system could produce more stocks. However, this should be monitored closely to prevent the unexpected negative impact from the growth of the system.
8. **Balancing Feedback Loops** – The balancing feedback loop is a self-correcting loop, and it should be strengthened by considering the impact which it is trying to correct. This leverage point is considered being less effective than strengthen the reinforcing feedback loop because it is less likely to be activated.
9. **Delays** – Delays are the length of time the system needs for the change. The shortening or prolonging of delays do not strongly affect the system since, slow or fast, the result or the core pattern of the system will remain the same.
10. **Stock and flow structures** – These are the physical structures of the system. It is crucial for the system, but the change in physical things do not always highly effect another aspect of the system.
11. **Buffers** – These are the size of stocks. The larger the stock is, the more stable and inflexible the system will be.
12. **Numbers** – This is the constant or the parameter of variables within the system.

Even though the lower places seem not to be as effective for system leverage as the higher ones, they can still affect the factors higher. These effects would result in more effectiveness of the measures (Meadows & Wright, 2009).

3.3 Designing the Research Approach

This section explains the research process of this thesis and the connection from literature review to data analysis, in accordance to the three research questions;

1. *Why did the municipality of Malmö and Copenhagen decide to integrate NBS into their stormwater management projects?*
2. *How did they implement the NBS?*
3. *How can the integration of NBS be scaled up?*

In order to answer these questions, the literature analysis, interviews, and data analysis were conducted. The table below shows the process and flow of this research. The structure of this research design adapts from case study research methods (Yin, 2009) and the examples of research structure of another three academic literature which are also using case study methods to examine the environmental transitions. These literature provide the pattern of the research

process which started with literature review, then forming the analytical framework from the findings and then provide the recommendations (Corvellec et al., 2013; Mguni, Herslund, & Jensen, 2015; Nickel et al., 2013). These process were synthesised with the case study research methodology to construct the structure of the research design for this thesis

The research design is presented in *Table 3-2* below. This research process has the RQs as a main framework. First, a literature review on Nature-based solution; sustainable urban planning; sustainable urban water management; urban decision-making process; system analysis; and methodology, is conducted. The review meant to give the basic understanding of the topic, prepare researcher for the interview with the professionals, and provide a baseline for the analytical framework. The data collection activities following the literature review are in accordance with the three RQs. The finding will be categorized into initiatives, implementations, drivers and barriers, and leverage points. These catagories are by the RQs where the implementation related RQs are separate into: implementation process, and drivers and barriers, in order to underline factors that drives or obstructs the integration of NBS.

Table 3-2 Research design process

	RQ 1 – Why implement NBS?	RQ 2 – How to implement NBS?	RQ 3 – How to scale up NBS?
Literature Review: Nature-based solution; sustainable urban planning; sustainable urban water management; urban decision-making process; system analysis; and methodology			
Interview Questions	• What initiate the integration of green infrastructure to stormwater management system?	• What is the role and activities of stakeholders? • What is the process for integration? • Does it include public participation in these process? • What are the incentives and barrier for these process?	• Which social innovation should take place to support the integration process, effectively? • The interviewee's vision towards integration of green infrastructure to other city infrastructure in the future.
Literature analysis	Case literature about the initiatives	Case literature e.g. report of activities, maps, tools, for supporting and comparing with the empirical findings.	Case literature: a report from stakeholders' workshop.
Analytical framework	The theoretical and empirical findings will be synthesised to answer this RQ.	The empirical findings in this column will be summarised in order to answer the question itself and will be analysed within the framework of the seven factors influencing urban decision-making approach (Ddamba et al., 2015)	
			The empirical findings in this column will be combined with the analysed data from RQ1 and 2 in form of casual loops diagrams to find the system leverage points according to 12 places to intervene in a system (Meadows, 2009).

The findings about implementation process and leverage points are catagorised according to the analytical framework, the seven factors influencing urban decision-making approach (Ddamba et al., 2015). The given significant factors from implementation process and leverage points will be chosen as variables for creating two different casual loop diagrams. As aforementioned in *Section 3.2* that the urban stormwater management will be viewed through system thinking lens, the casual loop diagram will be created to support the customized recommendations for scale up the integration of NBS.

This chapter also presents the details of the interviewing process. There were 28 e-mails sent to 28 persons working in the field of; research on NBS and stormwater management, municipality officers related to integrated NBS projects, and officers at the water utility company from both cities as well as officers from non-profit organisations such as Resilience Region and ICLEI-Local Governments for Sustainability. Out of 28 interview requests, 14 interviews were conducted from 16th March 2016 to 3rd May 2016. The following table shows the number of the interviews and the organisations which the interviewees are represented from the two cities. The interviewees were qualified as the key persons due to the contact sources such as recommendations from thesis supervisor, recommendations from one interviewee to another, and by the given contacts from the central website of the organisations.

Table 3-3 the number of the interviews and the organisations which the interviewees are represented from the city of Malmö and Copenhagen

	Municipality Officer	Water Utility Officer	Researcher	Non-profit organisation
Malmö	3	1	2	1
Copenhagen	2	1	4	

When cited the interviewees, the sources will be generalised into the municipality officers, the water utility company's officers, the researchers and the officers from a non-profit organisation. These generalisations were meant to protect the confidentiality of interviewees' personality. The detailed about interviewee's confidentiality and the attachment of transcription from the interviewees who allowed this thesis to use their identity as references could be found in the Appendix.

4 FINDINGS

This chapter presents the result from both literature and the practitioners' interviews from Malmö and Copenhagen, case by case. The structure of each case begins with an introduction to the city following by four sections in response to the three RQs. The first section presents the initiative for integrating NBS into the case's stormwater management. The second and third section response to the second RQs by introducing the implementation processes of the integration, then the barriers and drivers of these processes. The last section is the suggestions from the interviewees and literature about how can the implementation of NBS can be scaled up.

4.1 Copenhagen

Copenhagen is the capital city of Denmark. It is a low-lying coastal postmodern city (Mguni et al., 2015). The city sewer system was 90% combined system, where rainwater and wastewater were collected and drain through the same facility to the city's wastewater management plant (Sørenson et al., 2006). Copenhagen was facing multiple challenges regarding stormwater vulnerability due to climate change and the existing sewage system. According to the Copenhagen Climate Change Adaptation Plan (CCAP, 2011), the A2 scenario forecasted an increasing in precipitation of 25-55%. The cloudburst and severe floods in August 2010 and July 2011 seemed to ratify the predictions and signal the vulnerability of the city (Mguni et al., 2015) as well as the recent catastrophe in August 2014. The existing combined sewage system also vulnerable due to the increasing rainfall which could cause system overflow.

At the time of studying, the city had many plans related to NBS for stormwater management. There were also many local plans to be implemented, at the local level. There were Copenhagen Climate Change Adaptation Plan (2011); Cloudburst Management Plan (2012); and Bynatur I København (Urban nature in Copenhagen Strategy 2015); and the action plan, at the municipality level. There were four main organisations related to the implementation of NBS for stormwater management in Copenhagen: the municipality of Copenhagen; the Capital Area Utility Company (HOFOR)[4]; academic researchers; and the consultancy companies such as the environmental consultants and design firms.

4.1.1 Initiatives

According to one of the researchers in the 2BG project5, the first time that NBS came to the interest of the Danish stormwater management regime is the starting of 2BG project in 2006. The project was funded by the municipality of Copenhagen and HOFOR. It aimed to develop a trans-disciplinary study on how to implement GI to stormwater management, which had been looked at in the academic society but not yet emerging in the practice of the municipality. The result of the project showed many potentials for integrating NBS to the stormwater management system. However, the integration was not implemented due to the practitioners' doubt. The doubt caused by the lack of successful cases or solid technical proves that the solutions would work in the local context. At that time, there was tension between the NBS-pro, which mostly consist of landscape architects, and the engineers who doubt in the solutions.

[4] Hovedstadsområdets Forsyningsselskab (HOFOR), known as 'the Capital Area Utility Company' in English, is a water utility company which supplies water and sewerage services to the city of Copenhagen. (City of Copenhagen 2014)

[5] Danish National Research Programme ' Black, Blue and Green: Integrated Infrastructure Planning as key to Sustainable Urban Water Sytem'

Nevertheless, the 2BG project had initiated another two projects which raised the interest of integrating NBS to the stormwater management system among the practitioners in the municipality and HOFOR: 19 KO (19 municipalities) and Vand I Byer (water in urban areas). The 19 KO was a project which the water researchers collaborated with the water practitioners from 19 municipalities in Denmark. It focused on planning and modelling for stormwater management with NBS. The results showed potential for integration but quantitatively uncertain, and the tension between two believers was not released. However, engineers at the management level started to see the economic potential of using NBS due to the lower construction cost comparing to the conventional solutions. Several researchers from Copenhagen mentioned that the 19 KO, together with, the severe flood in 2010 and the urban nature think tank workshop organised by the municipality brought the issue of integrating NBS to stormwater management to be discussed widely.

In 2010, there were two major establishments: the Copenhagen Climate Change Adaptation Plan (CCAP), and the Vand I Byer (water in urban areas) network. The CCAP main objective was to address the climate change issue such as more frequent and intense rainfall, urban heat effect, and CO2 emission. The plan emphasised the integration of climate change issue into other city planning issues. The examples of the considerations were: the usage of green-blue infrastructure as a means to create an attractive and livable city; climate adaptation measures should result in the green growth; and the measures should resonate with other plans such as groundwater and waste water management so that CCAP could create valuable assets to the city. The CCAP also remarked that the investments have to base on sounds technical knowledge (CCAP 2011). The cloudburst management plan was a part of CCAP, which specifically address the stormwater management issue. As mentioned earlier, Bynatur I København (Urban nature in Copenhagen Strategy 2015) was another plan that supports the integration of NBS. A respondent from the project mentioned that the plan seeks to increase the quantity and quality of urban nature in response to the green city policy. It also seeks the opportunity to increase urban nature and biodiversity in coupling with stormwater management or other urban retrofitting project. The severe flood in 2010 and 2011, also accelerated the transition in the Danish water regime (Mguni et al., 2015).

From HOFOR perspective, they decided to integrate NBS due to the lower cost and effective hydraulic function of the solutions. The interest of the municipality to build a greener city also encouraged HOFOR to consider these solutions since the municipality was the owner of HOFOR. At the time of this thesis research, there were several NBS for stormwater management implemented in Copenhagen. The first climate change urban space, Tåsinge Plads, was officially opened in December 2014 as a part of the Østerbro climate resilient neighborhood project. The project covered the whole Østerbro neighborhood with various scales of NBS for stormwater management (Klimakvarter 2016). Several respondents from Copenhagen also noted that there would be 300 more projects for climate change adaptation coming in the next 20 years, which could be great potential to integrate NBS to these projects.

4.1.2 Implementation

There were many stakeholders involving in the implementation process, from the plans mentioned earlier to the practice, including, but not limited to: the municipality, especially the departments under the city development unit; the water utility company, HOFOR; the academic researcher; the consultant firms; the private landowners; and the citizens. They also had different responsibilities over the implementations as well.

The respondents from HOFOR described that it was the responsibility of the municipality to have a climate adaptation plan in their city development plan, where the Danish Nature Agency provided the guidelines for planning and construction. The municipality was also responsible for public property such as public parks, school grounds, roads and natural swale, while HOFOR was in charge of the stormwater management facility such as pipes or retention basin. According to the water sector act, the sewage system and the stormwater management facilities were under the responsibility of HOFOR, which financed through the water tariff paid directly from the citizens to them (State of Green 2015). HOFOR was also able to provide economic incentives to the private land owner to encourage the usage of NBS within their property.

There were several cases where the border of responsibilities was unclear: when the stormwater ran through several surfaces owned by different actors, and when the solutions had to be co-owned by several actors, for example, the construction of a public square which could turn into water retention basin during the event of extreme rainfall. In this regard, the 'co-financing regulation' allowed the municipality, HOFOR, and private landowners to co-finance the solutions. As HOFOR had a monopoly over water, wastewater and stormwater management, the Water Utility Secretary under the Danish Competition and Consumer Authority are monitoring their investment and activities (State of Green 2015). It was also, by law, obligate the municipality to include public participation in their planning process from strategy planning to detailed design. However, several interviewees mentioned that the level of public participation could vary due to the level of the plan and approach of the local authorities.

The private landowners had to get the building permit before having their project constructed or renovated. The criteria in the building permits obliged the building to be constructed in the way that the water and humidity cannot damage or cause inconvenience to the building and its users. The permit also allowed the municipality to work with the private landowners to regulate the amount of rainwater drained from the land to the public property (CCAP, 2011). According to one respondent from the municipality of Copenhagen, in the future, every building projects would need to comply with the 'biofactor' proposed by the Urban nature in Copenhagen Working Group. The 'biofactor' would be the tool which combines scientific data of water aspect, nature quality, nature quantity, and society aspects to calculate the need of natural elements for various function on the site, to create an ecosystem network within the city. It is now under the developing process by the city development unit of the municipality and will be tested by various stakeholders such as designers, developers, and contractors before having a consultant develop the final version. Many of the respondents mentioned that the consultant firms and academic researchers are having a supporting role during the implementation process

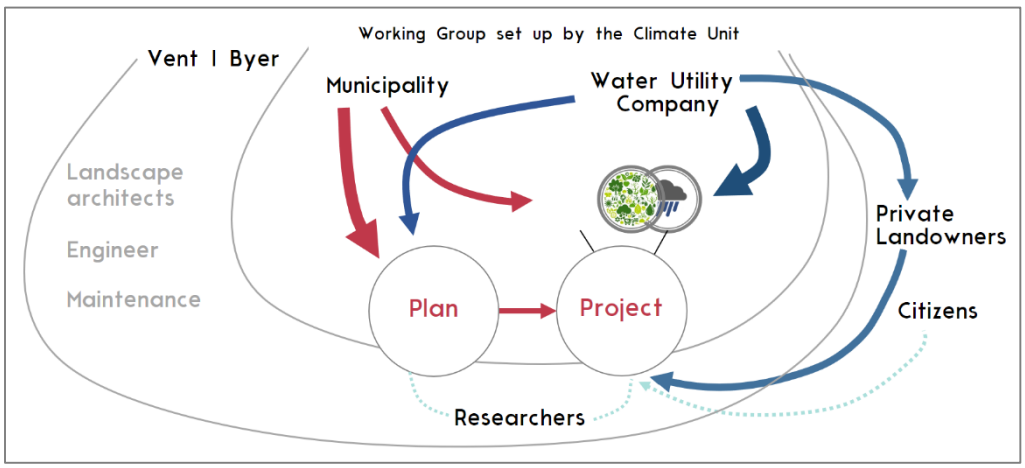

Figure 4-1Diagram for integration of NBS to stormwater management in Copenhagen

for integration of NBS to stormwater management in Copenhagen such as giving recommendations, providing scientific data, participate design competition, and evaluate the solutions.

There were two main steering groups which bring together practitioners and professional in stormwater management and NBS: climate unit of the municipality of Copenhagen, and the water in the urban areas network. At the administrative level, the climate unit played a major role as a platform for different departments in the municipality and HOFOR to collaborate, while the water in urban areas network provided a wider platform for the municipality, HOFOR, researchers, private consultants and companies to communicate. *Figure 4-1* shows the administrative structure for the implementation of integrating NBS to the urban stormwater management in Copenhagen. The figures below show the design process and visual of Enghaveparken, one of the NBS projects for Climate Change Adaptation in Copenhagen.

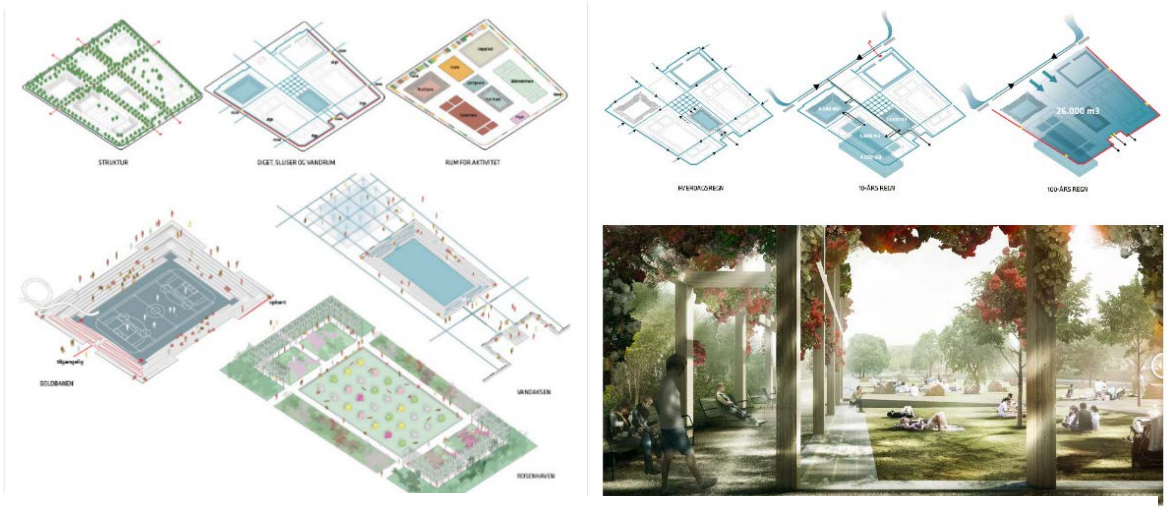

Figure 4-2 The multifunctionality aspect during the design process of NBS projects of

Source: http://tredjenatur.dk/portfolio/enghaveparken-her-og-nu/

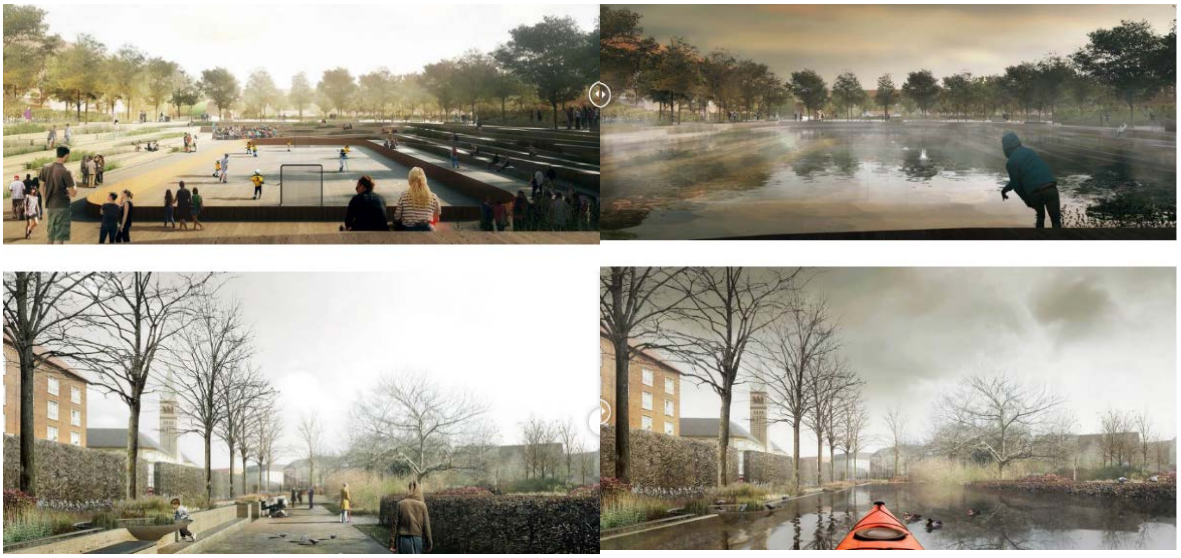

Figure 4-3 The perspective of the project transformation during usual days (dry) and the cloudburst events.

Source: http://tredjenatur.dk/portfolio/enghaveparken-her-og-nu

4.1.3 Implementations: Drivers and Barriers

The Climate Change Adaptation Action plan was already approved by the politicians and there would be other 300 climate change adaptation projects implemented in the next 30 years. There were plenty of potentials to integrate NBS to these projects, and some solutions were already in place. The drivers and barrier behind the decision-making were studied from available literature and the interviewees. These drivers and barriers are categorised by the seven factors influencing urban decision-making approach from Ddamba et al. (2015). *Table 4-4-1* presents barriers and drivers during the implementation process of integrating NBS to Copenhagen's stormwater solutions. The sources of these data which come from the literature will be referenced as usual in-text citations. If the sources were interviewees, they will be generalised as non-profit organisation staff (N), researchers (R), municipality officers (M), and the water utility company's officers (HOFOR) as described in *Section 3.3*.

Table 4-4-1 Barriers and Drivers during the implementation process of integrating NBS to Copenhagen's stormwater solutions.

Institutional embeddedness	
Drivers	It is the Danish tradition to collaborate that we should talk to the representative from these organisations as a way to communicate to many people (HOFOR, M)
Barriers	Command and control approach and data-based decision making (R)
Administrative Structure	
Drivers	Policy - The municipality had approved the Climate Change Adaptation Action Plan. The plan was considering the multifunction nature-based infrastructure (M, M, R, R, R). - The Urban Nature in Copenhagen Strategy supports and puts demand on the integration of nature and ecosystem service (M) - HOFOR authorised to provide economic incentive to private landowners which encourage local stormwater management (HOFOR) - The law has changed and become more supportive (R) Management Structure - High level of collaboration between HOFOR and the municipality from the planning process to the maintenance of the project. (M, HOFOR) - Steering group and knowledge sharing platform – VIB and the climate unit (M, HOFOR, R, R, R) - The separation of HOFOR allows the organisation to invest more freely (R)

Barriers	Policy - Disconnection could be found from the EU policy level: Water Framework Directive, Flood Directive, and The Urban Waster Water Management Directive. The missing link also causes the tension between the boundary of city and rural area. (R) - Contradict interests between national and municipality: evaluation vs. livability (R) - Contradict agendas within the municipality such as green vs. cheap or simpler local plan vs. adding the biofactor tools (R, M, M) - There is a law regarding water quality which no allow the usage of water that has been on the surface for more than 24 hours, or there has to be quality control of infiltrating water (R, HOFOR) - The law is always changing without notice (HOFOR) - There are many standard to pass when doing a project, which causes the project to be expensive and time-consuming. (M) - The change in political party makes the implementation become uncertainty (M) Management Structure - Work tension from the separation of HOFOR from the municipality. (R) - Unclear responsibility between stakeholders (HOFOR, R) (Mguni et al., 2015) - The municipality has to be evaluated by the criteria from the national level which prevent them from being experimental (R) - The implement has to be fast and economical, the administrative structure which requires the consideration of the cost does not allow the proper design to be implemented (M, M, R)
Funding	
Drivers	- HOFOR could invest more as they had separated, so more projects could be implemented (M, R) - Co-funding is possible (HOFOR, M) - Huge amount of funding was approved for CCA projects (R, M)
Barriers	- Very little amount of money from the CCA projects allocate to nature elements (R) - The unclear responsibility at the administrative level resulted in unclear funding for construction and management (HOFOR, R, R) (Mguni et al., 2015) - If NBS become more expensive than conventional solutions, HOFOR would consider the later. (HOFOR) - The nature elements are the first thing to be discarded when there is a need to lower the project cost (M) - It is easy to get external funding for the construction but not for maintenance. (R)
Spatial Scale	
Drivers	- The solutions are everywhere in the city, including various scale projects, which could be potential for integrating NBS (M, M, R) - Every district has their stormwater management plan (N)
Barriers	- The small scale project from large scale planning has higher opportunity to be viewed as unnecessary for the whole city (M) - Space is an issue when the decision maker need to choose between green solutions or more space for housing (M) - Missing link between urban and rural stormwater management (R) - Lack of regional overview (R) - The available computer models are not capable of calculation at the larger scale stormwater management, although several organisations are developing them. (R, R, HOFOR)

	- It is difficult to think holistically at the larger scale. (R)
Duration of the project	
Drivers	The CCA plans are the long term plan (M)
Barriers	There is a need to wait for another project to initiate in order to integrate NBS. (R)
Stakeholders* most referred to	
Drivers	Collaboration - Most of the stakeholders are willing to collaborate (HOFOR, M, M) - HOFOR is credible of knowing about the water and trusted to manage the system (HOFOR) - The municipality is willing to involve the citizens as early as possible so that the plan could match the citizens' vision (M) - Danish Engineer Association has a crucial influence to the engineers in Denmark (R, R) Mindset - An alignment in mindset that the city should be proactive (N, HOFOR, M) - The green solutions offer other value apart from stormwater management (M, R), and the solutions can be at various scales (M), and the CCAP is trying to connect as many things as possible (M) - Integrate as much ecosystem service as possible (M, M, R) - Politicians also want a greener city, especially focusing on trees, which resulted from the will of Copenhagen's citizens (M) - Increasing of ecological awareness among urban planners (R, M)
Barriers	Collaboration - Community collaboration process is difficult (HOFOR) - Lots of stakeholders could bring to lots of disagreement (HOFOR, R) - Business as usual (M, R, R) - Landscape architects are not familiar that they have ecological role (R) - Different departments within the municipality are working on different agenda (R) - It is difficult to find quality human resource in Danish water sector (R) - Level of public participation is vary (R) Mindset - Houses and schools (basic facility) are the priority for the municipality, not nature (M) - Biodiversity is very new and abstract to many citizens as well as the construction industry and municipality's planners (M, M) - The private landowners and citizens have not felt that they are also responsible for stormwater management (Mguni et al., 2015). - Nature elements are seen as decoration or recreation rather than resource (M, R) - Urban citizens seem to lack nature awareness due to lack of nature experience (R) - Wild plants are essential for the urban nature but now seen as weeds. (R) - Best solution perceived as the most economical solution, and politician is focusing on the cost (R)
Data	
Drivers	- Hydraulic models are developed to be capable of calculating the integration of NBS (HOFOR)

	- CBA shows that being proactive is better than fixing the damage from a catastrophe (HOFOR). - NBS is a good business case since they are cost less and provide multi-benefits (HOFOR) - CCAP has done based on a diagram which emphasises the need of nature in the city. (M) - The Urban Nature in Copenhagen working group is working on the 'biofactor' tools which will demand both quantity and quality of nature from the builders (M) - There are several tools and standard for supporting designers and engineers to integrate NBS (R, R, R) - Conflict between human and wildlife sprung from NBS could be settled by good design or simple techniques (R) - Inserting new pipes underground is very costly (R) - Knowing about landowners could support the collaboration process with them (R) - There are increasing number of successful NBS cases (R)
Barriers	- When cooperating NBS in the computer model, it becomes very complex and could take two days to deliver the calculation (HOFOR) - The results of the calculations from the developing tools are still in doubt (R, R) - It is very difficult to give a numerical value to nature quality or choosing of the aspect that should be accounted as 'quality' in nature, so the configuration of the model is needed to adjust case-by-case. (M, R) - Experimental projects can cause mistake and be expensive at the start. (R) - The existing urban infrastructure cause space issue and NBS are now used to support these structure. (R)

4.1.4 Leverage Points

This section response to the third research question which seeks to explore the possibility to scale up the integration on NBS to Copenhagen's stormwater management by collecting recommendations from the interviewees and academic literature which focus on Copenhagen's stormwater management. The recommendations are also categorised by the seven factors influencing urban decision-making approach (Ddamba et al., 2015).

Institutional Embeddedness - As Copenhagen stormwater management system was working based on a top-down and data-based approach, a respondent from the municipality suggested that communication with the politician and people at the administrative level would be crucial for transition in institutional structure and law and a researcher suggested that more polycentric governance is needed. However, the fact that the authorities and elites managed stormwater management regime from different professional groups provided Copenhagen with an excellent opportunity to change the discourse of stormwater management into a more sustainable one. This opportunity needed to be accelerated by empowering discourse which supports the transition (Mguni et al., 2015). Several researchers also pointed out that Danish culture of collaboration should be more emphasis, and involve the citizens in the project as early as possible.

Administrative Structure - The interviewees from HOFOR suggested that the clearer boundaries and responsibilities would make their work easier. They also suggested that the law should allow them to be able to provide a different form of incentive programmes for private

landowners' collaboration. A researcher suggested that the law should demand catchment based management and the incoherence between the laws should be addressed. Also, another researcher pointed out for a policy integration at the regional level.

When working on an actual project, a researcher noted that urban biodiversity should be included in the term of reference (TOR) of the project proposals, and the evaluation by scientists is needed. Another researcher suggested a higher level of collaboration within the municipality and emphasised that it should be by law. Also, several interviewees from the municipality and research programmes suggested that the new way of collaboration between stakeholders would be needed for getting more effective and inclusive solutions, while the respondent from the municipality was looking for the aligned dialogue and tools to work with NBS.

Funding (Public/Private) - To accommodate the simplicity among responsibilities and boundaries between stakeholders, an interviewee from HOFOR also suggested for a more simple financial structure, while the researchers suggested for the co-funding scheme and more incentives for the private property owner will increase their interest in implementing NBS.

Spatial Scale - A respondent from the municipality suggested that there should be more small scaled but the high quality of urban nature projects integrated to the whole city, while a researcher was looking at the larger scale. The researcher suggested that there are potentials of catchment based management which could arise from the unification among water utility companies from various municipalities.

Duration of the project - The researchers agreed that long-term planning is needed to scale up NBS for stormwater management.

Stakeholders - An interviewee from the municipality and a researcher suggested to: include biologist or other professional in the nature aspect to planning and design process; involve the local citizens at the beginning of the project to create sense of ownership; and communicate with the public to provide information and show them the good practice solutions of NBS, which could raise their awareness about the nature. The researcher also emphasised on multidisciplinary collaboration. An interviewee from the municipality also suggested that people who opposed the idea of NBS should be included to co-develop an aligned solution. A researcher pointed out that the establishment of water profession organisation should be in place to collect qualify human resources and suggested that solution should be done at the level of the household as well as stakeholder's co-design for more knowledge, effective solutions and engagement. Another researcher also recommended for an innovative co-design process as well as earlier participation to increase the sense of ownership.

In the aspect of stakeholders' mindset, the interviewee from the municipality suggested two changes: increasing ecological awareness among citizens to raise momentum among politicians and collaboration with maintenance staff so they could find an acceptable way to work with NBS. Another municipality officer also suggested a change in the mindset towards urban nature from recreation or decorative propose to solutions to the city's challenges. A researcher also pointed out the changes in the mindset of actual maintenance worker by creating a constructive dialogue with them as well as more awareness of using the native plants in the urban context.

Data - While no suggestion regarding the data was interpreted from the interview with HOFOR, the interviewees from the municipality and research groups were looking forward to

seeing more innovative design solutions that could be the new way to green the city as well as the development of trusted and inclusive decision-aiding tools. Regarding the tools, the researcher from VIB suggested that case-by-case configuration would be more accountable and suitable for providing data to the context-based projects. The interviewees from both groups also suggested the communication and accessibility of data will be necessary for scaling up NBS since it could raise awareness among citizens, practitioners, and politicians. The knowledge about the ecosystem service, multibenefits of NBS, and the stormwater management or other city development plans are suggested to be communicated to these stakeholders. The interviewees also raised that knowing about the increasing number of successful NBS cases would also support the integration. The London's Olympic Park 2012 were mentioned as an excellent case study of including management and local citizens participation issue in the project's TOR by the researcher participated in the Copenhagen's Urban green think tank workshop.

4.2 Malmö

Malmö is the third largest city in Sweden which located on the southern coast of the country. The city is connected to Copenhagen by the Øresund Bridge. Even though, the city sewer system is 35% combined system, the combined system covered most of the older parts of the city which both population and built structure are highly dense. Malmö stormwater management regime is also vulnerable due to climate change and the existing sewage system. Four major storm events in 2013 had cost more than 900 million Swedish Kroners would be a concrete example of the system's vulnerability (HagHigHatafSHar et al., 2014).

The integration of NBS for stormwater management in Malmö has been practicing since the 1980s (Stahre, 2008), and there has been an integration of the term ecosystem service into department's strategic documents since 2012 (HagHigHatafSHar et al., 2014). Therefore, NBS has been included in several plans such as municipality comprehensive plan[6] (2014), the Action Plan for Climate Change Adaptation (2012), the stormwater management strategy (2008), the green-blue infrastructure plan (internally published 2016) and the comprehensive plan for cloudburst management (internally published 2016). The key players in the decision-making for stormwater management in Malmö are Malmö Water (VA SYD); Municipality of Malmö, including but not limited to, Malmö Planning Authority, Malmö Public Works, Malmö Real Estate Authority, and Malmö Environmental Protection Authority; and academic researchers (Stahre, 2008).

4.2.1 Initiatives

As mentioned earlier the integration of NBS for stormwater management in Malmö has been practiced since the 1980s due to the active interest of Malmö Water to find the new technical solutions for slow down the peak flows of the urban runoff and protect the area downstream from system overflow during heavy rainfalls (Stahre, 2008). The first implemented NBS for stormwater management measure was in 1989, the "Toftanäs Wetland Park", as a part of the development of Toftanäs area. Malmö Water chose to use wetland as a mean to retain water within the site. There were many opposing arguments within the municipality since they trusted in the conventional system and there was no example in the region before. However, Malmö Water approached the Parks and City Environment Department and co-developed a vision of

[6] The Swedish planning process is organised in comprehensive and detail planning. Comprehensive Plans provide strategic, non-legally binding orientation for spatial planning and planning on a more detailed level. They cover the whole city, focus on a time horizon between 10 and 25 years and are updated every four years. Detail Plans are legally binding and comprise a specific residential area or a single plot. They cover built-up areas, create the preconditions for construction, define the purpose for the development and determine the townscape. (HagHigHatafSHar et al., 2014)

the wetland park, which could add other benefits to the city such as recreation and increased biodiversity. At that time, the environmental issues were just emerging in Sweden, so the implemented projects were perceived as innovative and become the pilot projects for both nationally and internationally, especially the Augustenborg eco-community and the Western Harbor BO01 project (Stahre, 2008).

Until 2014, there were 23 NBS projects done for stormwater management, but most of them located in the outer parts of the city (HagHigHatafSHar et al., 2014). The locations of the projects are illustrated in *Figure 4-4*, the pink area which indicates the existence of combined sewage system could refer to the inner city area.

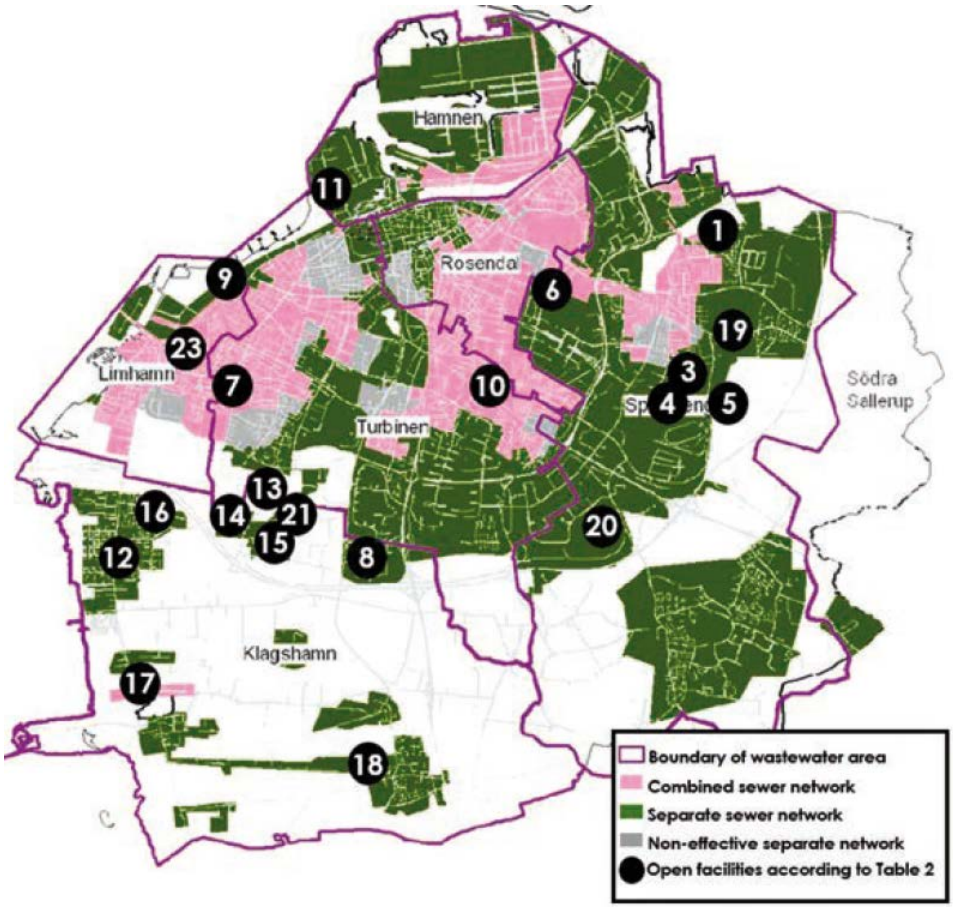

Figure 4-4 Different storm water collection networks as well as implemented open solutions in the urban areas of Malmö, Sweden. Measure No. 22 is disconnecting roof drain from combining system implemented within the combined sewer area wherever applicable.

Source: (HagHigHatafSHar et al., 2014)

From more than twenty years of practicing, the key factor to successful implementation is the collaboration between high managerial level within the municipality as well as a trustful and open cooperation between the municipality and other stakeholders such as landowners and academic researchers. The major motives behind these projects are: to integrate new stormwater solutions to urban development or urban regeneration projects; the predicted stress or incapability of existing conventional solutions; and the synchronisation with other urban function such as reducing vehicle speed. There was also the development of technical solutions and perspective towards NBS from ponds and wetlands as the main solutions to

multifunctional regional eco-corridors, which reflected the deepening of nature into the planning and design process (Stahre, 2008). Many of the interviewees and HagHigHatafSHar et al. (2014) credited Peter Stahre, the head of Malmö Water at the beginning of the regime, for all of these successful implementations and transitions towards integrating sustainable stormwater solutions to the city planning process. The transition also accelerates by the environmental department efforts to integrate of the term ecosystem service into department's strategic documents since 2012 (HagHigHatafSHar et al., 2014).

Even though, several NBS measures existed in Malmö, the storms in 2013 and 2014 proved that these actions were not sufficed for the future irregular pattern of rainfall. The new stormwater management plan, cloudburst management plan, and Blue-Green infrastructure plan were proposed, and going on the public consultation process.

4.2.2 Implementations

Like Copenhagen, Malmö also has various stakeholders involved in its stormwater management implementation process, from the plans to the practice. The stakeholders were including, but not limited to: the municipality, especially Malmö Planning Authority, Malmö Public Works, Malmö Real Estate Authority, and Malmö Environmental Protection Authority; the Malmö water company, VA SYD; the academic researchers; the consultant firms; the private landowners; and the citizens. Although the responsibilities varied among stakeholders, the administrative structure was already in place due to the long history of practicing sustainable urban water management in the city. The stormwater management strategy for Malmö (Dagvattenstrategi för Malmö), 2008, has provided a clear responsibility between administrative bodies: Malmö Water (VA SYD); Municipality of Malmö, including but not limited to, Malmö Planning Authority, Malmö Public Works, Malmö Real Estate Authority, and Malmö Environmental Protection Authority. According to the strategy, there were five main responsible areas: administration role, planning process, design process, construction process, and operation and maintenance process.

VA SYD and the Planning Authority were the main actors during the administration process. VA SYD had the overall knowledge and therefore responsible for the stormwater management strategy, structure and management techniques and needed to be included at the early age of planning. The Planning Authority was responsible for city planning process, so they needed to ensure that stormwater issues were addressed in their plan, and VA SYD as well as other relevant departments were included at the early stage of planning. The Planning Authority was also in charge of making the decision for their plans to ensure the good design solutions by weighing stormwater issues with other issues. The environmental department had to ensure that the plan is in accordance with the Environmental Code (Miljobalken) and addressing any environmental issue that could be raised from the plan. The Real Estate Authority could have different roles in this process depends on the ownership of the construction site. However, they had to ensure that every development projects had addressed their stormwater issue. The Publics Work was responsible as they owned the public assets which could be used to perform stormwater solutions. In addition, every administration actor had a joint responsibility to document and evaluate the whole process.

During the planning process, the main actor and decision maker was still the Planning authority who needed to initiate the collaborations and project group meetings, and ensure that the stormwater management is an important issue on the agendas. They were also in charge of making a decision towards an efficient outcome of the project for stormwater management and other urban livability functions. During this process, VA SYD had a role in setting up the

requirement for stormwater management and making the initial investigation of existing stormwater issue within the area. If there was any new stormwater solution proposed for the project, the operational staffs had to be included at the early stage, so the operation and maintenance issue were considered. The Public Work group was responsible for taking care of city's aesthetic, recreational, and ecological aspects as well as the operation of these urban spaces. Therefore, it was their responsibility to create the dialogue on nature and recreational issues. If the Real Estate Department owned the project, they were in charge of funding the site investigation process with the planning department and VA SYD as well as making land allocation and established the land buying and leasehold agreements. If the department did not own the land, it is the responsibility of the landowner to prepare the initial investigation for the initial consultation with VA SYD. The Environmental Authority only had consultation role during the planning process.

The main decision-maker during the design process was still the Planning Authority, who needs to balance different interests among stakeholders as well as collecting and settle issues arise. They also need to follow up the requirement of stormwater solutions stated in the plan, along with the building permit process. VA SYD also had a prominent role in this process. They were responsible for calculating the stormwater system and initiate agreement with other departments among specific funding, responsibility, and operational issues with other departments. Normally, VA SYD paid for technical solutions, and the Public Work paid for the aesthetic and landscape planning. The real estate department was in charge of the property legal issue and was the actor who connects the private developer to other authorities. In the cases, where the department owned the project, they were responsible for contacting VA SYD and the City Planning Authority to discuss the stormwater solutions. If the private developer owned the project, they were responsible for the consultation process as well. The main role of the Environmental Authority was still the consultation roles: keeping the plan accordance to the Environmental Code and processing the environmental assessment of the plan.

During the construction phase, the Environmental Authority had no role except for supervision, and the Real Estate Department only had coordination or project management roles if they own the project. The city planning had the consulting and monitoring role, so the project construct in accordance with the building permit. VA SYD and the Public Work were sharing responsibility during this phase as agreed in the design process, including hiring contractors and doing the site inspection. They also needed to take care of the project during operation and maintenance process following their agreement in the design phase as well. All administration bodies were in charge of documenting and evaluating the entire process.

During the operation and maintenance process, VA SYD and the Public Work were having a prominent role. The Real Estate Department and the City Planning Authority had no specific role apart from documentation and evaluation, as well as the Environmental Authority which additionally needed to monitor the accordance of the project with the Environmental Code. (Malmö Stad, 2008). The stormwater management strategy is also guided other implementation issues such as different stormwater solutions for different sites and activities' characteristics of the areas, and the criteria and design solutions for the different urban surfaces.

There were three main national laws govern the stormwater management in Malmö; the Environmental Code; the planning and building act; and the Law on Public Water service. The Environmental Code provides criteria on the environmental issues. It used to demand every constructed project to reach the "green factor" which aimed to ensure that there will be enough nature elements in the project (Wamsler, Luederitz, & Brink, 2014). However, according to a

respondent from the municipality, the green factor had been abolished in 2015 due to the opposition of the developers that the factors were not accountable. The Planning and Building Act provided criteria for the detailed in construction. According to a correspondent, it also used to allow VA SYD to demand the outflow requirement from the private developer, but it was no longer legal. While the Law on Public Water Service gave VA SYD the right to charge water tariffs, it did not allow the company to provide economic incentives for the private property owners to detain the stormwater within the site (Malmö Stad, 2008). There was also a law that obliges the municipality to include public participation into their planning and design process. However, the level of public participation could vary from the level of the plan and approach of the local authorities (Planning Authority per.com. 2016).

Despite that the national regulation was not very supportive, several projects were running within the municipality to increase the integration of NBS to the city stormwater solutions. For examples given by an interviewee from the municipality: MEST (Malmö Ecosystem Service) project was aiming for integrating ecosystem service into city infrastructure; and BEST (Building and Planning, and Ecosystem Service) which studied the existing legal basis of Planning and Building Act with the aim to provide recommendation to preserve, strengthen and create green-blue infrastructure. There were also many researchers working on supporting the integration of NBS, from various universities in Sweden as well as GREENSURGE, a research programme from ICLEI. However, there was no establishment of any steering group.

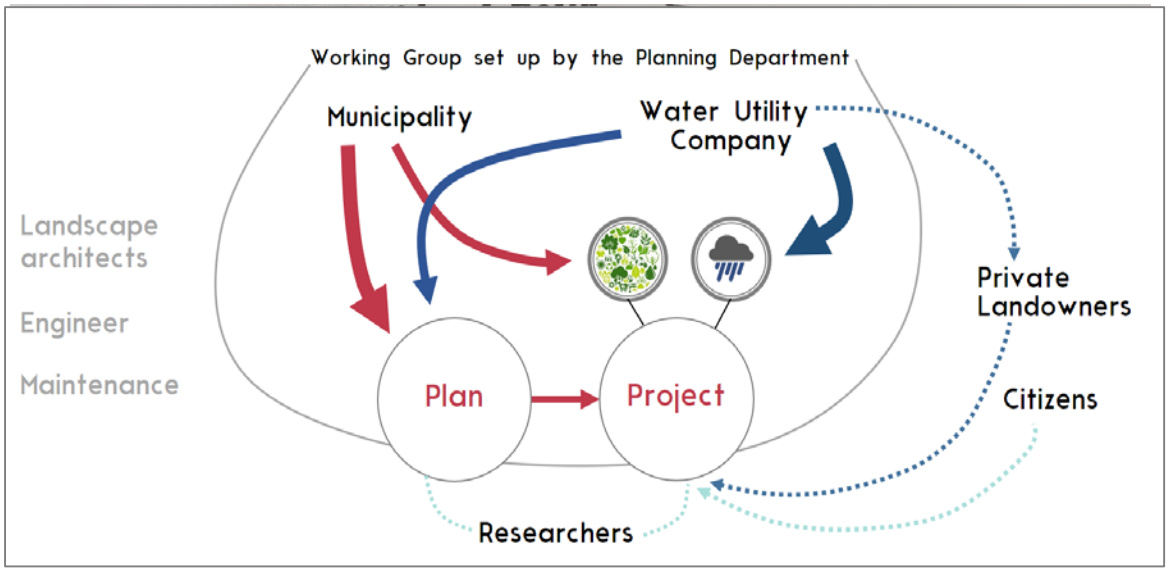

Figure 4-5 Process Diagram for integration of NBS to stormwater management in Malmö

4.2.3 Implementations: Drivers and Barriers

Although, in Malmö, the implementation of NBS has been established in the stormwater management regime and there are clear stormwater management plans available, many of the interviewees remarked that there should be more showcase projects like Augustenborg Eco-community or the Western Harbor BO01 implemented. The speed of scaling up the NBS integration seemed to be slow due to many barriers to decision making. In this section, the drivers and barrier behind the decision making were studied from available literature and the interviewees. These drivers and barriers are categorised with the seven factors influencing urban decision-making approach taken from Ddamba et al. (2015). *Table 4-4-2* presents barriers and drivers during the implementation process of integrating NBS to Malmö's stormwater

solutions. The sources of these data from the literature will be cited as the regular in-text citations. If the sources were interviewees, they will be generalised as researchers (R), municipality officers (M), and the water utility company's officers (VA SYD) as described in *Section 3.3*.

Table 4-4-2 Barriers and Drivers during implementation process of integrating NBS to Malmö's stormwater solutions

Institutional embeddedness	
Drivers	NBS has been implemented since the 1980s, so the institutional framework for implementation is existed (HagHigHatafSHar et al., 2014)
Barriers	- Top-down approach (M) - Municipal planning monopoly (Stahre, 2008)
Administrative Structure	
Drivers	Policy - The new cloudburst management strategy is focusing on various issues including biodiversity and trying to integrate other projects to this plan (M, M) - NBS will be considered by place-based approach (M) - The Planning Department is seeking to create a dialogue that could lead to legislation change. (M) Management Structure - Collaboration between VA Syd and the municipalities is natural (VA SYD, M) - There is internal collaboration within the municipality (M, M, R) - Looking centrally on how to integrate more aspect during the working progress (M) - The Planning Department collects the municipality's in-house knowledge through bringing people together (M)
Barriers	Policy - The different areas with different site characteristics should not be dealt with the same regulation (R) - Unsupportive national legislation: no right to demand stormwater detention from private owners (VA SYD, M); cannot provide incentive programme (VA SYD); the abolition of the green factor (M), and the municipality cannot use the collected water tariff directly (R) - The city master plan also not allow the municipality to regulate the green issues (M) - To integrate greener and denser city is very challenging (M) - Change in legislation is a long term and not an easy process. (R) - VA SYD responsibility only cover ten years rainfall (R) - The legal borders create issues between municipalities and create questions that coastal cities shall take all the cost of climate change (M). Management Structure - The responsibility for the water changes along the way (R) - There is no steering group (R)
Funding	
Drivers	- The municipality is making investment portfolio to communicate opportunities for co-investment (M)
Barriers	- Many of the research projects are depending on the external funding which is uncertain (M)

	- Many of the project proposed by research groups were not implement due to lack of funding (HagHigHatafSHar et al., 2014)
Spatial Scale	
Drivers	Even though there is a conflict over the land, but sometimes the NBS could get the space if the solution is certainly needed to solve the stormwater issue (VA SYD).
Barriers	- NBS needs lot of spaces, so they were implemented more in the suburban area or the less dense area (M) - The limited spaces cause tension between NBS and other interest e.g. space for housing, schools (VA SYD, M). The issue also related to funding issue where the majority funding bodies got to use the space the way they wanted. The scale of the solutions could also make the green solutions more expensive than the traditional solution due to the cost of the land. (VA SYD) - The small scale solutions are not expensive, but there is a need to have many of them to benefits the whole city, which could turn these solutions to be very expensive (R)
Duration of the project	
Drivers	- The blue-green infrastructure plan is a long term plan which requires ten years to be completed (M). - The withering existing infrastructure and urban spaces could provide potential for NBS integration (M).
Barriers	- The city cannot be transformed in a year or two due to the existing structure (R) - The historical city planning casts barrier and unclear responsibility to the current plan (M) - The societal or environmental gain needs a long term planning while economic gain needs to be achieved in a short time (M)
Stakeholders* most referred to	
Drivers	Collaboration - The service department who responsible for the schools or other public facilities is involved with the plan so that these areas can be used for NBS (M) - VA SYD would collaborate with the planning process as early as possible, because there might be some solutions that need more space and, together, they could see more potential for integrating it to other function in the earlier stages. (VA SYD) - There is an organisation of water department (Svenskt Vatten), and they are trying to create momentum for legislation change to be more supportive (VA SYD) - VA SYD creates a dialogue with the private landowners to encourage them to apply NBS. (VA SYD) - There is a strong relationship between the municipality and academic institution (R) - There has been increasing NGO participation in the public consultation process (M) - Cooperation with GREENSURGE provides information sharing platform with a lot of research opportunities (M) Mindset - The main concern of stormwater issue for the Planning Department is now in the dense city area where there are lots of hard surfaces (M) - If the business as usual continues, it will cost more and become very complicated to fix the damage from disaster in the future (M) - The street and park department interest in NBS due to its multifunctional and aesthetic aspect (R) - The climate adaptation project could bring NBS into consideration (M) - We have to see problems as possibility (M)

	- NBS can also link to the NGO movement in urban gardening (M) - Researchers are aiming for win-win solutions (R)
Barriers	Collaboration - There has not been enough collaboration like Augustenborg case. (R) - People can hardly relate to comprehensive plan but more likely to participate in the detailed plan process. (M) - The ambition and commitment of NGOs are uncertain (M) - No ecologist in the municipality (M) Mindset - The developers tend to put their interest in the economic issue. (VA SYD) - The municipality is, mostly, focusing on the housing (M) - VA SYD and the park department could have very different view on how to use open solutions, Blue vs. Green perspective. (R) - VA SYD is familiar with the conventional solutions which could create lock-in (R) - The existing landscape design did not support its ecological function as it should be (R) - Priority of the cloudburst plan in stormwater management (M) - Business as usual could create lock-in (M) - Nature has lower economic value comparing to the built structure (M) - The integration of nature element always comes at the later stage of planning process due to the perspective that seeing them as add-on elements. (M) - Missing the sense of urgency (M, R) - The citizens feel that they cannot or not empowered to do anything about stormwater issues and rely on the municipality to deal with the issue. They also cannot perceive the magnitude of damage from the stormwater mismanagement. (Mottagi, 2015)
Data	
Drivers	- The comprehensive plan will also provide a web-based education regarding stormwater management to the citizens, so they could see the vulnerability of the area they are living. It will also provide an in-house web-based cooperation between different departments as well as a material guide for the detailed plan. (M) - The incapability of the existing conventional system and the risk of system overflow support the use of NBS, especially the stress is increasing due to the climate change. (VA SYD, M) - The Cost-Benefit analysis shows that integrating NBS to stormwater management is better than having the conventional system alone. (M) - Ecosystem analysis as a problem-solving tool. (M)
Barriers	- VA SYD has no capacity to create incentive programme at the moment due to its complexity. (VA SYD) - The stormwater management model is now the combination of piping model and water vulnerability model. (VA SYD) - The challenge of getting public awareness over the solutions found by research programme is a challenge (R) - More examples are needed (R) - People do not know about the multibenefits of NBS as well as the politician and the consultancy (M, R) - It is very challenging to concern all of the aspect (M) - The economic value of the ecosystem service is unknown (M) - The Naturaboardsvaget is responsible for communicating and educating municipalities about the ecosystem service, but they are progressing slowly. (M)

4.2.4 Leverage Points

This section responses to the third research question which seeks to explore the possibility to scale up the integration of NBS to Malmö's stormwater management by collecting recommendations from the interviewees. The recommendations are also categorised by the seven factors influencing urban decision-making approach (Ddamba et al. 2015).

Institutional Embeddedness - There's no recommendation regarding the improvement of institutional embeddedness from interviewees in Malmö. However, there were several suggestions referred to the influence of communication and education among stakeholders that could shift the mindset of administrative people and politicians, and create an institutional transition that could support the integration of NBS.

Administrative Structure - Interviewees from all the three sectors recommended that there should be some adjustment in the law at national level. The researcher and VA SYD officer suggested that the laws should demand some of the local stormwater solutions to the citizens and allow VA SYD to be able to create incentives and regulate stormwater in the private properties. The municipality officer suggested for a sharper and aligned policy as well as the legal support which allow the civil servant to do as good as they wanted to. The respondents from the municipality also suggested that the nature and densification of the urban area should be equally important, and the ecosystem service should be considered at the early stage of the plan. They also recommended that the administrative structure should be adjusted towards a co-design approach where multidisciplinary actors are involved.

Funding (Public/Private) - A researcher suggested for a more willing to co-funding between departments in the municipality.

Spatial Scale - A researcher suggested that every single urban spaces and surfaces should be seen as an opportunity for integrating NBS.

Duration of the project - A researcher suggested that the long-term perspective towards integrating NBS to stormwater management is needed.

Stakeholders - The respondents from all sectors proposed for a higher and deeper collaboration and communications among stakeholders, both inter and intra organisation. The recommendations from the researchers were: to have more people from different disciplines involve with the process; ambitious person in managerial and operational level are needed; and the collaboration with the private landowners e.g. to provide them with economic incentives. An interviewee from a non-profit organisation suggested for including the consultant and insurance firms, and the neutral platform and proactive organisations could be useful for steering the NBS dialogue in the stormwater management regime. A municipality officer suggested for the more collaboration between municipality and developers around the ecosystem service planning and include an ecologist or biologist to the planning and implementation process. An interviewee from VA SYD suggested that everyone should be responsible for the stormwater management.

In the aspect of stakeholders' mindset, the researchers were suggested that people should see the stormwater management issue as an urban planning issue and have a long term perspective for it. They also suggested that we should see the stormwater management issues as the tools for creating urban livability as well as having more awareness towards the relationship of flooding and daily life. The municipality officers suggested that people need to learn new things

and do things differently, and the perspective towards the multifunctionality of every urban element should be raised. Another remarkable suggestion from a municipality officer was a need to change the structure from within to create a paradigm shift by closing the loop in the municipality, so everyone could own the same goal, the same understanding on the barrier and have more understanding between each other.

Data - The new solutions and implementations were suggested by the municipality officers and researchers as the practical knowledge which could accelerate the integration of NBS. While the researcher from SURF recommended for the more complex and context-based solutions, the municipality officers were looking forward to a more variety and increasing numbers of the solutions. The researcher from SLU also mentioned the London's Olympic Park 2012 as an excellent case study for planning and management.

The communication of knowledge was suggested by the interviewees from all groups. The researchers recommended the simpler ways to communicate the stormwater management and the urban nature issue. They also suggested that having water running on the surface could raise awareness of water issue, and supported conversations about the Cost-Benefits of NBS as a mean to raise citizens' awareness instead of creating the negative dialogue about catastrophes. The municipality officers suggested that the communication about the ecosystem services and stormwater management solutions could increase political support for the integration of NBS. They also suggested that collection of in-house knowledge would support the implementation of NBS within the municipality. The interviewees from the municipality and VA SYD suggested that the knowledge of NBS and stormwater management should be communicated to the politicians, practitioners and the private landowners. This communication could raise awareness of the stormwater responsibilities among these actors. The municipality officer also suggested that arranging workshops within the municipality would be an effective mean to educate the civil servants and politicians.

5 ANALYSIS AND DISCUSSION

This chapter presents a summary and a cross-case analysis for each of the sections from the previous chapters. The initiatives from the two cities will be compared and discussed on several factors that could influence the differences or similarities between them. The theoretical findings from *Chapter 2* will be used to discuss these factors as well. The implementation processes from Malmö and Copenhagen will also be compared and discussed base on theoretical findings and how the difference in initiatives could result in different processes, this also applies to the discussion on the drivers and barriers founded during implementation processes. Also, the main themes found among drivers and barriers will also be discussed in the section. Lastly, the discussion on the leverage points will present the main themes found in recommendations from the interviewees and literature. These themes will be discussed based on theoretical and empirical findings from the previous sections.

5.1 Initiatives

Malmö has been using NBS since the 1980's, which was the time where perspective towards having a nature area in the city was to zone huge area for nature and its function, for example, the wetland park. This point of view has been reflected in the type and outer locations of the projects implemented during the earlier time of the integration regime. Compared with this view, the implementation of the green roof in Augustenborg is considered as an innovation in both of the technical aspect and urban design aspect. The reason for the municipality to be interested in integrating NBS was due to the urban development plan where NBS could provide multifunction to the area within one infrastructure as well as to reduce stress on the combined sewage system. Recently, climate change adaptation and urban livability are other reasons for Malmö to integrate NBS. The success of initiation for implementing these solutions owed to Peter Stahre, the head of Malmö water at that time, who has been ambitious in using the open solutions for stormwater management. He also created a collaborative culture within and between organisations and raise the multifunctional issue of stormwater solutions as a means to create recreation and nature areas in the city.

While Malmö has been looking into the integration of NBS for more than twenty years, this issue was just emerging in Copenhagen in 2006. This timing seemed to be the right time to consider NBS for stormwater management due to the availability of other successful cases. The urban planning discipline at that time was also supporting the integration of nature rather than zoning it which was reflected in the usage of NBS in various scales in Østerbro, the climate resilient neighborhood. The examples of the implemented NBS in the neighborhood varies from urban square renewal, green roofs, and small resident projects. Similar to the current interest of Malmö, the municipality of Copenhagen is also interested in NBS as the solutions to climate change adaptation and urban livability. These interests in both cities reflect the shift in urban infrastructure governance regime from mono-functional and mono-sectoral thinking approach to a more collaborative and multi-functional approach. The success of initiation for implementing NBS in Copenhagen is owed to the aligned perspective among the administrators and practitioners in the need to be proactive, which has resulted from various collaborative research projects and workshops.

The difference in timing and the urban discipline perspective towards urban nature during the initiation of integrating NBS to stormwater solutions in both cities has influenced the two municipalities' to have different perspectives towards having nature as the stormwater management solutions, which was reflected in the scale, function, and location of the implemented projects. It is remarkable that both of the municipalities' recent climate change

adaptation plans are not only driven by the sustainable, resilient, livable trend in the urban design and management regime but also the catastrophes happened in the respective cities. The disaster driven issue raised a question among interviewees as well as myself about whether or not it is necessary to wait for a catastrophe to happen before addressing the issue of having more nature as a solution in the city. The keys to successful initiation for the implementation of NBS as the stormwater solutions from the two cities are an ambitious and hardworking leaders, and a creation of a constructive and aligned-dialogue towards proactive actions within and between organisations. These keys could be good examples for other municipalities or organisations which are looking forward to initiate any transition, not limited to NBS for stormwater management regime.

5.2 Implementations

The implementation process in Malmö and Copenhagen were quite similar. The municipality plans were governed by national legislations which are in accordance to several EU directives such as Water Framework Directives and Urban Waste Water Treatment Directives. The stormwater management plans were initiated by the municipality. It was the responsibility of the city's water company to address the technical aspect of the management, while the city planning departments made the development plan. The level of consideration about the urban nature varied due to the dialogue created within the planning process. In both municipalities, the water companies were in charge of designing, constructing, operating and maintaining the technical elements of the proposed solutions, while the city's planning and maintenance departments such as the Street and Park Department in Malmö, were in charge of the recreational and nature elements of the solutions. The input from researchers and research programmes were taken into account under the decision of the planning departments. Both municipalities were obliged to have public consultation processes, but the depth of public involvement could vary due to different level of the plan and the local authorities.

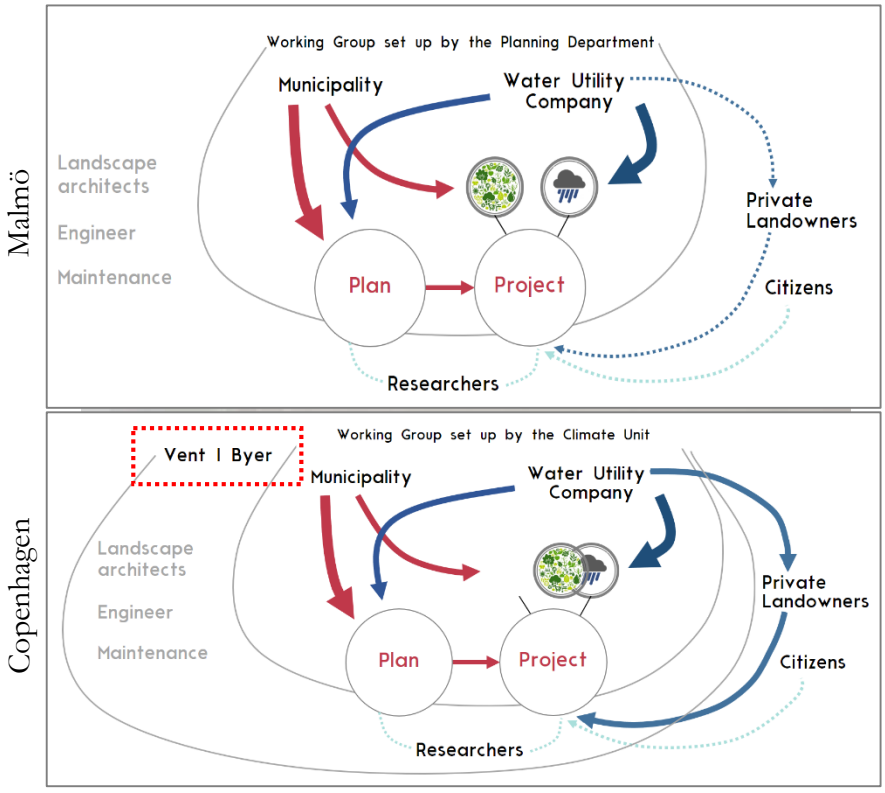

Figure 5-1 Process Diagram for integration of NBS to stormwater management in Malmö and Copenhagen

Even though both cities' implementation processes seemed to be similar, there were several details which differentiate these processes. Malmö adopted NBS as part of their stormwater solutions in the 1980s, and therefore the collaborations between administrative bodies such as VA SYD, Planning Authority, and the Public Work were already established as well as a clear responsibility between different organisations. This establishment made the integration process flow without having any steering group which is necessary for the municipality of Copenhagen. The steering groups in Copenhagen are VIB and the municipalities' climate units. They had a prominent role in accelerating the integration of NBS into the city's stormwater solutions. However, the responsibilities between different administrations were not clear yet, because their NBS implementation was younger than Malmö's. It is also remarkable that the role of the Environmental Department in Malmö was focusing on the monitoring and evaluation process rather than having a part in co-design with other authorities. The decreasing role of the Planning Authority was also discovered from Malmö stormwater plan. The minimisation of the roles could lead to misalignment between the planning and maintenance authorities if the maintenance officers were not included at the earlier stage.

Another area that was a noticeable difference between these two cities was the regulation. Copenhagen had more supportive national legislations which allowed HOFOR to use the money directly from their water tariff and to create economic incentives programme with the private landowners. The municipality was developing the "biofactor" which will create legal demand for quantity and quality urban spaces in the city. These legal and policy supports were lacking in Malmö. These difference in the practice of implementation made it necessary for the thesis to provide two different recommendations for the two cities to scaling up NBS.

5.3 Implementations: Drivers and Barriers

This section analyses factors which drives or obstructs the integration of NBS to the cities' stormwater management system. The factors will be compared between Malmö and Copenhagen.The categaries followed the analytical framework and the significance theme will be used as variables for the casual loop diagram for developing recommendations for the two cities.

Institutional Embeddedness - The main driver in the aspect of institutional embeddedness was that both cities had a collaborative culture, not only internal collaboration between administrations but also among the citizens and researchers. Institutions that got this collaboration embedded could result in a flow and constructive problem-solving dialogue for the integration of NBS to stormwater solutions from the city to the local scale. In Malmö, this culture was also due to the history of NBS integration and collaborations. However, both of the municipalities had been using the top-down approach for governing the city and infrastructure planning which could impede the innovative solutions coming up from the operation level to managerial level. Another barrier was the data-based approach towards decision making. This approach relies on the computer models which, at this moment, could not fully take ecological and social values into account.

Administrative Structure - The interviewees from both cities frequently mentioned the administrative structure issues. From the data collection process, two main themes within this factor were found. They are policy and management structure. As for the theme of policy, in Malmö, the national regulations and local planning tools were not supportive while the municipality policies were in place for supporting the integration of NBS. For example, limiting roles of VA SYD to create incentives for the private land owners and the cancellation of the

green-factor impeded the authority's management power at the local level. The municipality plans were also in place in Copenhagen and, unlike Malmö, the main national legislations were supportive for NBS integration. However, there were some barriers among policy issue such as incoherence between policies, quality control of water, and the lack of regional overview. The prominent barriers were founded in the more detailed policy issues such as the unclear responsibility between administration bodies, and the high standards of construction projects make NBS more costly. The problem of unsupportive national legislation was raised by many of the interviewees from Malmö, and they suspected that the national legal issues were due to the distance between Malmö and Stockholm, the capital city of Sweden where the lawmakers stayed. From my point of view, this distance could also influence the lawmakers' sense of urgency. In both cities, public participation process was in place and by law. This policy was considered as a driver for the integration of NBS since they would create a sense of ownership and prevent problems from citizens' opposition. The top-down approach for regulating urban stormwater founded in the institutional embeddedness could be a significant cause of these policy barriers and drivers.

For the management structure theme, collaboration within the municipality and the city's water company, as well as researchers, was the main driver for integration of NBS in both cities. The collaboration process was also focusing on integrating more aspects into stormwater management regime. Copenhagen had special drivers in the administration structure which were their steering groups and the HOFOR's freedom in investment. However, the separation of HOFOR from the municipality also created tension between the two organisations. Another barrier found in Copenhagen's management structure is the evaluation of municipality's effectiveness which focused on fast and cheap implementation of their projects. This barrier impedes the municipality to have a good design or an experimental solutions. In Malmö, the barriers in this aspect were that the responsibility for the water changed as it flows and they did not have any official steering group working on integrating NBS to stormwater management issues. It is remarkable that responsibility boundaries issues were raised be several interviewees from both cities, this could be due to the fact that water flows due to physical gravity, not the legal boundaries such as properties or municipalities boundaries. This issue should bring into consideration where making policy regarding stormwater management.

Funding (Public/Private) - The funding structure was another main difference in the implementation process of the two cities. Even though both municipalities allow the co-investment scheme, HOFOR has more freedom to invest, and there was a huge amount of money going to be invested for the CCAP. However, the barriers in this aspect were that it was uncertain on how much of the funding would be spent on the nature elements, and there was a concern that solutions for CCAP would be more focusing on the water solutions rather than nature and water solutions. In Malmö, the barriers from the funding aspect are that many research projects depended on the external funding which was uncertain and therefore often lack funding for the implementations. The issue of the lack of financing could also be linked to the interest of VA SYD on the technical solutions rather than the recreational or ecological aspect since they are the main investors for stormwater management projects as well as the inability to demand on-site management from the private landowners.

Spatial Scale - Although the space issues of NBS were raised by interviewees from both municipalities as their spatial scale barriers, which could create conflicts between different functions and results in the land cost issue, the municipality of Copenhagen had various scale of open solutions scattered everywhere in the city which could be potential for integrating nature into these projects. VA SYD also addressed this issue by giving a reason to the developer

that if the required spatial scale could not be fulfilled, the stormwater management issues on their land would not be solved. However, there were more barriers regarding the size of the project. The CCAP plan was working with the city scale; this macro-scaled plan made the implementation of small scale projects less prominent as people could feel that they would not provide much of the positive impact to the whole city. The researcher from SLU also mentioned that this perspective towards small scale projects as a barrier as well. Both municipalities also found barriers to implementing an effective NBS from the legal boundary and the capacity of available computer models or decision-makers' ability to address multiple and intangible issues on the larger scale projects. The issues regarding spatial scale are quite similar between the two municipalities due to the technical aspect of this subject.

Duration of the project - The action plans from both municipalities are long-term plans, which could provide the potential for integrating nature elements into these projects during their design phase. The long duration of these plans was due to the need to delay until the renewal period of the existing structure. These remarks from the interviewees reflected the fact that, for now, the nature elements are added at the later stage of the project and not considered as the base of the solutions which could be due to that they considered the water issue first, rather than considered the water and the nature issues together.

The interviewees from the municipality of Malmö also added that the historical city planning casts unclear responsibility and barrier to the current plans, and another temporal barrier could come from the contradiction of the temporal scale between the need for immediate economic gain and the long duration for the ecological and societal gain to be noticed. This temporal contradiction resonates with the requirement of the economical effectiveness of the stormwater solutions from the administrative structure of the municipality.

Stakeholders - This aspect was mentioned most frequently during the data collection process. There are two main themes embedded within this issue: collaboration and mindset. The input from interviewees in both municipalities pointed to the collaboration as drivers regarding the aspect of stakeholders, including: the strong willingness to collaborate; the trustful and open collaboration; and the established collaboration among different interested parties in the stormwater management and urban nature regime as well as the citizens. For Malmö, it is remarkable that VA SYD's collaboration at the earlier stage of planning could bring more integrated solutions into reality. The emerging NGO participation in stormwater management discourse could also support the integration of NBS due to the NGO's interests. The close relationship between the municipality and the researchers also provide the city with updated academic inputs and innovative solutions. Another driver for the integration of NBS is the establishment of Svenskst Vatten and their aim towards legislation change. For Copenhagen, obviously, the formation of VIB and the city's climate unit created platforms for stakeholders to collaborate and share knowledge. The role of the Danish Engineer Association which created professional norms, could also influence the practice of the Danish engineer and encourage them to consider more water solutions or other innovative practice. Another prominent driver for a successful implementation for Copenhagen would be the willingness to involve the citizens in the earlier process of city planning, so the plan could match the resident's vision and create a sense of ownership.

However, the collaboration with the citizens could also be the barrier to the integration of NBS since it is challenging to balance the different interests and mindsets if there are many stakeholders involved. Other public involvement issues are that the level of public participation varies among the various local plans, and the public participation is lower during the

consultations for the comprehensive plans due to their abstractness. These issues were raised from both municipalities and considered as barriers since they could impede the citizens' engagement with the plans. The interviewees from Malmö also noted that, even though the collaborative culture was established, the Augustenborg's level of collaboration had not been reached since then. They also think that the NGO's ambition and funding are uncertain, which could result in the uncertainty commitment and cooperation.

There were several positive mindsets that drive the implementation process in the two cities: the municipality should be proactive for climate change; business as usual cannot continue; NBS are solutions that could provide multibenefits; the NBS could be integrated with the solutions for climate change adaptation plan; and stakeholders are seeking for win-win solutions. Other positive mindsets revealed from the interviewees that could support the NBS integration were: the NGO and citizens' interest in urban gardening; the focal area of the stormwater management plan is in the dense city; and the view towards problems as possibilities. The supportive mindsets in Copenhagen were: the citizens' interest in the nature issue and demand more urban trees, which raised the urban nature issue into political consideration; and the increasing ecological awareness among practitioners.

While many positive mindsets are supporting the integration of NBS to stormwater management in Malmö and Copenhagen, there were also several mindset barriers. The mindset barriers that were shared between the two municipalities are: the municipalities prioritise housing and other built facilities over nature; the perspective towards best solutions are the most economically efficient ones while the economic value of ecological and social functions was not yet calculable; the urban biodiversity issues are very new and abstract to the citizens, politicians, and even practitioners; the landscape architects did not consider ecological issue enough; the citizens did not feel that they are responsible or could do anything to manage stormwater; the open stormwater solutions focused more on the water issue than integration; and the urban nature was seen as add-on element rather than problem-solving, and thus is integrated at the later stage of planning and design. The mindset barrier found in Malmö but not in Copenhagen is that the sense of urgency was missing. This distinction could be due to the level of the catastrophes were not as critical as in Copenhagen. In Copenhagen, the mindset barrier was the lack of nature experience and awareness among the citizens.

Data - This aspect was also mentioned frequently during the interview process. The data factors that driven the integration of NBS into both cities' stormwater solutions were: the decay of the existing infrastructure and the incapacity to take care of increasing rainfall causing by climate change; the cost for renew these existing infrastructure is very high; the Cost-Benefits Analysis shows that open stormwater and NBS are more cost effective comparing to having the hard infrastructure alone; and in both cities the more complex hydraulic and other models for aiding decision making are continuously developed. In Malmö, the department of planning is developing a web-based education and maps showing water vulnerability in different areas, which will also be considered in all city development plan. The planning department also encouraged developers to do a basic ecological analysis to find potentials for using nature as solutions in different cases. The interviewees from Copenhagen also mentioned that: their climate change adaptation plans were base on the synthesised needs for their city which include ecosystem service, so nature is concerned at the earlier stage of planning; and the importance of knowing about the citizens as one of the crucial data that could support their work.

For the barrier regarding data issues, interviewees from both municipalities mentioned the intangibility of many factors that are needed to be concerned during the decision-making

process. This issue, specifically the complexity of giving monetary value to different solutions in different areas, was one of the barriers that prevents VA SYD to create incentive programme. For Copenhagen, the issue risen from the computer models were that the current hydraulic models were not complex enough to calculate all the aspect of water and cannot cover a calculation in large scale. Even though the decision aiding tools were being developed by researchers, many of them were still in doubt to be used by the practitioner due to the configuration relating to the values of the intangible elements such as the aesthetic and social benefits. The interviewee in Malmö also given that regarding data, it was very challenging to concern every aspect related to stormwater, and they found challenges in communicating the data and knowledge to stakeholders at all levels.

5.4 Leverage Points

This section analyses factors recommended by the interviewees in order to scale up the integration of NBS to the cities' stormwater management system. The factors will be compared between Malmö and Copenhagen.The categaries followed the analytical framework and the significance theme will be used as variables for the casual loop diagram for developing recommendations for the two cities.

Institutional Embeddedness - While none of the interviewees from Malmö directly gave suggestions regarding this issue, a researcher from Copenhagen addressed the top-down and data-based governance approach by an institutional reform to a more polycentric governance. However, a literature suggested that Copenhagen's top-down governance has high potential to drive the integration of NBS, but the continuous empowering discourses are needed.

For the data-based approach in the decision-making process, Copenhagen was working on improving their computer model, while an anonymous interviewee from the municipality of Malmö suggested that the city should have an ecosystem network and have it as a basis for development by creating a dialogue with the developer instead of demanding green factors. The 2BG researcher also suggested that the collaborative embedded culture should be emphasised by including the citizens to the project at the earlier stage of planning. The earlier involvement of citizens could leverage the implementation because the citizens will share the same questions with the administrations and have a sense of ownership towards the project. These suggestions could be adopted to Malmö as well since the municipality structure also embedded with similar issues.

Administrative Structure - Since policies are one of the prominent barriers in both cities' administration structure, the supportive and aligned policies are required. Both municipalities were looking for the laws that allow them to be creative with the incentives programme for encouraging the private landowners to adopt NBS for stormwater management into their property. The interviewees from Copenhagen also added that legislation demand for catchment base management, regional overview, and municipality's internal collaborations. For the management structure, interviewees from both cities sought for the ecological requirement in the planning stage and higher collaboration between actors through co-design approach. The interviewees from Malmö suggested allocation of responsibility to the citizens, and creating a paradigm shift within the municipality, while the interviewees from Copenhagen were looking forward to an aligned dialogue and tools to support the collaboration.

Funding (Public/Private) - The given recommendations toward funding for integrating NBS into stormwater management in Copenhagen were: to have a simpler funding structure which

will result in a simpler responsibilities structure, co-investment, and more creative incentive programmes. A researcher from Malmö also raised the issue of co-investment between departments. Even though the practice in co-funding was already established, different departments still have to use their budget, and it could get complicated when they could co-invest and want others to share more costs. It is remarkable that the interviewees from Malmö did not mention the issue of a simpler investment scheme. This distinction could be due to the long establishment of the complex co-funding scheme, and people are familiar with this issue. From my point of view, having a case by case funding and responsibility structure could be complex, but the issue could be addressed by effective communications between actors.

Spatial Scale - A researcher from SURF suggested that every single urban space and surface should be seen as an opportunity for integrating NBS, that is the chance to bring these solutions to the inner city areas of Malmö. This challenge was not problematic in Copenhagen since they already planned for the solutions even in the inner city areas. However, an architect from the Urban in Nature working group added that these projects could be on smaller scales but high in quality of urban nature. The researcher from DHI also suggested for an implementation plan from the scale of water catchment. It was remarkable that not only the barriers and drivers among the issue of spatial scales are similar between the two cities, the recommendations from the interviewees were also aligned. Again, this could be because the scale issues are mostly technical.

Duration of the project - All of the interviewees suggested a long-term plan to support the integration of NBS which requires times for their multibenefits outcomes to be felt.

Stakeholders - The recommendations about the stakeholders issue from the interviewees in both cities were pointing to the same direction. They suggested a higher level of collaboration at the earlier stage of planning to set up an aligned outcome of the plan, allow for integration of different stakeholder interests, and create a sense of ownership. In this sense, multidisciplinary collaboration was emphasised with the inclusion of a biologist or ecologist into the stormwater management planning process. The communication and education are crucial for supporting these collaborations since they could raise awareness towards nature and create supportive political momentum. The major shift in mindset towards nature, from an add-on element to a problems solver were also suggested. Another major factor that could leverage the integration of NBS was to build the sense of responsibility for stormwater management issue among the citizens, so there could be more NBS implemented at the household level.

Data - The main themes discovered from the interviewees regarding the recommendation towards the data or knowledge that could support the NBS integration were: the new design solutions and the communication of knowledge. The solutions they were looking for should be in variety and the interviewee from Malmö emphasis that they should be complex and context-based. These suggestions towards innovative NBS coherence with the findings that both municipalities had ambitious practitioners. It is remarkable that interviewees from Malmö did not recommend the development of decision-aiding tools. This distinction could be due to their experiences in the complexity and ambiguity when dealing with these instruments or the insufficient capacity of the organisation mentioned in Malmö's data barrier.

The communication theme was also given in the literature related to an effective decision-making process (van Stigt et al., 2015; Wang et al., 2014). The interviewees from both municipalities suggested that knowledge about the ecosystem services, the multibenefits, and the cost-effectiveness of NBS should be communicated to raise awareness among citizens,

practitioners, and politicians. The similarity could be due to the findings that both municipalities' cost-benefit analysis showed the cost-effectiveness of NBS and both of them were facing the mindset barriers that people do not know about the ecosystem services. The communications should also be accessible: easy to find and easy to understand. A remarkable difference between the recommendations from the two cities was that Copenhagen mentioned the communication of the plans to the citizens, while the interviewee from Malmö suggested communication within the municipality. This difference reflected the perspective towards public involvement among the two cities and underlined the monopoly in Malmö's city planning as mention by Stahre (2008).

6 System Diagrams and Recommendations

From the previous chapters, the differences in the initiatives, implementation processes, and suggested leverage points in Malmö and Copenhagen were investigated. As the two cities were different, the recommendations should be customised for each of the cities. In this regard, the findings and analysis were used to create two casual loop diagrams, to see the connections between actions and stakeholders which could suggest the more effective actions to leverage the system. The steps of creating these casual loop diagrams could be found in *Table 3-3-1*. The issue of concern to management is the third research question, "***How can the integration of NBS be scaled up?***" and the data collection was done in the previous chapters. Since the findings pointed to the significance of stakeholders and their roles, these factors become variables for the diagrams in *Figure 6-1* and *Figure 6-2*.

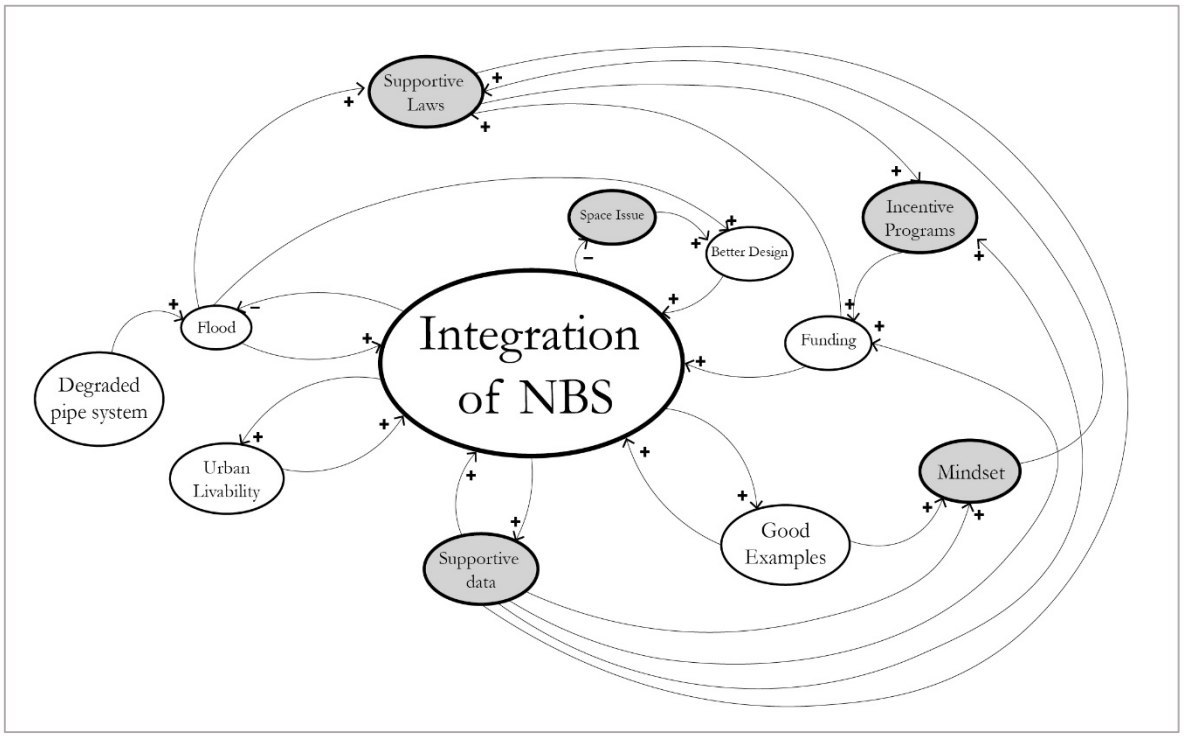

Figure 6-1 Casual Loop Diagram for Malmo's NBS scaled up recommendations

The key leverage points for Malmö are the shifting in legislation, mindsets, funding and innovative solutions, where communications are the key action to leverage these points. The recommendations towards scaling up NBS integration to Malmö's stormwater management would be the establishment of an official steering group which brings together all the relevant actors to facilitate a knowledge sharing platform which collects and shares the input from researchers, practitioners, developers, and the citizens. The steering group should also focus on communication and education about the multifunctionality of NBS and create an inclusive dialogue where nature is the solutions to urban challenges, other than recreational and aesthetic functions. The communication should be adjusted to suit various types of stakeholder, yet coherence. The communication strategy and platform should be user-friendly as well. These communications should be transparent and based on the reliable data. These data would need the contribution from researchers, including a cost-benefit analysis, modeling tools, and new design solutions where NBS could be implemented in the dense urban area. In addition, the NBS themselves could also be considered as the supportive data as well since they provide successful cases to acknowledge citizens and other stakeholders.

These data and communication could create the shift in mindset towards the integration of NBS to urban stormwater management. These mindsets could create political momentum, interest from the business sector and household level actions towards the integration. The political dynamic could lead to a more supportive legislations including legalisation of managing stormwater on the private property, creation of incentive programmes and tools such as "green factor" which demand a certain level of nature and water solutions in every construction projects. The incentives programme, together with the political support and interest from business sector could provide more sources and innovative ways of funding. However, the characteristic of case-by-case responsibilities allocation should keep on continuing and adapt into the law and planning as well. Nevertheless, these actions would not be possible without the collaboration of all stakeholders towards the committed, aligned, and constructive dialogue about the urban nature and stormwater management issues.

For Copenhagen, the key leverage points are a clearer responsibility, shifting in mindset and more supportive data. The key action to leverage these points are, similar to Malmö, communications. However, the steering group and communication platforms are already available in the city, and therefore the recommendations for leverage strategy are different.

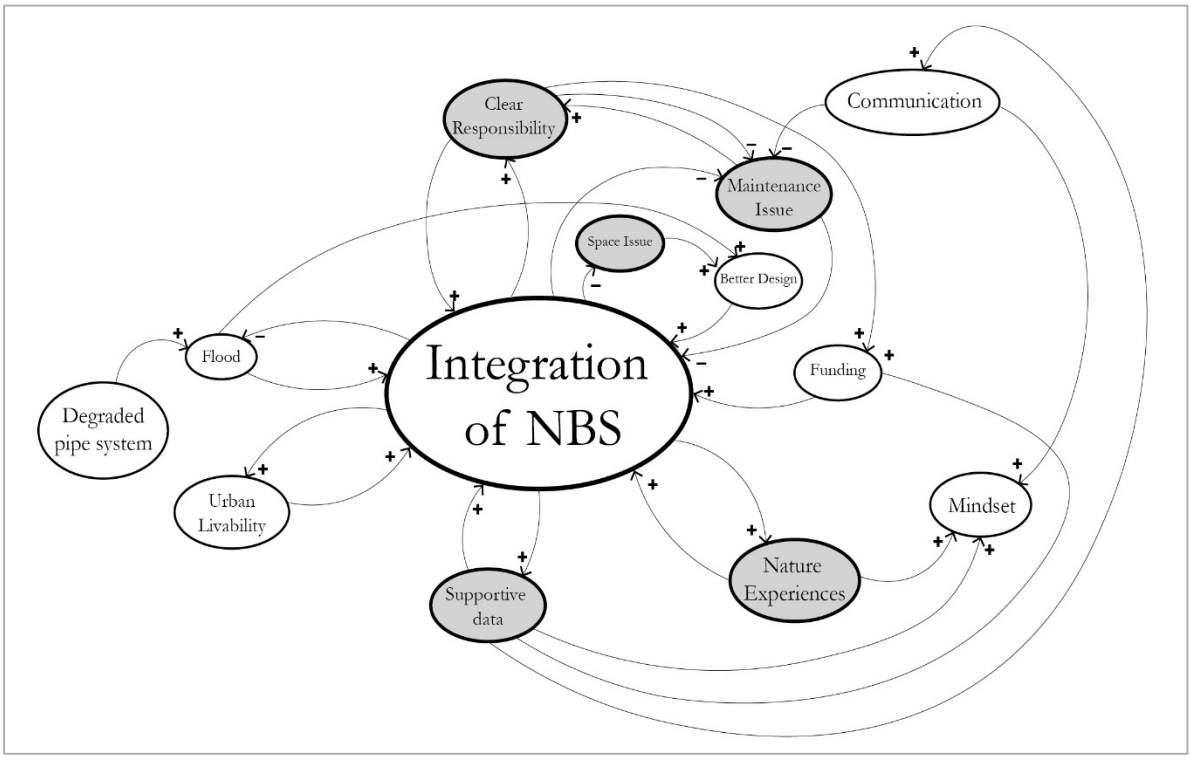

Figure 6-2 Casual Loop Diagram for Copenhagen's NBS scaled up recommendations

The communication within authorities is crucial to obtain a clearer responsibility among departments, HOFOR, and developers. The current difficulty could be due to the less experienced towards integration of NBS comparing to Malmö. The more practice of communication and implementation of NBS, case-by-case, could build up experience and establish the city's way of collaboration and responsibilities allocation. This action should be considered rather than setting up a clear responsibilities boundary which could be inflexible for the implementation. The coherence between policies should also be addressed through communication between working groups as well. This communication could be done by including more working group into the municipality's climate unit. Another crucial

communication within the municipality is the communication to the staff at the operation level to create an efficient and economical ways of maintaining the NBS.

Supportive data is also needed in Copenhagen. The data should be focusing on a complex hydraulic modeling, innovative solution to address the space and maintenance issue, as well as the water quality of the water which runs through the NBS. These data could also be used in the communication strategy to the citizens to raise the political supports and interest from the business sectors. The communication strategy to the citizens should also focus on the multifunctionality of the NBS and the perspective towards nature as the potential for engineering and other societal solutions in addition to its aesthetic and recreational value. Since some respondent mentioned that the nature awareness in the city was lack due to the lack of nature experience, the implemented NBS itself could be a part of the communication strategy since it could provide these experiences, in addition to offering a good example for acknowledging the stakeholders.

There are various communication platform in Copenhagen such as: http://www.vandibyer.dk/, which collecting successful cases and ongoing research projects; http://wsud-denmark.com/your-idea/34601, which is a part of VIB project and provides an user-friendly communication platform; http://www.klimatilpasning.dk/vaerktoejer.aspx where citizens can see the vulnerability in their area as well as the projects done by the municipality; http://stateofgreen.com/en, which is a platform to learn about Danish plan towards the green economy with collections of solutions from around the world and the investment opportunities; and the ongoing projects could be found in http://klimakvarter.dk/projekt/bryggervangen/. These platforms are user-friendly. It is recommended to promote them so that the citizens would have more interest towards the issues.

The diagrams also showed that if the NBS could be scaled up and providing the positive multibenefit results, they could address the livable urban environment objectives. In this regard, there would be no need to wait for the catastrophe to happen. Even though the strategy for the two cities are different, the main themes for recommendations are communication and collaboration, since they could create the more effective leverage actions. According to the leverage points and twelve places to intervene in a system by Meadows & Wright (2009), these measures would influence the paradigm shift within the system which would be highly effective intervention to the system and could affect the goals, the rules and other actions within the system. It is also necessary that the communication should be inclusive, committed, aligned, and constructive towards the integration of NBS to the urban stormwater management.

7 REFLECTIONS AND CONCLUSIONS

In this last chapter of this thesis, there will be conclusions to the three research questions, remarks, research gaps, self-reflection, as well as the conclusion to this thesis. The chapter will begin with the short answering to the research questions.

Why did the municipality of Malmö and Copenhagen decide to integrate NBS into their stormwater management projects?

Two main keys initiated the integration of NBS in the two cities stormwater management regime. First, the multifunctionality of NBS served the urban livability policies and showed the cost-effectiveness of the solutions. Second, the degrading and incapability of the existing sewage system was too costly to renew with the conventional approach without having NBS's support. It is also remarkable that the cloudburst events which recently happened in the respective cities are also driven these cities to seek for innovative solutions for managing stormwater. The keys to successful initiation for the implementation of NBS as the stormwater solutions of the two municipalities are the ambitious and hardworking leader, and the creation of the constructive and aligned-dialogue towards proactive actions within and between organisations.

How did they implement the NBS?

The implementation process in Malmö and Copenhagen were quite similar, but there were several details which made the two systems distinct. The timing and initiative process had a prominent role in the different approach the two cities were taken towards the integration of NBS as well as the legislation support. It was remarkable that many respondents from Malmö municipality suspected that the distance between the city and Stockholm, the capital of Sweden, could cause the unsupportive legislations. In Copenhagen, while there were supportive legislation, the lower experience comparing to Malmö created the issue among responsibilities allocation for implementing NBS for stormwater management.

The main drivers that the two cities shared were: the collaborative culture and there were climate change adaptation plans ready in the two cities which could be a potential to integrate NBS into these measures. Malmö's distinct driver was their experience in implementing NBS and Copenhagen's prominent driver was the establishment of the two official steering groups: the municipality climate unit and VIB programme. The main barriers that the two cities shared were: insufficient supportive data and design solutions, space issues, funding problems and the mindset towards the urban nature among all of the stakeholder. While Malmö's distinct barrier was the unsupportive legislation and policies, Copenhagen was facing the unclear roles and responsibility issues

How can the integration of NBS be scaled up?

The main actions for scaling up NBS integration are communication and collaboration along with the continual development of innovative solutions and research on the related issues. These scaling up strategies could create the more effective leverage actions. It is also necessary that the communication should be inclusive, committed, aligned, and constructive towards the integration of NBS to the urban stormwater management.

During the research process, there were several remarks which should be included in the conclusion part. First, the newness of the term NBS in the literature and practice in EU shows huge knowledge gaps from two dimensions, knowledge gap between the geographical region and between disciplines (design - academia). These knowledge gaps were found due to the richness of literature about NBS from the United States of America and had long been practiced in both North America and Europe. Second, there are a large number of terms relating to NBS such as green infrastructure or ecological-based approach. There could be very

high potential to collect, synthesise, and develop the knowledge risen from these separate terms if there could be clearer definitions or reduction in redundancy. Third, setting up stormwater management as the main questions in the dialogue of integrating NBS to the city could impede the thinking structure of having nature as the base because the planners need to prioritise stormwater management and could unconsciously discard the ecological function of nature elements.

While findings the answers to these three research questions several research gaps were noted. First, the development in modelling such as hydraulic model, ecological assessment model, and economic model, is needed. Second, the innovative design, construction, operation, and maintenance solutions are also necessary to address the space, maintenance, and cost issue. Third, the more in-depth holistic research on the policy, collaboration, and implementation impacts on the physical solutions would be needed for finding innovative collaboration methods. Fourth, more research that uses system thinking approach to studying urban management issues should be done. The research could aim for a more detailed casual loop diagram or develop more complex diagrams. It would be great to see more practitioners being interviewed and have their input in this kind of modelling to create an inclusive detailed leverage strategy for scaling up NBS for stormwater management.

Many self-reflections were emerging during this research procedure. First, it was a very challenge for a person who come from a technical background to write an academic thesis. This challenge allowed me to improve my academic language and thinking structure. Second, it was a great opportunity for me to widen my vision due to the broader scale and the complexity of the thesis topic. I also had to admit that setting up the thesis topic of integrating NBS to stormwater management did impede my vision from a broader perspective. The question also impeded myself to looking at the actual nature-based idea since I was searching for their integration into stormwater management practice, and the integration of these nature elements always come after other aspects of the projects had proposed. This thesis also allowed me to adapt my design thinking into the research process and acknowledge that design background could also be useful for the academic research. Third, coming from a country where authorities were highly technocratic and not fully functioned, I was impressed by visions of the practitioners especially the interviewees from both municipalities. They had inspired and acknowledged me on how good governance could be done. Last, but most important, self-reflection is that this thesis had answered the very first questions I wondered when entering my landscape architecture professional which also one of the reasons for choosing MESPOM as my master programme.

In conclusion, even though the technical issue were a concern towards the integration of NBS to stormwater management, the collaboration and management issues were also prominent. Both of the issues would need to be holistically developed to scaling up the integration of NBS. However, the important question is how to create a constructive dialogue of having nature as the based for the stormwater management solutions.Setting up stormwater management as the major challenge to initiate the integration should not be the only outcome which decision-makers should be in concern. They should set the holistic outcome for the whole city to working forward together such as the city with the high quality of nature, and resilience to climate change and population growth. In this sense, there could be more innovative solutions and possibilities towards having nature as the base of thinking when considering any of the city challenges, not only stormwater issue.

Bibliography

Anderson, V., & Johnson, L. (1997). *Systems thinking basics : from concepts to causal loops*: Cambridge, Mass. : Pegasus Communications, c1997.

Banister, D. (1997). Reducing the need to travel. *Environment and Planning B: Planning and Design, 24*, 437-449.

Balian E., Eggermont H. & Le Roux X. (2014). Outputs of the Strategic Foresight workshop "Nature-Based Solutions in a BiodivERsA context", Brussels June 11-12 2014. BiodivERsA report, 45.

Beierle T.C. & Cayford J. (2002). *Democracy in practice: Public participation in environmental decisions*: RFF Press.

Benyus, J. M. (1997). *Biomimicry: Innovation inspired by nature*. New York: William Morrow.

Braun, E., van den Berg, P. L., & van der Meer, J. (2012). *National policy responses to urban challenges in Europe*. Aldershot: Ashgate

Brink, E., Aalders, T., Ádám, D., Feller, R., Henselek, Y., Hoffmann, A., ... & Rau, A. L. (2016). Cascades of green: a review of ecosystem-based adaptation in urban areas. *Global Environmental Change*, 36, 111-123.

Brown, R. R. (2005). Impediments to Integrated Urban Stormwater Management: The Need for Institutional Reform. *Environmental Management*, 36(3), 455-468. doi:10.1007/s00267-004-0217-4

Bulkeley, H., Broto, V. C., & Maassen, A. (2014). Low-carbon Transitions and the Reconfiguration of Urban Infrastructure. *URBAN STUDIES,* 51*(7)*, 1471-1486.

Burton, E. (2003). Housing for an urban renaissance: implications for social equity. *Housing Studies, 18*, 537-562.

Corvellec, H. A., Zapata Campos, M. J. A., Zapata, P. A., Göteborgs universitet, H. G. R. I. P., University of Gothenburg, S. o. B. E., Law, G. R. I. P., . . . University of Gothenburg, F. o. S. S. S. o. P. A. P. (2013). Infrastructures, lock-in, and sustainable urban development. The case of waste incineration in the Göteborg Metropolitan Area. *Journal of Cleaner Production*, 32. doi:10.1016/j.jclepro.2012.12.009

Creswell, J. W., & Creswell, J. W. (2013). *Qualitative inquiry and research design : choosing among five approaches*: Thousand Oaks : SAGE Publications, cop. 2013.

Copenhagen Climate Adaptation Plan (CCAP). (2011). *Copenhagen Carbon Neutral by 2025*. City of Copenhagen.

Delleur, J.W. (2003). The evolution of urban hydrology: past, present,and future. *Journal Of Hydraulic Engineering*, 129(8), 563.

Ddamba Kibuuka, J., Dittrich, Y., Rasmusson, M., Hallin, P.-O., Guldåker, N., de Klerk, A., ... Dobner, S. (2015). *Urban Decision-making and Expert Integration* (p. 63). UrbanData2Decide

Dhakal, K., & Chevalier, L. (2016). Urban Stormwater Governance: The Need for a Paradigm Shift. *Environmental Management, 57*(5), 1112-1124. doi:10.1007/s00267-016-0667-5

Directorate I 'Climate Action and Resource Efficiency'. (2014a). *Debrief: European Conference "Re-naturing Cities: Addressing Environmental Challenges and the Effects of the Economic Crisis through Nature-Based Solutions"*. Brussels

.

Dominguez D., Truffer B. & Gujer W. (2011). Tackling uncertainties in infrastructure sectors through strategic planning: The contribution of discursive approaches in the urban water sector. *Water Policy*, 13(3), 299–316

Doswald, N., Munroe, R., Roe, D., Giuliani, A., Castelli, I., Stephens, J., . . . Reid, H. (2014). Effectiveness of ecosystem-based approaches for adaptation: review of the evidence-base. *CLIMATE AND DEVELOPMENT*, 6(2), 185-201.

European Commission (EC). (2015). Nature-Based Solutions & Re-Naturing Cities Final Report of the Horizon 2020 Expert Group on Nature-Based Solutions and Re-Naturing Cities. Luxembourg: Publications Office of the European Union.

FISRWG. (1998). Stream Corridor Restoration: Principles, Processes, and Practices. By the Federal Interagency Stream Restoration Working Group (15 Federal agencies of the US gov't).

Flick, U. (2009). *An introduction to qualitative research.* London : SAGE.

Füssel, H.-M., & Jol, A. (2012). *Climate change, impacts and vulnerability in Europe 2012 an indicator-based report.* Copenhagen: European Environmental Agency.

Georgi, B., Isoard, S., Kurnik, B., Foltescu, V. L., Swart, R., Marinova, N., . . . Kazmierczak, A. (2012). *Urban adaptation to climate change in Europe: Challenges and opportunities for cities together with supportive national and European policies.* Copenhagen: Europen Environmental Agency.

Gillham, O. (2002). *The limitless city: a primer on the urban sprawl debate.* Washington, DC: Island Press.

HagHigHatafSHar, S., la Cour JanSen, J., Aspegren, H., Lidström, V., Mattsson, A., & Jönsson, K. (2014). Storm-water management in malmö and Copenhagen with regard to Climate Change SCenarioS. *VATTEN-Journal of Water Management and Research, 70*(3), 159-168.

Haughton, G., & Hunter, C. (2003). *Sustainable cities.* London: Routledge Press.

Hirt, S., & Zahm, D. L. (2012). *The Urban Wisdom of Jane Jacobs.* New York, NY: Routledge.

Howard E. (1965 (1902)). *Garden cities of tomorrow.* Cambridge, MA: M.I.T. Press.

International Union For Conservation Of Nature (IUCN). (2012). *The IUCN Programme 2013–16.* IUCN, Gland, Switzerland.

Jha, A. K., Bloch, R., & Lamond, J. (2012). *Cities and flooding: a guide to integrated urban flood risk management for the 21st century*: World Bank Publications.

Jenks, M., Williams, K., & Burton, E. (2000). Urban consolidation and the benefits of intensification. In Roo, G. D. and Miller, D. (Eds), *Compact cities and sustainable urban development: a critical assessment of policies and plans from an international perspective.* Aldershot: Ashgate.

Kaika, M. (2005). *City of flows : modernity, nature, and the city.* New York : Routledge, c2005.

Kayser, K. and S. Kunst. (2002). Decentralised Wastewater Treatment-Wastewater Treatment in Rural Areas. In *Sustainable Water and Soil Management.* Springer. Berlin Heidelberg, 137-182.

Klimakvarter. (2016). *Copenhagen's First Climate Resilient Neighborhood.* Klimakvarter.

Kopperoinen, L., Stange, E., Rusch, G., Baró, F., Blanco, G. G., & Mederly, P. (2015). Integrating nature-based solutions in urban planning. OpenNESS brief no. 03, November 2015. EC FP7 Grant Agreement no. 308428.

LeCorbusier. (1987 (1924)). *The city of tomorrow*. London: The Architectural Press.

Maani, K. E., & Cavana, R. Y. (2000). *Systems thinking and modelling : understanding change and complexity*: Auckland : Prentice Hall, cop. 2000.

Maksimović, Č., Kurian, M., & Ardakanian, R. (2015). *Rethinking Infrastructure Design for Multi-Use Water Services. [Elektronisk resurs]*: Cham : Springer, 2015.

Malekpour, S., Brown, R. R., & de Haan, F. J. (2015). Strategic planning of urban infrastructure for environmental sustainability: Understanding the past to intervene for the future. *Cities, 46*, 67-75. doi:http://dx.doi.org/10.1016/j.cities.2015.05.003

Malmö Stad. (2008). *Dagvattenstrategi for Malmö.* Malmö.

Malmö Stad. (2014). *Oversiktsplan for Malmö. : Planstrategi*. Malmö.

Marcinkoski, C. (2016). Designing Cities Module 4.2 Ecological Urbanism [Online Lecture]. Retrieved from https://www.coursera.org/learn/designing-cities/lecture/5dFIU/ecological-urbanism

McHarg, I. L. (1971). *Design with nature*. Garden City, N.Y. : Doubleday for the American Museum of Natural History, 1971.

Meadows, D. H., & Wright, D. (2009). *Thinking in systems : a primer*: London : Earthscan, 2009.

Mguni, P., Herslund, L., & Jensen, M. B. (2015). Green infrastructure for flood-risk management in Dar es Salaam and Copenhagen: exploring the potential for transitions towards sustainable urban water management. *Water Policy, 17*(1), 126-142. doi:10.2166/wp.2014.047

Mottagi, M. (2015). *Malmö Water Plan, From Idea to Practice Workshop.* Malmö, 2015

Mostafavi, M., & Doherty, G. (2010). *Ecological urbanism*: Baden : Lars Muller ; Cambridge, MA : Harvard University. Graduate School of Design, 2010.

Muller, J. (1998). Paradigms and planning practice: Conceptual and contextual considerations. *International Planning Studies*, 3 (3) (1998), pp. 287–302

Newman, O. (1966). *Creating defensible space*. New Brunswick, NJ: Diane Publishing.

Nickel, D., Schoenfelder, W., Medearis, D., Dolowitz, D. P., Keeley, M., & Shuster, W. (2013). German experience in managing stormwater with green infrastructure. *Journal of Environmental Planning and Management*. doi:10.1080/09640568.2012.748652

Novotny V, Ahern J, Brown PR. (2010). *Water centric sustainable communities: planning, retrofitting, and building the next urban environment*. Wiley, Hoboken

Olsson, M.-O., & Sjöstedt, G. (2004). *Systems approaches and their application : examples from Sweden*: Boston, Mass. : Kluwer Academic, cop. 2004.

Potschin, M., Kretsch, C., Haines-Young, R., E. Furman, Berry, P., Baró, F. (2015). Nature-based solutions. In: Potschin, M. and K. Jax (eds): *OpenNESS Ecosystem* Service *Reference Book*. EC FP7 Grant Agreement no. 308428. Available via: www.openness-project.eu/library/reference-book

Revi, A., Satterthwaite, D.E., Aragón-Durand, F., Corfee-Morlot, J., Kiunsi, R.B.R., Pelling, M., Roberts, D.C., Solecki, W., 2014. Urban areas. In: Field, C.B., Barros, V. R., Dokken, D.J., Mach, K.J., Mastrandrea, M.D., Bilir, T.E., Chatterjee, M., Ebi, K.L., Estrada, Y.O., Genova, R.C., Girma, B., Kissel, E.S., Levy, A.N., MacCracken, S., Mastrandrea, P.R., White, L.L. (Eds.). (2014). *Climate Change 2014: Impacts, Adaptation, and Vulnerability*. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel of Climate Change. Cambridge University Press, Cambridge, United Kingdom and New York, New York, USA, pp. 535-612.

Scott, M., Lennon, M., Haase, D., Kazmierczak, A., Clabby, G., & Beatley, T. (2016). Nature-based solutions for the contemporary city/Re-naturing the city/Reflections on urban landscapes, ecosystems services and nature-based solutions in cities/Multifunctional green infrastructure and climate change adaptation: brownfield greening as an adaptation strategy for vulnerable communities?/Delivering green infrastructure through planning: insights from practice in Fingal, Ireland/Planning for biophilic cities: from theory to practice. *Planning Theory & Practice, 17*(2), 267-300. doi:10.1080/14649357.2016.1158907

Sharifi, A. (2016). From garden city to eco-urbanism: the quest for sustainable neighborhood development. *Sustainable Cities and Society, 20*, 1–16

Stahre, P. (2008). *Blue-green fingerprints in the city of Malmö, Sweden: Malmö's way towards a sustainable urban drainage*: Va syd.

Sørensen, S., Petersen, B., Kofod, N. & Jacobsen, P. (2006). Historical overview of the Copenhagen sewerage system. *Water Practice & Technology 1*(1).

United Nation (UN). (2012). *World Urbanization Prospects, the 2011Revision*. Population Division of the Department of Economic and Social Affairs of the United Nations. http://esa.un.org/unpd/wup/index.htm.

United Nations (UN). (2013). Integrating Nature-based Solutions into Urban Planning Can Help Lead to Better Water Future, Secretary-General Says in Message for Day of Biodiversity. Press Release – Dept. of UN Secretary General, New York.

van Stigt, R., Driessen, P. P. J., & Spit, T. J. M. (2015). A user perspective on the gap between science and decision-making. Local administrators' views on expert knowledge in urban planning. *Environmental Science & Policy, 47*, 167-176. doi:http://dx.doi.org/10.1016/j.envsci.2014.12.002

Waldheim, C. (2006). *The Landscape urbanism reader*: New York : Princeton Arch.Pr. , cop. 2006.

Wamsler, C., Luederitz, C., & Brink, E. (2014). Local levers for change: Mainstreaming ecosystem-based adaptation into municipal planning to foster sustainability transitions. *Global Environmental Change, 29*, 189-201. doi:http://dx.doi.org/10.1016/j.gloenvcha.2014.09.008

Wang, H., Shen, Q., Tang, B.-s., Lu, C., Peng, Y., & Tang, L. (2014). A framework of decision-making factors and supporting information for facilitating sustainable site planning in urban renewal projects. *Cities, 40, Part A*, 44-55. doi:http://dx.doi.org/10.1016/j.cities.2014.04.005

Wilkinson, C., Saarne, T., Peterson, G. D., & Colding, J. (2013). Strategic spatial planning and the ecosystem services concept - An historical exploration. *Ecology and Society*, *18*.

Wright F. L. (1932). *The disappearing city*. New York City, NY: W.F. Payson.

Yamagata-Lynch, L. C. (2010). *Activity Systems Analysis Methods. [Elektronisk resurs] : Understanding Complex Learning Environments*: Boston, MA : Springer US, 2010.

Yin, R. K. (2009). *Case study research : design and methods*: London : SAGE, cop. 2009

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Appendix Interviews

This section of thesis is about the interviewees, their confidentiality and the transciption. The table below shows the follow up process about the approval of attaching their identity and interview transcription with the report. However, this section has not completed since some of the interviewees still need some time to revise their transcription.

No.	Organisation	Relevancy	Confidentiality	Name	Date interview	Duration of the interview
1	Danish Technological Institute	Project leader, VIB	None	Ulrik Hindsberger	29/03/2016	1 hr.
2	Department of Geoscience and Natural Resource Management, University of Copenhagen	Copenhagen Urban Biodiversity Think-Tank	None	Associate Professor Hans Peter Ravn	05/04/2016	50 mins.
3	HOFOR	Director of Environmental and Collaboration department	Not to attach the transcription	Frank Brodersen	25/04/2016	1 hr
4	HOFOR	Landscape Architect	Not to attach the transcription	Søren Hansen		
5	Municipality of Copenhagen	Anonymous	Anonymous	Anonymous	28/04/2016	1 hr.
6	Municipality of Copenhagen	Anonymous	Anonymous	Anonymous	21/04/2016	1 hr.
7	Aalborg University	Anonymous	Anonymous	Anonymous	18/03/2016	1 hr. 40 mins.
8	Danish water and waste water association	Anonymous	Anonymous	Anonymous	04/04/2016	30 mins.
9	Swedish University of Agricultural Sciences	Lecturer at Department of landscape architecture, planning and management	None	Anders Kristoffersson	21/04/2016	1 hr. 20 mins.
10	Municipality of Malmö	Malmö stormwater strategy	None	Tim Delshammar	22/03/2016	35 mins.
11	Municipality of Malmö	Anonymous	Anonymous	Anonymous	05/04/2016	1 hr. 20 mins.
12	Municipality of Malmö	Anonymous	Anonymous	Anonymous	16/03/2016	55 mins.
13	Lund University	Anonymous	Anonymous	Anonymous	03/05/2016	50 mins
14	VA SYD	Project Engineer	None	Helena Flinkberg	03/05/2016	50 mins

Interviewee: Ulrik Hindsberger

Manager of Pipe Centre at Danish Technological Institute

Project Leader, VIB

What's your role in the VIB?
I am the project leader of the innovation network Water in Urban Areas)VIB(. It started as an innovation partnership in 2010 and in the beginning, the Danish Technological Institute)TI(had a project leading role, but when it became a innovationnetwork in 2015, I became the project leader of the innovation network. The secretary is also here at TI. Also, Aalborg University, Copenhagen University, DTI and DHI are still part of the management team.

The initiative.
All the university were talking a lot about this issue already. The difficult thing is that there is many stakeholders working with climate adaption fx the municipalities, the utilities and the private consultants working on the climate adaptation plan. I think VIB is a good place to meet all the stakeholders who work on the climate actions. The private company working here are not only the consultants but also the entrepreneur, product developer, and landscape architects. So there are a lot of people who need to be here and discuss the challenge in each area in order to work closer together.

Role as a project leader.
Organize meeting with all stakeholders. There are also several projects within VIB called innovation projects, and we also provide the with information from these projects as well as other projects, and it could be the project from our university or the municipality or the utility about the good practice, what should be improved. There are a lot of research as well as the practical things and how to involve the citizen in our project since they are very visible solutions that we are using now.

People could see the water since the solution is more on the surface. Even Though, we are still using pipes if that's the best solution, but it is very expensive to make new pipes because there are a lot of other pipes in the ground and not only for water but for the electricity and gas and other stuff, so it is expensive to insert new pipes in the ground. Therefore, the surface solutions often are cheaper, and a lot of people including me think that it is nice to see the water running above ground, so it is a value for the city

Best solution
Model, tools. It is very difficult to compare different solutions. We have some tools that could do the price for the pipes since we know exactly what they are but for the new projects since we are unsure. Also, for the new project, it could be more expensive in the beginning. It could be the first time you try them, and you make some small mistakes that it will not happen for the next time. But we have some tools and one of our innovation project is working on it. It is difficult to get the right value of many things, e.g. what's the value if you could see the water, the social value, and others. I think we have some indicators and the price for things to be built)tangible object(, but the societal value e.g. value of more green open space is more difficult to tell the cost. It depends on the personal view. It's getting better, but I think in the next 3-5 years, it's one of the key questions that we have to be better to answer which solution is the best - most economical.

The configuration of the model is also difficult and have to be adjusted case by case, due to the view of citizen and how could it be combined with other infrastructure projects or existing projects. If there is a park going to be made and you could integrate this, it would be very valuable. Sometimes you may need to wait for other projects to take place in order to combine them. It is a difficult thing because there are several department in the city working with the parks, the roads and the environment. They have to work together more than ever before. There is not a clear answer, but we need to do better with the cost since the politicians are really focusing on the cost. We can know the cost from the tools we already have, but they are not precise enough at the moment.

Incentives

Apart from the cost that already mentioned, there is also recreation value. A lot of people really like these solutions. For me, this solution provides added value when we can retain water in the city and use it for other things not only for recreation such as cleaning cars, use it in parks. BUT the water quality aspect in Denmark does not allow the usage of water that has been on the surface more than 24 hours for many things due to the uncertainty about contamination. I think there are lot of added value, and it depends on the specific project, and the kind of water we are talking about e.g. water from the road and water from the roof are very different. You can see in Aarhus; they used to have a big pipe going through the city center, and now they opened it to become a stream and people really enjoy it especially the cafe owners nearby.

It is very difficult to price this even though you can calculate from increased revenue but it is still difficult to predict what will happen after you use these solutions since this would be different case by case. In Copenhagen, there are some smaller scale projects with the channel)see VIB homepage via LAR i Denmark(. The skater park is one of the famous projects for rainwater management. There's also a white paper called the sustainable urban drainage systems that have been made wit State of Green, and here you can findmany examples of the good solutions.

Barrier

The barriers are that it is difficult to see how much could the surface sulutions be cheaper or is it cheaper at all. It is also difficult because, before, when you put water in pipe it is invisible, but now it is more visible which means all the maintenance goes from the people and the utility to other people including; citizen, people from the municipality who has to clean the garbage or take care of the tree and small bushes and flowers. The maintenance cost is another big factor for the decision makers, and they have to be sure about the cost of the choice they are choosing and be able to compare it to another.

What about decision-making in the former projects?

It varies a lot between municipalities. In Denmark, the area with intensive cloudburst such as Copenhagen will have a detailed plan for climate action. They have 200-300 projects that are going to be implemented in the next 20-30 years. The future projects)GI(that are not thought of yet could also be combined with these projects. It started 1-2 years ago. Other municipalities also have this plan, but the main barrier for them is the process where the plan is turning into a real project. It is also important for them to have input from researchers or good practice from other countries. There are people who still want to use pipe and people who said we should use rain garden or green roofs or open channel. It is very difficult to find what solution is the best in these areas. So, I think it is important that we have some data, and decision-making tools that can help the planners and decision makers to have a clearer and better decision and, us, at VIB are working on that.

Copenhagen CCA plan
They use a consultant to help them, and sometimes VIB also helps this consultant. We are asking them about the status, the good things, the bad things and the economic relating to these projects but we are not a partner in all the project.)See some of the projects in given website(

However, we still have some area that we need to use the pipe since those areas do not have enough space for the surface drainage and the amount of rain is too huge to be drained by the surface solution. Copenhagen is still working on pipe solution but trying on integrating GI to them.

Other Environmental Concern
Infiltration is needed to refill groundwater but in Denmark, there are enough water generally except Copenhagen. The biodiversity is also another concern)the toads→ how they live in a green city(. It is greener and more exciting if the project could also create habitat for new animal and plants that have never been in the city. VIB is also working in this perspective as well)increase biodiversity in Copenhagen(.

Integration
I think when we started 5-6 years ago, we knew something about the 3 main areas, how much water can the solution manage, 3 different level of water to manage)daily rain event, 5-10 years <current dimension>, and extreme rain(. Before VIB, we were not thinking much about the extreme rain events and put it in others responsibility, but now we are getting more concern about it. It is difficult since there is some important spots/infrastructure that you really need to protect such as a hospital or a kindergarten. It might be better to have water on the roads or in the park to keep the people safe. You also need to make some calculation for the extreme rain event outside our standard dimension. You need to be sure of how much water can the solution manage and what is the quality of the water and can you use them as a resource and what are the perspective of the citizen. The perspective of the citizen is very important since they might have to be in the part of the maintenance team, so the inclusion of the citizen and sports clubs, especially, football club would be very important for the plan. The football club is one of example that we could use football stadium as a retention area. It is much cheaper to put water in these green areas instead of the crowded neighborhood. It could solve many problems. It is cheaper if we could do surface drainage and keep the water in the area that would cost less to be damaged rather than keep it in a sensitive area. However, you have to be innovative. It is very new to do this inclusive design and how can we involve citizen more than we done in the past.

Participation
In most projects in Denmark, the citizen would like to be involved as early as possible. If they could take part and come up with some suggestion for the project, they will be more likely to like it, get more involved with the project and feels like they are having ownership over the project. There can be some project that we need to do some calculation and data collection before present the project to them. If you want the citizen to take part in the project, you need to give them several solution or design schemes to choose.

The example of a football stadium, you need to find out the ownership of the space you want to integrate your plan to their land. Also, it is important to know the frequency of the event, tell them that they cannot play football under the thunderstorm that comes once every 10 years and tells them how long it would take for the area to be recovered, and they can use it again. If it is 2-3 days, it should not be a problem, but if it's going to take weeks or months the people are not likely to accept it. You also need to be very clear about the communication, so there

will not be rumors. Your homework)research(is very important to have the as precise as possible data to present to them.

Indicators - Priority

We have these 14 innovation projects; you can find indicators on the website, see www.vandibyer.dk. Also, we have a standard dimension tool for the rain garden and other green infrastructure which is now being used as a standard for design by the architects and consultants)see in e-mail(. Priority is vary from cases, municipalities, and decision makers. There are people at the municipality, and their job is to protect the groundwater for example, and they will not want the surface water that is polluted from roads or the salt in the winter time to infiltrate to the groundwater. There could be doctors who could come up with research that surface water is not safe, and there could be some people who want to try these things and trying to be more clever, smarter in the future, maybe even a better way to clean surface water in the future but they would like to see some innovation projects as an experiment. Some decision makers are more open to new things while others would like to see successful result from other countries or other projects and want to be safe. And I think in some project we really need to be safe for example, the hospital area that we cannot take the risk of the older people, children, and other vulnerable people. You have to protect them but in other areas you can try more exciting projects.

Vision

There will be a lot more greener project, but you have to make economic way for the decision makers to see it. However, I think the tools we have now are not good enough to do so. It is difficult to compare different solutions like comparing an apple and an orange. It would not be easy to come up with the cost-benefit analysis since there will be some value that you cannot give a precise cost. So in some project, these costs are left to the decision maker to decide what are the extra values that you could get from the flowers, the green spaces, animals, skaterpark value to the citizen. You can help them with some tools, but it's up to them to find out for some other extra value. We should help them to find out these value in a better way that we are doing today.

How can GI integration be supported?

Information is very important as well as how we communicate it. It is also important that we could find a new way of working together with municipalities, researchers, and consultants. The water utility is paying a lot for this solution, so it is important to include them in these projects. But you also have to do the overall planning very well. As, I say earlier that, if we have a new project, we could make a climate action project in collaboration with these projects. If we are going to do it alone, it would be too costly. It is needed to be combined with other projects and long term planning. The politician has to be more sure with the tools that could help them to find out the best solution. We have to work in many different areas in order to be better with this in the future.

Interviewee: Associate Professor Hans Peter Ravn

Department of Geoscience and Natural Resource Management, University of Copenhagen

Copenhagen Urban Biodiversity Think-Tank

Role and activities

I am an entomologist working on trees and forestry, as well as urban trees and open land area. For the last four years, we've been teaching a course, 'Biodiversity in Urban Nature' where we have gathered and present documentation on how urban area could have enhanced biodiversity, what is documented, scientifically and what is just a wishful thinking. When it comes to exploiting native plant species in urban nature, it is very difficult to persuade my colleagues landscape architects that the plants have an important biological role, and it is important to support the biodiversity richness especially by using native flora element. There is also an aesthetic consideration, but it should and could go together with biodiversity in order to achive diversity in the urban area.

The municipality of Copenhagen has arranged 6-7 workshops for the urban green think tank. They had invited people from both inside and outside of the municipality. The background is the cloudburst in 2011 and last autumn the municipality of Copenhagen in decided to spend 16 billion DDK during the next 20 years for climate adaptation and cloudburst management. They made an overall plan where they have tried to see how can we manage this and try to combine green issue with the blue issue and they come up with 300 projects for stormwater management. Sometimes, it is a road that could turn into a river during the storm-burst event. There is also the retainment of the storm water locally, which is the major issue in this plan. The plan also aims for reducing urban heat island effect. This is called the potential stormwater ways which will eventually end up in the harbor. They had calculated on how to retain it as much as possible locally, but the capacity is not enough to retain all the water. So, they had decided that they have to turn some of the streets into the canal during the extreme events. This is the green and blue area potential. However, at the end of this program, it is not the green issue that dominates. Priority is of course the blue issue. And during this work, we were told that of the total of 16 billion DKK that is going to be spent on these stormwater management projects, only one billion is going to be spent on the aesthetic and the green adjustment. So, it is only the minor proportion, but you could say that we have started out the new way of thinking because we need to think in a different way when we plan and everything should be connected in this green strategy plan. After starting out with big green ambitions. it was a bit of disappointment that actually we need to consider carefully on how to get the most out of the money you invested and by this way of thinking, the only little amount of money is allocated into greening the infrastructure. Mainly you will need additional funding from outside to turn these 300 projects into the green project as well.

On the last workshopsI shared group with the everyday management and maintenance people. I realized that they are very conservative because they know that for every tree planted, they will need to maintain it for a very long time. It is not just about planting the trees, most of it is the expense of the following maintenance. For instance, if you, in a public park want to include elements inspired from a therapy garden, they would oppose this very much. They would say that they would need a lot of maintenance, and they would need to spend more manpower on it. It is much more easy to get funding to build up green projects but for maintenance, it is impossible to get funding from outside. So since the rule is that the municipality will reduce the general budget every year, new green projects should be less maintenance demanding. So you have to anticipate the issue of maintenance cost and the green issue, which I think is the major obstacle to the integration. I don't think that it is always the case, but it is very difficult

to persuade people from the maintenance work that this kind of projects can be done in a different way which they could be green and inexpensive. But, trying to persuade these people is the most difficult challenge in my opinion. Perhaps some good examples is the only way forward.

How could you persuade them?
For example, the weekly cutting the grass is a rather simpleand easy element to them because they know how to deal with it, it is a steady post on the budget. But if you suggest using native grasses and leave them to be cut only for twice a year, it is difficult for them because they had never dealt with it. Perhaps it is because there are too many administrative levels, the guys you should get acquainted with are the guys who is actually using the lawn cutter. We should persuade them how to manage in practice. I think this could work.

We had brought the municipality leaders attention to the London's Olympic park 2012 plan because the competition criteria for this project were designed to include the material for the 10 years' management plan. The responsibility did not end the day the park was delivered, but should reach 10 years ui to the future. The management plan should be included in the competition package with different scenarios, for example, if a certain biodiversity goal – e.g. a certain number of bird or insect species - was not achieved, then there should be some adjustments in order to full fil the plan. The management plan considers biodiversity, for example, a certain way of managing the park have to be done in order to achieve certain kinds of bird life or wildflower. I think this design had inspired people from the municipality of Copenhagen because, usually, the responsibility of the entrepreneur company usually is finished when they delivered the project and this is not always working well in practice. So, the maintenance after the deliver of the project should be a part of the contract, and there should be local attachment and engagement like the Olympic park's plan, there was an obligatory request that more than 50% local people should be involved in the development of the project, and it should include a certain proportion of immigrants and gender equality. The concept is that it should be the local people who take care of their area. It was 2012. I actually don't know what the current situation is there, but it would be intersting to make a follow up on. I think it is very interesting if you could highlight the local engagement in the project description, and this should last for many years.

And the management cost you could reduce by saving the the lawn cutting. This could be acheived by established a self-supporting meadow system that using wild plants that should be cut only once a year. You only need to cut regularly for the part where people walk or picnic. For instance, the therapy garden in the NorthZealand)Copenhagen(have a budget for maintenance of 4.5 DKK/SQ.M./year which is very low. When I mentioned this to the management people, they argued that this would be impossible to implement in a park in Copenhagen, where they have millions of users yearly. These people will not like it, if the park does not look tidy, neat and unworn. Actually, if some part of the lawn could be replaced with bare soil, which is not always be negative since we have a lot of ground nesting insects which love the open soil and can live with heavy traffic of human user.

What I've learned from these workshops is that they have a very high ideal, but sometimes it could not be implemented good intentions due to the maintenance cost. You can have money for establishing these projects but what had been a crucial point is how much does it cost for the daily maintenance.

How could you integrate the green perspective into these plans? Is there any point in the planning process that you participated?
Of course, when you have this issue of water, I would suggest that you made some arrangement for permanent water surface. One thing that is the most difficult to established as long as I understood is the running water because when you have the cloudburst, and there are a surplus of water which you want to get rid of, perhaps you could have some storage capacity which could use for recirculating. Of course, this would cost some maintenance as well, but it is possible. There are people working with the fountains that could recirculate the rainwater, and if you have the solar cell to run it, the maintenance could be minimized and that running water is a very important element in the therapy garden.
Another thing is to have a green area where you have sufficient water supply. I mean if you have the capacity for water storage, you could irrigate you garden with that water during the dry season. You could gain more biodiversity because you could use the plant that would not be able to live in urban context during the dry season. You could have swamps which will bring more amphibians, and you could use the management plan for a seasonal change of the area. For example, the pond that could be temporary dry out because if you have too many fish in the ponds, there won't be a lot of amphibians since the fish will eat them. You could regulate this issue. For example, you can have ponds with fish and ponds without fish. You can also support bird life with ponds. I could see many different possibilities of integrating ecosystem with water regime when you could store some of this water.

When making a water management plan, at which point the biodiversity should be concerned?
Of course, it should be even before the design. Usually, the designed criteria are provided by the municipality who is setting the rule for the design competition for a project)TOR(. Different design companies will present their design to the municipality, and the winner will be selected. The biodiversity should be included in this document)TOR(that a certain level of biodiversity should be concerned. It could be as specific as to bring wild birds, insects, amphibians to the project. This criterion will demand that the design company will have to employ a biologist, and I think that could be a good idea. At our course, Biodiversity in Urban Nature, about half of the students are landscape architects and half are a biologist, forestry as well as other backgrounds. It is very fruitful because when you mix student from a different background, sometimes you get very, very good solutions.

There is a book called 40 species of Danish native species, where you have varieties of native trees and bushes with the condition they could thrive with the information about which birds or other life they could support. I think it is very useful for plant selection in the design process. It also has data about the appearance and how fast and where does it grow. It is available on the Internet.

What is the public view on the creation of urban nature where there could be wildlife and insect in the city?
The example of the problem with mosquitoes, to some extent you can manipulate that. I have sometimes been involved with insect problem in the city, but if you can manipulate the system sometimes, you can avoid them. For instance, if you have canal with mosquitoes, you can have the fish that would eat the mosquito's larvae. There could also be a problem with the ticks that live on wildlife which could be transmitted to house pet and in some situation you just have to accept these ticks if you want to have wildlife. In this kind of situation, it is manipulating to some extents only, and the part where you cannot, you have to live with it.

The other way where you can deal with this issue is to provide information to the public about the project, informed them about the issue and how they could deal with the issue. I think the

mosquito's problem with storm water retainment, sometimes it is a myth rather than the case. I live in the part of CPH where they had already implemented water retention area and build up swales around the private garden. People think that they had experienced more mosquitos after the implementation, but I'm not sure if it is the case because I had not seen any mosquitos in my garden. I don't know if it's the fear of mosquitos or actually the case. So you need to find out the fact behind these issues.

Do you think the municipality already include the issue of biodiversity into their plan when they are making TOR?
I think there are increasing awareness among city planners that they need to have more wildlife at all level. At least, that's what the leading landscape architect of the municipality of Copenhagen said of what she had learned from the workshop. A that certainly is an acknowledged change in attitude. When I first met her – at a Green Roof Conference I Copenhagen in 2012 - she mainly talked about the design and aesthetic, and not much about biodiversity. An occasion – Urban Farming Conference, last autumn - she in her presentation told us about her experience of nature – coming from Jutland - and what it means to her, that I find an acknowledgeable change in attitude. She also made the promissing statement, that she wishes to increase nature area to the city.

If you go back half a century ago, all people in Denmark had to some extend experienced nature. For example, they or their parents came from the countryside and had experienced the natural process: taking care of animals, noticing how they give birth and grow. Now, some people lived all their life in urban context and lost the relationship to that kind of nature experience. I think there's an increasing awareness of in order to become a whole person; you actually need to have that kind of experience both from the ethical and biological side. I think people get mentally poor if they do not have nature experiences.

Nature experiences could be very different; they could be just to experience the changes in season. Here, we have four seasons and when you are used to that; it is a positive nature experience. The municipality of Frederiksberg, which is located surrounded by the municipality of Copenhagen has a goal that every citizen, from where they live, should have an eye view to at least one tree because then, you can follow the season. I think it is a nice goal and statement purposed by a municipality that every citizen could see a tree from their windows. Nature experience could also be some flowers that come in the spring; bird life, especially small birds which are very popular. The bird will need insects to feed on, but people do no need to see these insects. Speaking about insects, the most popular ones are butterfly and ladybird beetles, which birds do not feed on. Most young birds should be fed on larvae of insects such as larvae of moth which often live on the specific wild host plants. That's why native, wild plants are important. In a horticultural context usually all wild plants are seen as weeds only. You need to change that attitude if you want to increase biodiversity. However, that is not difficult because you can select wild plants that look nice. There's actually a Ph.D. student here who study on wild plant's aesthetic and their capability to grow in the urban area. She has lots of experience in this area on which plant will do well in the urban context and look nice.

I think that should be included in the TOR when they are proposing for a project, and I think there will be more and more awareness of using the native plants in the urban context.

Do you think they should include scientist and people from other disciplines when they do this document?
We have tried to persuade them that at least they should try to follow up if they achieved their goal. In that aspect, they should consult scientist in terms of evaluation method. If you set out some objectives and change it during the implementation process, you should evaluate for why

it has ended up as it is. And, weather you have a functioning ecosystem as part of your plan, it is mentioned in this document as well. At least they claimed that they would include that in this project.

What do you think is the incentive for integrating Green Infrastructure to urban stormwater management?
It is important to include ecosystem service to the plans in overall. For example, service for pollinators will sustain the ecosystem within the city. You should consider if the demand will be fulfilled. Other services, some of it, are very abstract. For example, the experience of being in nature, it is very difficult to put value into this. Some of this you can measure and some you cannot. However, it is possible. There are some researchers pointed that you will have lower criminal actions in the area where there is access to nature, you have a better mental health and a faster recovery from sickness if you are surrounded by nature elements.

Apart from the maintenance issue, is there other barriers to the integration?
Yes, I think perhaps it is the mental barrier. People not actually aware of what nature means to them. And for some people that claim that nature do not mean a lot to them or they are not conscious about it. But I think it is valuable anyway because there are –as many studies have pointed out – mental and other benefits for human beings to be surrounded by nature elements. Usually, even when you present a hardcore urbanized citizen, they recognized that they like these structure, but they always forget about it. I think it's good, as far as I learned from these workshops, that the administrator bodies in the municipality of Copenhagen are taking action on this and want to have Copenhagen to be greener for the benefit of their citizen. And what could prevent this to happen could be the citizen acceptance which could be fixed by providing some examples to them. We have been discussing this issue in the workshop - that sometimes we just have to do something, and then we must learn from it. And there, we must do the follow up by evaluating the process, if it turns out to fail, you could adjust from both physical construction and the management regime. Then you should learn from this process, and gather these experience which could be a resource for other projects in the future. It is a running process to develop the way you manipulate the system and manipulating might sounds very artificial but actually, one thing that you could start with is to evaluate if you have some wild natural left within the area. I am sure, in Copenhagen, you could find some elements that are still here from the time that this area was still a countryside since it is not so long ago. For example, we have two bachelor students here who are looking at the green area near the church which was green since that time and seeing if there are still some original fauna living in that area. This research could result in the size and the type of ecosystem that these original faunas could still be reproduced.

And if you find the original natural element you should keep them because they could host the original wildlife also! And the methods to evaluate the ecosystem within a tree is not complex, a researcher from Lund, Mikael Sörensen has developed a method to evaluate the wildlife)redlisted xylophagous beetles(that a tree would host by just by observing if the tree has cavities, dead brances, sap flow, bark wounds etc. If you have enough of such elements on your site, you could with certainty claim that this tree does host rare and redlisted beetles. And they are basic for other important, good life as well.

What's your vision towards the integration?
We need some concrete example to work on. This could be when designing the new area with natural swale which could bring biodiversity including faunas.

Interviewee: Anders Kristoffersson

Lecturer at Department of landscape architecture, planning and management, Faculty of landscape architecture, garden and plant production Science

Swedish University of Agricultural Sciences

Roles

I've been participating in various projects in cooperation with Malmö. Starting in 2005, so it's been quite a long time. My background is the nature science and engineering, but my main focus is on the management, business, and economics. So, I am looking at stormwater management from the management perspective, how to integrate them, how to use them, what people think about them and how we can improve the use of the open stormwater solution. So, we have made an evaluation of what people think about the stormwater solutions in Augustenborg. I think it's a nice area where they have planned well by integrating public spaces and privately owned spaces for managing stormwater. There are also storage areas which will be dry most of the time and be able to retain water during the rain events. We asked, in the early stage, what people living around and the professionals think about these measures to try to find the core idea of what people think about this.

I think we have this report where you can find the summary in English. It is quite obvious that the professionals and the public were having very different views on stormwater solutions. The pubic were quite unsure about the performance of these solutions, and they have had different stages of development at Augustenborg. In the early stage, they started with the stone canal and people were invited to the discussion on the design and how these things are going to perform. The tenants were expecting that they should get an open water solution, but they just had these empty canals, and it becomes canal with water only during the rain events. Now the municipality have decided to have these canal filled with pumped water all the time with. This is actually one of the examples of a different perspective of the public and the professionals. The professionals know that most solutions will be dry most time of the year, and I think that a lot of people would like to see the running canals, but the main part of the solutions will be dry.

There is also an obvious line between the park department and the water department (VA SYD) regarding what they thought about these kinds of solutions. There are differences between the blue people, people from the water department, who are confident in using pipes and they really think that it is good and efficient and under their control since they know about the construction and how to use it. Most people at the water department have been working for a long time with traditional solutions, and they still prefer the traditional solutions. Even though the good example from Augustenborg has been there for almost twenty years, many people from the water department still think that it's better to bring water to an underground structure because they know how to deal with it. There are also people from the water department, especially at the management level, who wants to use the open water solution and know that these solutions are good in several aspects. Nevertheless, people who are working with it still want to use the pipes. For the green people, from street and park department, normally they would like to have these open solutions and this is their area of expertise when it comes to dealing with parks and gardening. From this point, they are interested in using these stormwater solutions which could provide aesthetics as well. The combination of blue and green is what they would like. It is different perspectives when these departments look at the same question.

There is a complicated relationship between different departments in the city. The VA SYD actually have responsibility for the stormwater when it is below the surface, but above the surface, the responsibility would go to street and parks department. So they have to cooperate when the rain flows from the park or the street to the pipes. That complicates when they have the open solution where they need to negotiate on this responsibility. Who shall be responsible for maintaining the open pond? Since VA SYD is not familiar with maintenance techniques, they have to ask the street and park department to help them. For example, buying the service from the municipality. So, they need to cooperate over this issue for all of the decisions of open solutions they make. This is an example of how water flows through the border of these departments. The water goes on its way, and the responsibility for it changes along the way.

Now, we are talking about the municipality, but we also have the private landowners and also the private owners of other buildings. They should take care of their own stormwater and then let it out to the system. If VA SYD or the municipality want to take care of the whole system, they have to cooperate with all the land owners in the city also. If they only focus on the public property, they would only be able to handle half of the city, regarding permeability. For example, people who are having gardens could make the surface permeable or retain the water which is the huge potential for VA SYD to work with. However, there is a little complication since VA SYD, as well as other organizations, would focus on growth but if they cooperate with the citizen, they might get 50% less water to manage and then their organization will get less to do, less money and not expanding. There is a contradiction between this growth and getting less water. I think this is the point that they will not talk about. They also have a little economic payment when people retain water within their property; then you get paid once like 5,000 SEK. But you don't get paid according to on how much water you could retain. And if you could change the way that you are charging people in the city where people who could store their water pay less tax would be an incentive to take care of this economically. However, VA SYD has to consider their economic situation if they want to implement this on a bigger scale, and that is complicated.

We have also been working on a project about root intrusion and how to manage the roots to not getting into the pipes. We've provided solutions regarding this issues. For example, the tree could be relocated with new techniques (and not just be felled) and then redesign the place with a new solution that could combine blue and green interest. I also have another colleague who is working on green roof techniques such as new soil combinations, thickness of the greenroof, and plant selection which could affect how much it could retain water. We also have people working on pervious pavements and underground storage under the pavement. There are many possible win-win solutions we are working on now. These solutions are developed together with the city we are working with, so they will get informed about the development and try to use it. But there is a big challenge to get these solutions spread to the public, different parts of the departments in the municipality, the consulting firm, the design firm or the construction firm who are going to use these solutions. This is also another focus of our work at the moment, how to introduce open stormwater solution more effectively.

So we have had Augustenborg for twenty years now, but we don't have many other solutions like that case. There is a research pointed out regarding how the consulting firm can use these solutions more often, they need to be sure that they will be effective. If you have new solutions that have not been fully tested, there will be some risk, and they might not want to take the risk by using these new solutions. The municipality also must not know how to ask for the possibilities since they are not reading all the research reports, but they have to know what to

ask for. So, there is the educational aspect on how to provide the knowledge and get the new solutions to be used the city.

There is also the planning aspect. When you are building new parts of the city, you can start to plan for these solutions from the beginning of the project. But in the dense city, space is very limited, so where could the open solution be located? Or if there are spaces but the plan has been made twenty or hundred years ago, can it be changed? So there are many aspects when working with old dense city areas compared to building new city parts. Actually, there is another master student here who is working on spaces where we are not allowed to park and use them for rain gardens. Nowadays, that we are trying to limit the traffic, there could be many more solutions. That's one possibility to find spaces for the open water solutions. If you could implement these on a bigger scale, it could do a lot.

So we think that it is essential to expand the view and not to focus only on stormwater but looking at the city as a whole regarding the climate, the environment, and the human aspect. Today 85% of Swedish citizens are living in a city, so it is important to make the city livable, and the Blue-Green solutions could be part of this. We just had a lecture from the London Olympic Park's project manager this morning, which is a good example on how these projects should be done. The area was a downgrade area of London with pollutions and considered as brownfield area. The city made a decision that by 2030, this whole part of the city should be revitalized and the Olympic game will be a good reason to invest in regeneration of this area. They have a very smart plan that integrates the blue and green solutions, transportation, human aspects and biodiversity for a modern city planning in one project. Stormwater solutions have to be seen in that context and VA SYD would not be able to think like this without the help from other departments. If these solutions are going to be implemented on a larger scale, they will have to think of them as tools for creating a livable city as well as managing stormwater and heat island effect. I think that one of the ideas to improve this integration is to have this livable city perspective. I think there is a good possibility if we have this kind of view.

Initiative

In Augustenborg there were several specific reasons to use green solutions. It was not only focused on stormwater problems. First, there was a serious flooding in Augustenborg, and if they want to use the pipes to manage this flooding they would have to invest in a huge pipe downstream, so pipes upstream would not help with the flooding downstream. One important reason for prioritizing the open solutions in Augustenborg was that the investment downstream would be too big, so it was better and cheaper to make an investment upstream to take care of water in open solutions instead of pipes. The housing company of the municipality (MKB) also played an important role since they owned all of the houses in the area, which was degrading, and they wanted to develop these areas. So they decided to develop the houses as well as the outdoor environment in cooperation with VA SYD on stormwater management and various departments in the municipality. For examples, the park department created the park and the school department allowed using the school yard for the open solution. They were working on a lot on things at the same time like what I was talking about on the livable city aspect. It was not a specific urban stormwater project but more like the development of the degraded area as in London. It was easier in Augustenborg since MKB owns all the houses. If you are working in areas with many private landowners, you would need to provide them with economic incentives to persuade them to implement these solutions. So, you need to widen the perspective from a stormwater management perspective to urban planning perspective and have a long term perspective for it.

We are also working on a project with Lund and another municipality to see how we can use stormwater solutions there. So, we are starting from the management perspective with the question of what has happened, what are the problems and what need to be solved in order to bring this to realization. Then we will look at the operational level and stormwater policy that the city level. Policies are always very ambitious and differs from the implementation in real life. Also, how could different departments cooperate to make this solution come to realisation? We were talking about the lack of knowledge among people on the political level of the city, for instance, they may want the city to be livable but they might not know about how the stormwater solution could be one of the tools. Even, the consultants know too little or may be unsure of using these solutions. We are trying to look at the practical level and how to integrate these levels to improve the use of stormwater. One of the solutions is that we have to look from the wider perspective, we cannot talk only about a stormwater solutions, but the whole livable city. If we work on a single raingarden solution without a perspective like that, and we the talk to VA SYD, they would say that it is too expensive and would not be really have the time since their main focus is still on solving the problems from the 2014 flooding in Malmö. In the case of Lund, VA SYD would say that the main problem is that the run-off pollutes the river, and they need to clean the stormwater by delay the storm water, so it becomes less polluted. In this case, only one small scale solution would not provide effective results, and therefore, it cannot be looked upon with the short term perspective. To reduce pollution in the river the long term perspective is needed where they could implement these small solutions little by little. You cannot change the city in a year or two; it takes time. This is also another barrier. We have to respect the existing structure of the city. We cannot transform the whole city in short time. For example, one rain garden is not expensive, but when having many of them for the city plans, it could be very expensive. This has to be related to the flooding costs and the maintenance cost for changing old pipes.

The other problem mentioned is that the underground system is getting old and need to be changed. This is the real big problem for VA SYD, and most other Swedish municipalities, because the pace of changing these pipes are to slow, and the process of changing the pipes would take 400 years while many parts of the pipe system will have to be changed in less than 50 years. So, the open solution could be part of the solutions for this maintenance problem. You will also have to consider that there will have to be different solutions in different cities. For example, if you have clay you cannot have infiltration and the solutions have to be adapted to the city structure as well as land ownership. So, this is a complex problem to solve, but there are drivers like these "ticking time bombs" under the ground that are going to expire soon and the cost of having new pipes are high compared to open solutions.

Barrier

I think one of the answers is the cooperation. There has not been enough power to get this done in other areas. There has not been enough cooperation as we seen from the case of Augustenborg. I could also say that there is a time barrier that changes this cooperation structure within the city. At the time of Augustenborg, there was a very motivated head of VA SYD, who was interested in this question and having a good relationship with the head of street and park department, so they had the will to cooperate and set the scene for the rest of the organization. Then, people changed at the management level, and things are changed over time. Normally, you will need at least one person who is burning for doing using these solutions at the management level and preferably even at the implementation level.

Different departments have different budgets, and no one is asking them to cooperate regarding the investment. Also, sometimes the head of departments are not allies and that would result in no cooperation at all. Reluctance to change is also another barrier.

Public participation

To make open solutions affect the livability, human and social aspects should be the considered. There is a lot of evidence that we as human beings need nature. The simple way to explain to the public why we need green is that we need green to feel well.

Social innovation

Collaboration and having more people involved in the process is a possibility to improve the pace of using these solutions. Also, if we go back to the 50% of the privately owned land, we should look at this possibility which will need less public investment. These solutions could be part of the project of integrating immigrants by offering a job or to create social events for urban gardening. We are also talking about a pedagogical aspect of raising environmental awareness of this issue by keeping rainwater above ground because when it is underground people will not be aware of them. Once again to integrate this issue into the livable city aspect.

Interviewee: Tim Delshammar

Landscape Architect at the Environmental Department, Municipality of Malmö

Blue, green fingerprint, Malmö stormwater strategy

Roles and activities
Tim Delshammar, my interviewee, has a role in developing Malmö's cloudburst management plan. His role as a researcher and practitioner is to provide the municipalities with measures for stormwater management, which derived from data and research.

Integration Process
Infrastructure for stormwater management is a large infrastructure. In Malmö, the plan required the coordination between many departments especially the technical department e.g. street and park department, city planning department, real estate department, internal service, risk and safety and the water department. The plan will be reviewed in many stages and will be integrated with other plans throughout the reviewing stages. This process results in the estimation that the plan would be implemented by the beginning of 2017.

For the technical planning process of integrating the green infrastructure to other plans, this process is done case specific. The interviewee mentioned that it was important to have a combined system between grey and green infrastructure, where the green infrastructure functioned as retention and infiltration area and the grey infrastructure function as fast drainage.

As his role is focusing on the development of the plan, the report provided to the municipality is evidence and scientific based.

The priority concerns during the planning process
The Cloudburst project is focusing on ecosystem service and cooperates it in the plan as far as possible. It also focuses on the multi-benefits of the green infrastructure regarding ecosystem service e.g. recreational service and biodiversity. However, the stormwater management is the priority.

The factors which initiate, incentivise and prevent the integration of green infrastructure
The evidence of the benefits of other green infrastructure project built formerly such as Augustenborg. Other incentives are that the cost-benefit of the combined system is better than the traditional system alone. Another incentive is that the cost of the risk from cloudburst is very high, and the best)cost-effective, multi-benefit(way of build up resiliency is needed.

The barrier to the integration is the competition of the land, especially in the dense urban area where the land is also necessary for housing and business activity. The green infrastructure will be considered case by case according to the characteristic of the land and the project.

Governance and financing structure
The plan is a long-term planning which requires ten years to be completed and will be fully functioned in 12-13 years due to the cost and funding of the projects as well as that the construction process would need to wait until the former infrastructure get expire and need to be rebuild/retrofit.

Your vision towards integration of green infrastructure

The municipal is likely to adopt this plan and likely to be implemented by the beginning of next year.

Interviewee: Helena Flinkberg

Project Engineer at VA SYD

Role and Activity

VA SYD was founded in 2008. Before that, it was a part of the municipality as the water department. The initiative in Malmo come from the pioneers, for example, Peter Stahre, who was working intensively on this issue. They were trying the integrate green infrastructure into water infrastructure and try to integrate this kind of thinking to the municipality that the green infrastructure and stormwater management issue should be part of the urban planning from the beginning stages of the planning process, which was around the 80's. Malmo also developed city's stormwater plan in the year of 2000 and a stormwater strategy in 2008. When we got separated, the role is a bit different, but it's still our responsibility to manage stormwater and initiate plans. In the strategy, there is one part which describes the area of responsibility when it comes to the stormwater issue. For example, it's the VA SYD role to take care and make sure that the stormwater treatment is there.

VA SYD doesn't own any land, so we had to cooperate with the street and park department who owns the land, and we pay them for the maintenance of the infrastructure such as grass mowing. It's our role to take initiatives, but we are very happy if someone else have an idea for this issue whether the private land owners or city planners. We need to make sure that the solution is there. Sometimes there is no space for GI, and we have to use pipes. If there are enough space, we will try our best to use GI.

We would like to collaborate with the planning process as early as possible, because there might be some solutions that need more space and, together, we could see more potential for integrating it to other function in the earlier stages. Then, we also have to look at detail plan as well. It is a hard job for city planner to combine all of these aspects. Sometimes, there are not enough spaces for this infrastructure. The housing company also need space for their houses, and they have more money than us. So, we have to fight for our cause, but it's the city planner's decision if they want to use these solutions. It is not only the planning department that we need to work with but also other departments. For us, GI is good for the issue of flooding, but, for another department, it's the issue of recreation and biodiversity or other urban quality value. In order to meet with all the benefits, we need to work together.

When we face this space issue, we have to use underground storage instead or detention solutions downstream. It's in the detail. We try to fight for the green solution and most of the time we get the space because, often, if we do not have enough spaces, we cannot deal with the stormwater and we cannot fulfill our responsibility. Otherwise, we need to consider other solutions.

We have tools for decision making. We are looking at the recipient if they are water sensitive or not, and most of the recipient in Malmo city center is very water sensitive. When the harbor is our recipient, it's not as sensitive, and we can just direct the water to the harbor. If the stormwater tends to go to our combined system or waste water treatment system, we think is better to use green solution to prevent that system from getting overflow. So, we are looking at both recipient and pipe system. Also, we have computer models for the piping system, so we could ask people who are working with the model about the capacity of the existing system when we try to design something new in that area. I think the recipient is very important as

well as numbers of the basement in the areas when we consider about the sensitivity and choose which solution we should use.

As engineers, we are working with architects on the physical design. The volume, depth, inlet level and outlet level are designed by us. Then the architect design on the aesthetic and multi-functionality parts. So, it's like working back and forth. This is how we work when it is the public land. We also want to work with the private landowner as well. We use to collaborate with them a lot in the past, but the legislation change makes it's difficult to force them to use these solutions. For example, green roofs, we don't build a green roof, but we try to encourage real estate owner to build them. We encourage private landowner through discussion during the planning process, trying to explain the benefits of these green solution and point out that people will like them since they give more aesthetic and livability value to the property. We do not have any incentive program at the moment. Before, we used to have this legislation where we can limit the inflow from private property, and they have to manage the water on their property. Now, the legislation changed, and we cannot say this anymore.

Also, the lawmakers forget that we have stormwater and water moves. Water moves without considering the legislation, so it can be flooded in the area downstream and not in the upstream, so we cannot use the same legislation in the different area. VA SYD is part of Svenskt Vatten, an association for municipal water departments in Sweden)The Swedish Water & Wastewater Association was set up by the municipalities in 1962 to assist with technical, economic and administrative issues and to represent the interests of the municipalities in negotiations with authorities and other organisations on regulations. Svenskt Vatten works intensely to change the legislation in this field because we feel that we cannot work like this. Cloudburst will be more common as well as the extreme rainfall so that the problem will increase and there is a need to change legislation to deal with them.

What kind of legislation changes you or VA SYD wish for?
First of all, they should start with define stormwater. Our main interest for legislation change is to change the urban planning and building law, which is the most important law for us. . There are 3-4 laws which regulate stormwater but the plan and building law is the most important, even that it just changed in 2010. The urban planning and building law should change to that we can regulate private land; to make it possible for us to limit the inflow from private property to our stormwater system. There could be more things, but I'm not sure since I'm not a law expert. We should also work together, and everyone should take responsibility to make detention for stormwater. Sometimes it is better for the private landowners to do their part on their own land since it covered more area. So, the law should change and let us regulate the private land as well.

I know that the municipality of Umea has this incentive program to reduce water price for private land owners, but it is very difficult. It takes a lot of work to do that, and we do not have that capacity at the moment. Maybe we also hadn't thought that it is necessary, or we haven't tried. We don't even know if it's even legal to do that. So far it is the lack of capacity, and it might not be worth for us. It is hard to decide how much of the price should be reduced for each solution in the different areas. There could be hundreds of solutions. The decision on how much the price should be reduced is very difficult. It would require lots of effort to figure this out, and we don't have this capacity at the moment.

For the responsibility, we are responsible for the water in the pipe system. We are responsible for designing stormwater systems that work for up to 10-30 years rainfall depends on the vulnerability of the area. It used to be two years, but just recently changed. That correlate to the pond as well, so we responsible for the 10-30 years rainfall level and above that it's the responsibility of the municipality. We also manage the pipe system completely, but for the pond, we share responsibility with the municipality. If the city wants to do a big pond for cloudburst, it's their responsibility. It's not just VA SYD approach but it's the standard for all of the water utility in Sweden (P110). In Malmö, we have a stormwater strategy. The piping system is always the responsibility of the water utility. Element above ground is the municipality's responsibility, but it's not always clear which department in the municipality should be responsible, and sometimes it requires collaboration between two or more departments.

Incentives
We prefer GI because we have lots of problem with flooding. We need GI to slow down the speed of the water, so they will not flood the city. That's the main reason, especially, for Malmo, we are using a lot of combined system (stormwater and sewage water), and there are many basements. The retention area would lower the load of this combined system. This is the main reason we choose green infrastructure.

Barriers
Sometimes the cost is the barrier, but it's not always the case because the pipe system can be very expensive as well. The cost for building underground retention reservoirs with pipes is often much larger than building green infrastructure above ground. But, the GI takes a lot more space, and this could be the cost issue for other departments or stakeholders. For us, it's the cost that we will need to pay more for the maintenance which needs more frequent maintenance. We have to look at the most appropriate solutions, which sometimes could be the traditional system.

Space and legislation are the most important barrier as I had mentioned. Space has many different potentials that people can use it in different ways. People wants to build so many things, so space and cost always come together.

Public participation
I guess in the city planning, and detail plan process is the process that we invite the public to the design. Sometimes we have to work with the developers on the design. We try to have a discussion with them earlier in the process. The developers tend to have an interest in the economic issue, which could also be a barrier to GI since they want to exploit as much land as possible. It is sometimes possible to convince developers that GI has many positive sides, not just for stormwater but also for attraction for the residents for example.

Social innovation
To inform, to use information to make people realized of what could happen if we are continue using conventional pipe system which cannot take as much stormwater as we need since climate change is real and we are going to have more stormwater. The city is getting more and more developed, and the surface gets exploited. There will be less space for the water to infiltrate naturally. We need to make people aware that we need green infrastructure to make a sustainable city which will not be flooded so often. I think that's one thing that we need to do continuously. It is very important to make people aware that they also have responsibility. It is

popular now, that the regular house owner to pave their backyard. This little change makes a great different in the larger scale. We need to increase awareness among the politician as well since they make a decision on how to develop the city.

Vision

I think it will be more and more important to integrate green infrastructures since the climate change is real and there will be more water coming as well as the denser impermeable city and sea level rising. Another increasing focus not only to how to retain the water but how to purify them, so we don't pollute the recipient which is happening right now that the environmental department is getting more concern about this issue. There are many issues that will bring a lot more attention to integrating GI to the city. That's what I hope for.