# URBAN CLIMATE ADAPTATION

## - A STUDY OF ENHANCED URBAN RESILIENCE THROUGH AN ECOSYSTEM BASED APPROACH

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Front page picture: Carlson, D. (2010)

"*Sustainable cities are resilient because they recognize and plan ahead for the shocks they may experience in the future*"

*Jeffrey D. Sachs (2015)*

# Preface

This thesis is written on the 4th and final semester of the Sustainable Cities study-programme on Aalborg University in Copenhagen. At the beginning of the work with this thesis, an opportunity to collaborate with the consultancy company Sweco, emerged, and our interest was transformed into action, and a collaboration was established. The collaboration consisted of the making of a report regarding urban resilience and climate adaptation, in which this thesis potentially can be part of the academic foundation for said report. Throughout the writing of the thesis, Sweco have been helpful in terms of allocating resources to assist us with and to identifying potential respondents for interviews. Likewise, they have assisted throughout the writing process with their thoughts on the matter and with their professional perspective. In this regard, we would like to thank Jonathan Leonardsen, Enrico Moens and George Parsons for their valuable inputs, and fruitful discussion sessions during the work with this thesis.

Likewise, we would like to thank the respondents who took time out of their schedule to help us answer our interview questions, in an uncertain time. More specifically we would like to give our warmest thanks to; Jörg Breuning, Stephan Brenneisen, Lykke Leonardsen, Christina Salmhofer, Rebecca Gohlke, Fiona Wolff, Gustav Näsländer and Tanja Hasselmark Mason.
Our final thank you is directed towards our supervisor Monia Niero, Associate Professor at the Department of Planning, whose guidance and kind and warm nature, has helped guide the work process in many different regards and assisted us with clarity during these odd times.

Finally, we would like to pay our last respects to our late study secretary, Karin Toft, who tragically passed away after a short period of illness. Honored be her memory.

# Abstract

This thesis examines how an ecosystem-based approach, and more specifically, the utilization of green roofs, can become implemented at a larger scale, as part of cities strategies to become more resilient i.e. towards the impacts of global climate changes. In addition to these impacts, climate scientists predict that increased levels of precipitation will become a future challenge for Northern European cities in particular.

In this regard, green roofs have gained renewed attention the past few years. This technology has the ability to contribute with multiple benefits in an urban environment, where more dense buildings and structures challenge the space available for ecosystem services to be present. Green roofs were chosen as a main focus because of their abilities to not only adapt and mitigate climate related challenges, but also because of its ability to become implemented in areas with poorly utilized space, such as on rooftops.

Through the use of Polycentric Governance, the drivers, barriers, networks and tools used to either expand or impede the use of green roofs in cities, have been identified and processed. This has been done in a way to allow a framework for successful implementation of green roofs to be constructed. This framework has been structured through an exclusively qualitative data collection and used to propose how both public and private actors could collaborate in order to ensure that a larger volume of ecosystem services becomes a part of the future urban landscape.

# Danish Summary

Dette speciale undersøger hvordan en økosystembaseret tilgang, og mere specifikt, udnyttelsen af grønne tage, kan implementeres i større skala, som en del af byernes strategier til at blive mere resiliente mod konsekvenserne af de globale klimaforandringer. Udover disse konsekvenser forudser klimaforskere, at øgede nedbørsniveauer vil blive en fremtidig udfordring for især byer der er lokaliseret i Nordeuropa. I den forbindelse har grønne tage fået fornyet opmærksomhed de seneste par år. Denne teknologi har evnen til at bidrage med flere fordele i et bymiljø, hvor en større andel af tæt bebyggelse og strukturer udfordrer den plads, der er til rådighed for at økosystemtjenester kan være til stede i byen. Grønne tage blev valgt som et hovedfokus på baggrund af deres evner til ikke kun at være i stand til at tilpasse og begrænse klimarelaterede udfordringer, men også på grund af deres evne til at blive implementeret i områder med dårligt udnyttet plads, såsom på hustage. Gennem brug af teorien 'Polycentric Governance' er de drivkræfter, barrierer, netværker og værktøjer, der anvendes til enten at udvide eller hindre brugen af grønne tage i byerne, blevet identificeret og behandlet. Analysen er blevet udfærdiget med baggrund i dette speciales problemformulering og følgende underspørgsmål, som har fungeret som analysekategorier gennem denne. Gennem resultaterne fra analysen, som blandt andet tæller hvordan de forskellige aktører bruger netværker, og hvor stor en rolle de har, blev det muligt at kunne sammensætte den samlede viden i et samlet framework. Frameworket er blevet struktureret gennem en udelukkende kvalitativ dataindsamling og kan bruges til at foreslå, hvordan både offentlige og private aktører kan samarbejde for at sikre, at en større mængde økosystemtjenester bliver en del af det fremtidige bylandskab. Dette er gennemført på en måde, der gør det muligt at skabe et framework for en succesfuld implementering af grønne tage. Ydermere er dette framework også ment som et værktøj der kunne bruges til at observere hvordan de mange dokumenterede fordele ved grønne tage kan bidrage til at øge urban resiliens. Ved at kombinere disse med et 'Polycentric Governance' perspektiv, er det efter forfatternes opfattelse en valid og tilpasselig tilgang til at kunne øge chancerne for succesfuld implementering og udnyttelse af økosystemtjenester.

# Disclaimer Regarding COVID-19

In the period from March the 12th and to the submission of this thesis, the facilities of Aalborg University have been closed. In addition - and with regard to the consequences of the lock-down measures and initiatives that the Danish government launched in order to mitigate the damage of the COVID-19 outbreak - Aalborg University have recommended that all students enrolled at the department of planning, should provide a reflection to the readers of their projects, which addresses the way that COVID-19 has impacted the processes and final outcome of their work (Appendix 8).

The COVID-19 outbreak has to some extend impacted the data collection of this thesis. Firstly, because a range of travels were planned to take place in order to gather qualitative data, and to achieve on-site involvement and practical experience with green roofs to offset the natural limitations of literature. The authors were in the process of applying for grants that could be of assistance to enable the preliminarily scheduled travels to Berlin and Stockholm, and most importantly Rotterdam, where an internal meeting with Sweco experts regarding a new report, that is going to be published sometime later in 2020, had been discussed.
Secondly, COVID-19 were often presented as an argument, when potential respondents rejected our inquiry on whether they would like to participate in an interview with the authors. It is anticipated that the alternate way of working (e.g. work from home) have increased the workload and pressure on many people, in a time where job insecurity and economic crisis are on many people's mind - including our own.

Coordination efforts have also been impacted, as the university in some periods suggested that group work should not include physical meetings. As a result, the authors have been using various digital platforms to coordinate work and to conduct interviews. In some cases, technical difficulties challenged the process, but only rarely to such an extent that it caused any significant challenges.

COVID-19 has not impacted the process of supervision and guidance. It has, however, been a new experience to receive supervisor feedback using online meeting platforms. The communication has, however, been as frequent as on previous semesters.

Everyone has to adapt to this new situation, including university students on their final semester. The challenges have been tough at times, but manageable. It has, at times, been a stressful experience, and a situation that has taken up some mental capacity, which has required some extra attention and focus, that could have been focused elsewhere under normal circumstances.

# Table of Contents

## Table of Contents

Preface....
Abstract....
Disclaimer Regarding COVID-19....
Table of Contents....
1. Introduction....1
1.1. Climate Change and Future Precipitation Levels....1
1.2. Water Retention Measures and the Ecosystem-Based Approach....3
1.3. Relevance for Sustainable Cities....4
2. Scope of the Project....7
3. What Defines a Green Roof?....9
3.1. The Structure of a Green Roof....9
3.2. Most Common Types of Green Roofs....10
3.2.1. The Extensive Green Roof....10
3.2.2. The Semi-intensive Green Roof....11
3.2.3. The Intensive Green Roof....11
3.3. Main Benefits and Disadvantages of Green Roofs....12
3.3.1. Benefits and Disadvantages:....13
3.3.2. Prevalent Benefits Mentioned in the Literature:....14
4. State-of-the-Art....18
4.1. State-of-the-Art on the Benefits Gained From Green Roofs:....18
5. Methodology....25
5.1. Research Design....25
5.2. Theoretical Perspective....28
5.2.1. Introduction to Polycentric Governance:....28
5.2.2. Key Concepts in Polycentric Governance:....28
5.2.3. The Advantages of Polycentric Governance:....32
5.2.4. Challenges and Barriers of Polycentric Governance:....35
5.3. Methods....40
5.3.1. Introduction to Methods:....40
5.3.2. Desk Research and Netnography:....40
5.3.3. Document Analysis:....43

5.3.4. Interviews and Transcription: ....46
5.4. Applied Methods ....48
5.4.1. Introduction: ....48
5.4.2. The Validity and Reliability of the Collected Data and the Qualitative Studies: ....48
5.4.3. Introduction to the Applied Methods: ....50
5.4.4. Desk Research: ....50
5.4.5. Netnography: ....51
5.4.6. Document Analysis: ....52
5.4.7. Interviews: ....54
5.4.8. List of respondents: ....56
5.4.9. Transcription Strategy: ....58
6. Analysis ....60
6.1. Barriers and Challenges Pertaining to Green Roof solutions ....61
6.1.1. The Danish Perspective on the Barriers and Challenges for the Implementation of Green Roofs: ....61
6.1.2. The Swedish Perspective on the Barriers and Challenges for the Implementation of Green Roofs: ....66
6.1.3. The German Perspective on the Barriers and Challenges for the Implementation of Green Roofs: ....68
6.1.4. The Swiss Perspective on the Barriers and Challenges for the Implementation of Green Roofs: ....70
6.1.5. The Baltimore and Stuttgart Perspective on the Barriers and Challenges for the Implementation of Green Roofs: ....74
6.2. Advantages and Drivers ....80
6.2.1. Copenhagen, Denmark ....80
6.2.2. Stockholm, Sweden ....82
6.2.3. Berlin, Germany ....85
6.2.4. Basel, Switzerland ....86
6.2.5. Baltimore and Stuttgart, United States and Germany ....91
6.2.6. Sub-Conclusion ....94
6.3. Legislative /Political tools ....98
6.3.1. Copenhagen, Denmark ....98
6.3.2. Stockholm, Sweden ....102
6.3.3. Berlin, Germany ....104
6.3.4. Basel, Switzerland ....106
6.3.5. Baltimore and Stuttgart, United States and Germany ....109

6.3.6 Sub Conclusion on the Different Tools Utilized by Actors Working with Green Roofs: ....113
6.4. Networks and synergies ....114
6.4.1. Copenhagen, Denmark....114
6.4.2. Stockholm, Sweden ....118
6.4.3. Berlin, Germany....119
6.4.4. Basel, Switzerland ....120
6.4.5. Baltimore and Stuttgart, United States and Germany ....121
6.4.6. Subconclusion ....122
7. Discussion....123
7.1. How Can a Created Framework Based on Best Practice Examples Contribute to Enhance Urban Resilience Through Utilization of Green Roofs?: ....123
7.1.1. Inclusion of Different Cross-Scale Actors and Cross-Sector networking:....124
7.1.2. Legislative Guidelines, Regional Laws and Local Incentives: ....126
7.1.3. Best Practice Tools Suggested by Respondents: ....128
7.2. The “Green Roof Implementation Framework”....132
7.2.1 The Green Roof Implementation Framework and the practical utilization:....133
7.2.2. Contributions to Urban Resilience ....135
7.2.3. Elaboration of Critical Points in the Illustrated Framework: ....136
8. Conclusion ....138
9. Bibliography ....140

# 1. Introduction

Humans are a creative, innovative and progressive species, who always pushed the boundaries for what is possible to achieve. Between the mid-18$^{th}$ to the mid-19$^{th}$ century, the industrialization and the industrial revolution(s) acted as huge catalysts to technological advancement, innovation and urbanization, providing us with multiple benefits such as mobility improvements, better and more reliable production systems and infrastructure. Though the benefits of these innovations are indisputable, several externalities have impacted the earth as a consequence, destabilizing systems and creating positive feedback loops which all harms the planet. Some scientists advocate that human impacts on the ecosystems of the earth are so profound that our current geological epoch should be named "*The Anthropocene*", which is a reference to the anthropological impacts on the environment, and that these should be taken into account as well when naming our current epoch (Carrington, 2016). The impacts addressed by these scientists are (amongst others); "*Global climate change, shifting global cycles of the weather, widespread pollution, radioactive fallout, plastic accumulation, species invasions, the mass extinction of species*" (Ellis, 2018).

## 1.1. Climate Change and Future Precipitation Levels

Especially the consequences of global climate change are gaining a lot of attention from both industry stakeholders, policy makers, scientists and other individuals. The severe consequences are impacting the globe in very different ways, making it a challenging issue to both predict and handle. As the issues of climate change however is profound and evidently impacting the environment, governments, businesses, municipalities and other stakeholders act in order to adapt and mitigate the consequences. For instance, some nations are acting to prevent the indisputable valuable resource of water from evaporating, as one consequence of climate change are reduced access to water resources from areas where this is already a scarce resource (Howard, 2015). Other nations, such as many of the ones located in the Northern part of Europe, are exposed to the opposite impact, as more frequent stormwater events are predicted to become an issue in not only the future landscape, but also in present time (EEA, 2019). It is however difficult to predict the exact outcome of the climate changes, which is why data, climate models and forecasting methods are relevant. Not only for policymakers, but also for urban planners, consultants, people within the scientific community etc. In the pursuit of predicting the future anticipated

precipitation levels, climate scientists make calculations in order to present some scenarios with different outcomes. These outcomes are correlated to the level of mitigation actions launched throughout the globe, as it is evident, that the severity of the impacts are depending on the measures taken by nations in order to combat greenhouse gas emissions and climate changes (NSW Government, n.d.).

The illustration below, and the picture of Europe on the left in particular, gives a graphic overview of how especially northern european countries will become impacted by climate changes, as precipitation levels are anticipated to rise significantly over the coming 80 years (EEA, 2019). In Denmark, which is one of the countries in center of Europe, it is predicted that the annual increase in precipitation lies between 1.6 - 6.9% in 2081-2100, compared to the referencial period of 1986-2005 (DMI & Klima-, Energi-, og Bygningsministeriet, 2014). Furthermore, the intensity and frequency of precipitation is expected to rise, resulting in additional and more powerful stormwater events (ibid.). To support these scientific claims, 2019 almost became a record-breaking year for Danish precipitation levels. Equal to 1999, it shares the doubtful honor of being the year with the highest measured level of precipitation in Danish history, with a total of 905,2 mm of rain (DR, 2019). Data and current measurements suggest that the same pattern is being followed in 2020, as February 2020 were the February month with the highest precipitation levels ever measured in Denmark (DMI, 2020). The pattern is clear. Higher levels of stormwater is, and will become, a large challenge for, especially cities to handle in the future.

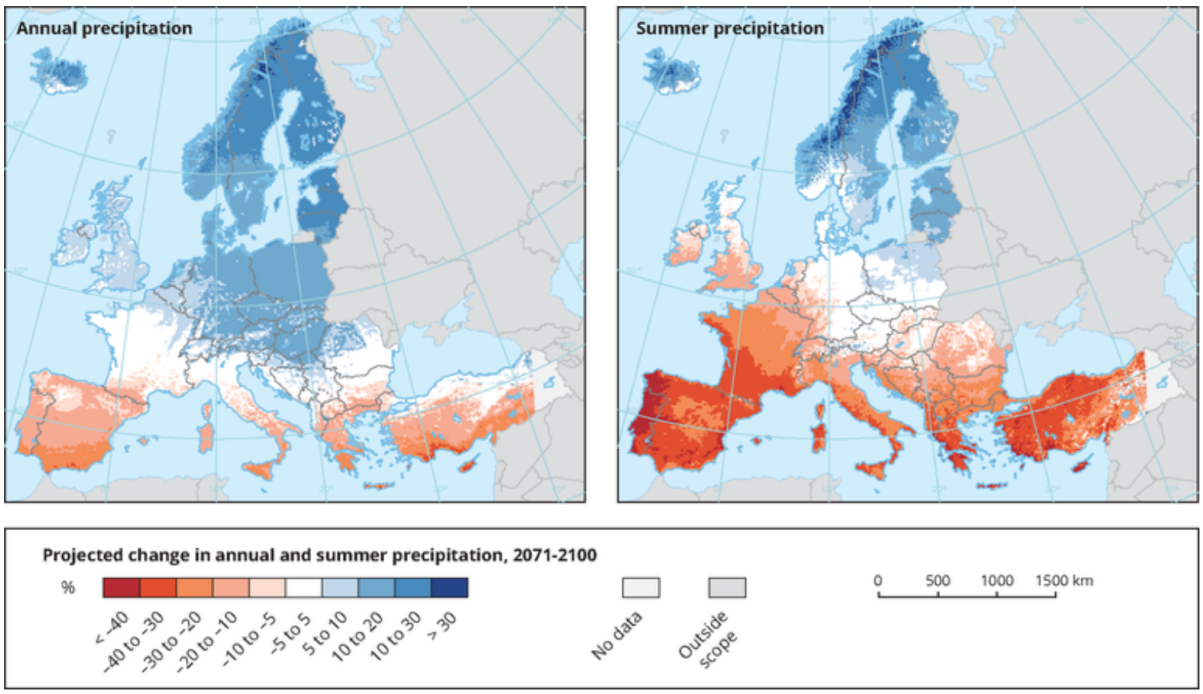


*Figure 1: The projected change in annual and summer precipitation between 2071-2100 (EEA, 2019)*

## 1.2. Water Retention Measures and the Ecosystem-Based Approach

As a result of the above-mentioned features of climate changes, action is needed in order to adapt to the future levels of stormwater (Fich, 2019). This is where water retention systems become highly relevant. Retention systems are able to withhold a certain amount of water, and in this way, handle some of the precipitation that falls in the city. Since the UN have projected that 68% of all humans will live in urban areas by 2050, retention measures and stormwater management in general have huge importance for i.e. urban planners and policymakers in the pursuit of sustainable urbanisation (UN, 2018).

The value of water retention measures can be expressed through the use of hydrographs. In all its simplicity, the yellow graph represents the total water flow of a system, which is significantly reduced through the use of water retention measures (the blue curve). Not only is the peak flow delayed through retention measures, but also the aggregated amount of water that is being channelled are being reduced through retention measures. This could for instance be a result of the evapotranspirational processes. The figure below (figure 2) can be of assistance in terms of illustrating the impacts of retention measures.

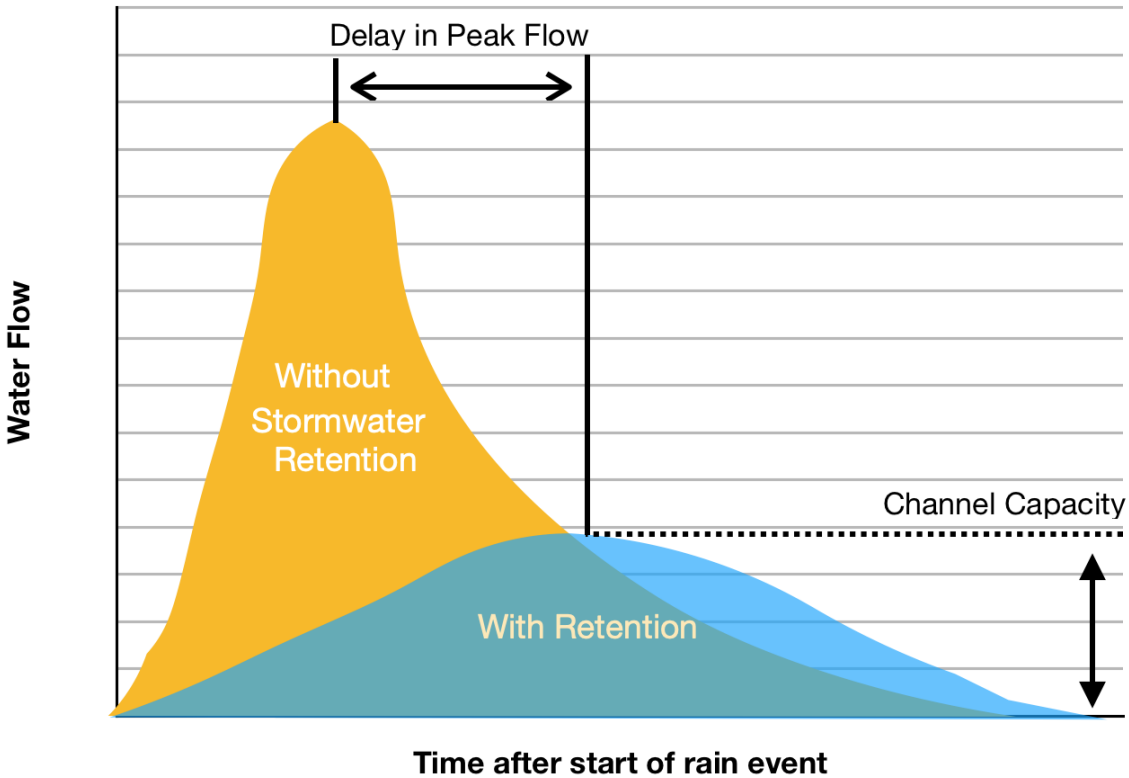


*Figure 2: Own illustration with inspiration from (Watkins, n.d)*

One technique that is able to secure a higher level of retention measures in the cities, are though the exploitation of ecosystem-based approaches. Researchers within the field of ecosystem-based approaches have formerly defined the concept as; "*the use of biodiversity and ecosystem services to help people adapt to the adverse effects of climate change*" (Zandersen et al., 2014; 19). This quote presents another relevant phrase; "Ecosystem services". In this thesis, the authors have used the same definition of the concept as Zandersen et al. (2014), which is that; "*Ecosystem Services are the benefits people obtain directly or indirectly from ecosystem functions such as protection from storm surges, air quality regulation, food, fibre and freshwater*" (Zandersen et al., 2014; 19). One example of an ecosystem-based approach which provides ecosystem services, is green roofs. Green roofs can be utilized as a climate adaptation technology, and has gained renewed advertence the past few years, in the light of the evident consequences of climate changes. A green roof can shortly be described as an "additional" roof layer on top of a conventional roof, which is covered with soil, plants and vegetation in order to minimize a variety of urban challenges. The multiple benefits of this technology within ecosystem-services will be further elaborated in chapter 3, which also entails a more detailed description of the most common types of green roofs.

## 1.3. Relevance for Sustainable Cities

In a sustainable cities perspective, water management systems in urban areas plays a significant role - especially for the cities that are highly impacted by climate changes, and increased precipitation levels. An issue in center of this problem, is that many cities have been caught up using conventional and non cost-effective climate adaptation techniques in order to deal with the increased amount of precipitation (Charlesworth and Booth, 2016). Huge underground pipes of concrete, or combined sewage systems that directs both the wastewater from households, industry etc. to the treatment plants along with the stormwater runoff, is no longer a sustainable water management method, as cities struggle to keep up with the large amounts of water (Charlesworth and Booth, 2016). These solutions do not, in any significant way, contribute to the compliance with the UN Sustainable Development Goals (SDGs), but green roofs might. Green roofs have the potential to, at least, comply with the four following SDGs;

- Industry, innovation and infrastructure (SDG no. 9)
- Sustainable Cities and Communities (SDG no. 11)

- Climate Action (SDG no. 13)
- Life on land (SDG no. 15)


*Figure 3: The 17 UN Sustainable development goals (Source: Lindberg, n.d.)*

A singular green roof installation does not necessarily have any significant impact in a climate adaptation perspective, but if they are implemented at a large scale, and in a systematic way, their potential rise, and by complying with, at least, four SDGs, green roofs can be considered a step in more sustainable direction.

There is a need to rethink the system in which stormwater is managed, and to be creative in terms of dealing with the future precipitation projections, which brings the story that many nations, especially in the Northern part of Europe, along with many other places in the world, will be hugely impacted by the consequences of climate change in terms of rising stormwater levels. Sustainable solutions for adapting this challenge is already existing, but there is a need to further utilize its benefits within all three levels of the sustainability triangle; the social, the economical and the environmental. As it will be argued throughout this thesis, green roofs bring all of these aspects into account, which makes them a relevant climate adaptation technology to consider both now and in the future. All of the above-mentioned perspectives ultimately led to the research question in center of this thesis, along with its associated sub-questions questions, which is:

- *How can an ecosystem-based approach enhance urban resilience through the implementation of green roofs, and which elements could be included in a framework that can be utilized to promote green roofs in cities?*
    - *What are the most significant barriers and drivers regarding the implementation of green roofs in different cities?*
    - *Which tools are being utilized when green roofs are implemented, both private and public, and which incentives do they encourage?*
    - *What is the role of cross-scale collaborations and networks, and how do these affect the expansion of green roofs?*
    - *How can a framework based on best practice solutions contribute to enhance urban resilience through the utilization of green roofs?*

# 2. Scope of the Project

The scope of this thesis has, from the very beginning, included green roofs as a specific focal point. What has followed, however, is the more specific focuses that has been chosen throughout the work with the thesis, and the boundaries that has been chosen for the work. The scope has primarily focused on a Northern European context, with countries in i.e. Scandinavia and Germany being examined in terms of their capabilities for implementing green roofs, amongst other things. The reasoning behind the choice to examine countries in Northern Europe is found in the many similarities between the societal structure in each of the countries, their access to research and technology, and the similarities in climate. Especially the climate of the chosen cities has been a determining factor, as it was thought necessary to examine how each of the cities utilized and implemented green roofs differently, despite having nearly similar challenges to deal with. Northern Europe is a geographical location which is subject to increasing amounts of precipitation, but in recent years, also longer periods of drought and higher temperatures. Green roofs have the potential to be a contributing factor in finding solutions to these issues, and by being able to compare different approaches from similar countries and cities, major findings are surely to be discovered.

To maintain focus on the choice of green roofs as a specific solution to climate adaptation, green roofs carry a large range of interesting and unique features which has influenced the choice of topic for this thesis. There are many documented benefits that can be gained from green roofs, many pertaining to stormwater management, reduction of various damaging externalities such as Urban Heat Island (UHI) effects, and the contribution to a better environment in cities due to biodiversity and health benefits derived from bringing green into the cities. Along with the possible benefits, green roofs are interesting as they can be constructed on previously unused areas atop building roofs. Many of the benefits also contribute to urban resilience, which is important for cities to withstand and work with the challenges of the future. There are huge potentials for expansion on roofs, as these areas are mostly unused, and by not utilizing them, it can be considered a missed opportunity to add value to areas that would otherwise be considered more redundant. As a final remark, there is also an interest in bringing green infrastructure into the cities, which green roofs also contribute to, and is part of. By bringing nature into the cities, there are multiple benefits to the human health, both physically and mentally, and there is also the fact that people likes

vegetation, and by utilizing this, cities can attract potential new residents. Based on all of the above, the authors of this thesis chose the focus of this thesis, which is how green roofs can enhance urban resilience through the many benefits and values gained from green roofs, and how these can be utilized to a larger extend.

# 3. What Defines a Green Roof?

Green roofs are able to provide a wide range of ecosystem-services. A conventional roof with no vegetation is not enhancing the quality of nature and life in the cities, and with the huge quantity of building mass in the cities, the potential benefits of establishing green roofs could be quite significant. This paragraph will focus on the definition as well as potential benefits and disadvantages of establishing green roofs in the cities and will also include a detailed description of how green roofs are structured. The understanding of the composition of green roofs have, in addition, been used to strengthen the authors dialogue with respondents at a later point of this thesis. The subsequent paragraph will present the differences between the three most common types of green roofs.

## 3.1. The Structure of a Green Roof

A green roof is a multi-layered structure which has several functions. In order for the roof construction to be able to carry the green roof, multiple layers, as illustrated below (in figure 4), serves a purpose that ultimately allows the green roof to be implemented.


*Figure 4: The structure of a green roof (Zandersen et al. 2014; 22)*

At the bottom of the green roof, is the **structural support.** The structural support is the top of the conventional roof and is where the green roof is being installed on top of.
Above this layer is a protective **roofing membrane**-layer which ensures that the structural support is not taking any damage from the green roof installation.
On top of this layer is the **membrane protection and root barrier**-layer which serves the purpose to prevent roots from the roofs' plant layer from penetrating the roof and cause any damage to the structural support of the roof. Both membrane layers are implemented to protect the building from any natural damage.
The next layer is an **insulation** layer, which allows the building to heat and cool in a healthier manner.
**The drainage, aeration, water storage and root barrier** layer, which is then laid, aims to store the stormwater so that the plants from the green roof can slowly absorb the water, stored in the reservoir. In addition, the drainage layer helps to counteract that i.e. the sedum coating is overwatered and drowning, but also protects the drainage reservoirs as it prevents eroded soil and sand from the green roof from filling them.
On top of the drainage, aeration, water storage and root barrier layer are the **growing medium**. This is where the plant seeds are planted, and when they grow, they enter the **vegetation layer**, which is the only visible layer on the roof. The thickness and weight of the growth layer are relying on the composition of vegetation that are planted, as well as the type of green roof (Zandersen et al, 2014; Miljøpunkt Østerbro, 2014; Thorvil et al, 2015).

## 3.2. Most Common Types of Green Roofs

This paragraph will present the three most commonly known types of green roofs. This includes a description of the extensive, semi-intensive and the intensive type of green roofs. Though the three roof types are fundamentally similar, different attributes and requirements are important to consider when a green roof is established. The different roof-types are finally summarized in a table which presents the key elements of each roof-type.

### 3.2.1. The Extensive Green Roof

The extensive green roof is the cheapest, and most commonly used type of green roof. It has a thin growth layer between 60-200 mm. As a result, it is not possible to grow any larger plants on the roof. The most commonly used vegetations are sedum plants, mosses, herbs, onion plants and different types of grass (Thorvil et al, 2015). Human access to extensive roofs are very rare, as they are often installed on top of roofs with a low bearing capacity

such as car and bicycle sheds or similar roofs, however, it is possible to install extensive green roofs with access for humans (Zandersen et al, 2014). The care level of an extensive green roof is, due to its composition and vegetation, minimal. The water need of the plants can often be met through natural precipitation cycles, and the roots of the plants do not stick as deep as it is the case with other types of green roofs, which results in potentially less damage on the building structure (Thorvil et al, 2015).

### 3.2.2. The Semi-intensive Green Roof

The semi-intensive green roof is a bit more expensive to implement, as the requirements needed to install such type of green roof is more extensive than a extensive green roof. A semi-intensive green roof is characterized as a roof with a growth layer somewhere between 120-250 mm. The nature of this thicker vegetation layer means that more options in terms of vegetation are able to be planted on this specific type of roof. Typical roof-specific plants for this kind of green roof entails: *small shrubs, perennials and different types of ground cover plants* (Thorvil et al, 2015). As these plants are larger than the ones typical for an extensive type of roof, they also have the potential to absorb larger quantities of water, and in this regard, serve as a more efficient retention measure. Finally, it is more common that human access to these roof-types are included in the implementation, but of course the carrying capacity of the roof has to be able to withstand the excessive weight of human interaction (ibid.).

### 3.2.3. The Intensive Green Roof

An intensive type of roof is installed with the thickest layer of growth, compared to the extensive and semi-intensive green roof. As a result, intensive green roofs are capable of reaching high weights of up to 1200 kg. per. sq. meter, in a water-saturated state (Thorvil et al, 2015). If the roof should be able to carry any additional weight in terms of human interaction on top of the roof, it requires a really high carrying capacity for the construction beneath the green roof (Ibid.). The intensive type of roof is furthermore able to accommodate the largest types of plants, and even trees, with the most common types vegetation being: *Lawn, perennial plants, shrubs and trees* (Københavns Kommune, 2013). Found below is a schematic summary/overview of the different specifications that each type of green roof entails.

| Type of green roofs | Extensive | Semi-intensive | Intensive |
|---|---|---|---|
| **Use** | Environmental landscape | Gardens / Environmental landscape | Gardens / Parks |
| **Type of vegetation** | Mosses, herbs, grass | Grass, herbs, shrubs | Lawn, perennial plants, shrubs, trees |
| **Watering** | None | Periodically | Regularly |
| **Depth of substrate** | 60-200 mm | 120-250 mm | 150-400 mm |
| **Weight** | 60-150 kg/$m^2$ | 120-200 kg/$m^2$ | 180-500 kg/$m^2$ |
| **Costs** | Low | Middle | High |
| **Access/Stay** | Rarely | Often | Yes |

Table 1: Own illustration with inspiration from (Københavns Kommune, 2013; Thorvil et al, 2015).

## 3.3. Main Benefits and Disadvantages of Green Roofs

In this section, the different benefits and disadvantages of green roofs which has been mentioned in the literature, is listed in a table, with the intent of clarifying and making a more explanatory overview of both the pros and cons of this type of technology. Following the table, a list of some of the different benefits and disadvantages will be described, which will lead to a selection and explanation of four of the most prevalent benefits mentioned in the literature. Subsequently, an explanation is given on these four prevalent benefits, a state-of-the-art examination of some chosen literature will serve as examples of how other researchers has approached working with uncovering and examining these benefits, and what their results were. The reasoning for this is found in a desire from the authors point-of-view, to be as transparent as possible, and to give some insight into some of the benefits and challenges that has a significant role in this thesis, and how other researchers have chosen to work with these.

### 3.3.1. Benefits and Disadvantages:

Below is the aforementioned table covering the different possible benefits and disadvantages which can be gained and derived from green roofs. These benefits and disadvantages have been uncovered through the literature which has been read and examined, counting both physical books, academic journals and texts, and internet sources from authorities and organisations working with green roofs. Some of these benefits, as will be elaborated even further, are more prevalent than others. As with the benefits, the disadvantages also have their own often mentioned core disadvantages, some being the main barriers for green roof implementation in general. Some of the disadvantages are not as prevalent in some countries as they are in others, which can be attributed to how i.e. legislation is formulated.

| Benefits | Disadvantages |
|---|---|
| ● Urban Heat Island-effect (reduced)<br>● Stormwater Pollution (reduced)<br>● Insulation capability (Improved) - Decrease in energy consumption<br>● Stormwater retention and evaporation<br>● Social benefits (mental health improved)<br>● Biodiversity (Increased)<br>● Urban farming and local (organic) crop production<br>● Risk of flooding (reduced)<br>● Increased real estate value<br>● Evaporative cooling<br>● Filter CO2 and air pollutants<br>● Increase roof's lifespan | ● Installation costs<br>● Maintenance<br>● Making repairs under the soil and plants is difficult and expensive<br>● The majority cannot tolerate foot traffic<br>● Lack of common standards<br>● Doubts regarding fire hazards<br>● Structural Issues<br>● Leakage and damage to waterproofing<br>● Lack of expertise<br>● Lack of policy |

| | |
|---|---|
| • Habitat for plants, insects, and animals in an urban setting | |

(Table 2; Listing of benefits and disadvantages. Authors own creation)

As illustrated in table 2, there are more benefits than disadvantages gained from green roofs, although some of the benefits are related to one another. Disadvantages and the benefits can be context dependent, and some are not relevant in new urban developments, but more so in existing building masses, such as the structural issues. In the next subsection, the most prevalent benefits mentioned in the literature will be listed, and an elaboration on what these benefits entail and why they are important will be given.

### 3.3.2. Prevalent Benefits Mentioned in the Literature:

The benefits listed below are the ones that are mentioned more often than other benefits in the literature, which, in the eyes of the authors, must indicate that they are some of the more important ones. With the presentation of each individual benefit follows a reference to a certain text which elaborates the specific benefit. Some of these texts are also the ones that will be delved into and examined further in the state-of-the-art section, regarding how the benefits are examined in other research.

**Reduction of Urban Heat Island (UHI)-effect** is one of the most prevalent benefits mentioned in the literature. One of the texts mentioning the reduction of the UHI-effect and how green roofs are perceived as being a great tool to reduce this, is *Klein, Juhola and Landauer (2016)*. Other texts do, however, also mention the reduction of the UHI-effect, such as *"Green Roofs Copenhagen"* written by Københavns Kommune (2013).

**What is the UHI-effect:**
The UHI-effect is impacting urban areas in a way that temperatures are climbing to a significantly higher level, due to the absence of the albedo effect and cooling mechanisms in many urban spaces. The cause of this is the fact that many surfaces in the urban landscape are black and therefore absorbs and keep heat within the city, resulting in a variation of temperature on 4-5 degrees celsius, compared to rural areas (Veron, 2019). The use of manmade materials is a contributing factor to the UHI, which, as a side effect, contributes to

increased energy consumption (due to cooling of homes and businesses), which in itself is also a contributing factor to the UHI. The UHI has tremendous consequences for human health and well-being and the reduction of this effect is therefore seen as highly important. One approach for dealing with the reduction of the UHI is utilization of green spaces, city trees and green roofs (Mohajerani, Bakaric and Jeffrey-Bailey, 2017).

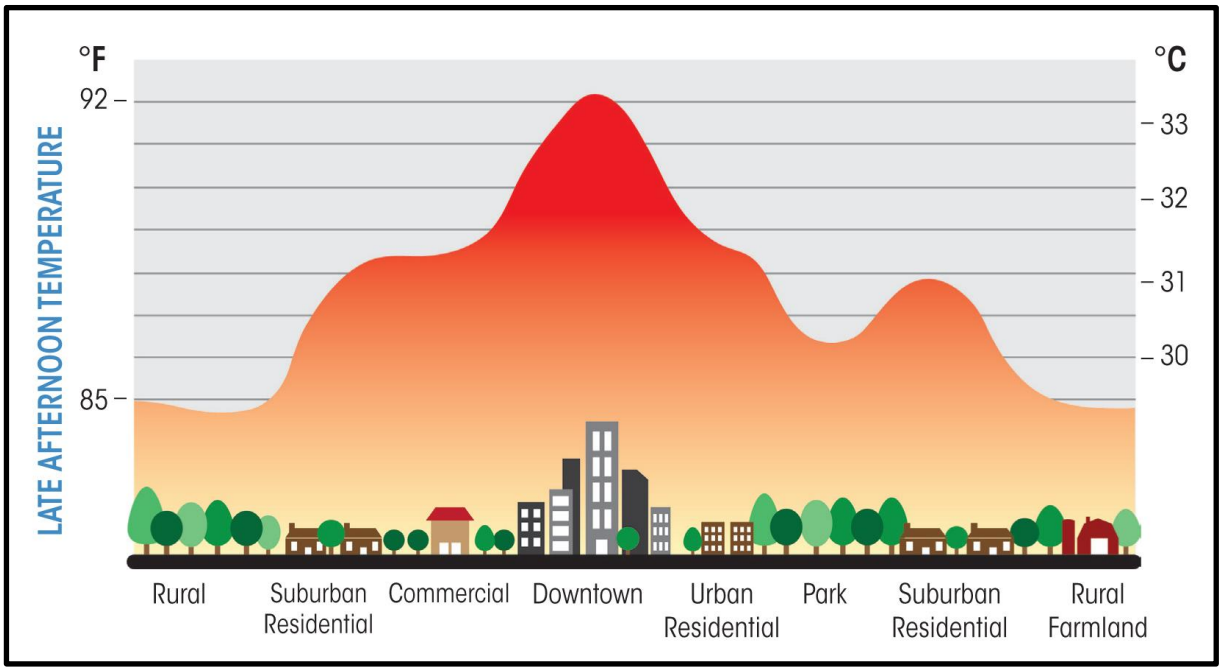


*Figure 5: Illustration of the UHI-effect and temperature variations (Veron, 2019).*

**Insulation capacity increase (and reduced energy consumption)** is, just as the UHI-effect, mentioned in many different texts as being a clear benefit gained from green roofs. Some of the texts mentioning this benefit are *Zhao & Srebric (2012)*, *Sailor, Elley and Gibson (2011)* and *Københavns Kommune (2010)* and their text *"Notat om grønne tage"*.

**Reduction of energy consumption through increased insulation capacity:**
Increasing the insulation capacity of buildings, through the implementation of green roofs, is a benefit that is mentioned in several texts. This insulating effect is active both during the summer months, where green roofs helps to cool buildings, and during the winter months, where the roofs contribute to keeping the heat inside the buildings. By increasing the insulation capacity of buildings, reduction in energy consumption is achieved, as the increased insulation layer results in less heating and cooling being used. During the hot summer months, air conditioners are generating cool air to keep a pleasant temperature inside the buildings, whereas heaters are operating in order to heat up buildings in the

winter. This can be associated to a reduction in the UHI-effect as less energy consumption due to the utilization of green roofs will contribute to a cooler city.

**Stormwater retention and evaporation** is mentioned as one of the, if not the most important benefit gained from green roofs, especially in Northern Europe. Texts that mention this benefit is, among others, *Ercolani et al. (2018)*, and *Københavns Kommune (2013)*.

**The importance of retaining stormwater and the role of evaporation:**
As have already been mentioned in the introduction to this thesis and the problem area, the yearly amount of precipitation is expected to rise significantly in the coming years and further into the future. This will, if nothing is done, result in cities experiences floods more regularly, which can result in water damages on properties and belongings for several million euros (Københavns Kommune, 2012). Many European cities are quite old, and even if the sewage systems are regularly being renovated, it will be under heavy stress under extreme weather events with huge amounts of stormwater. More people move to the city which put stress on the sewage systems daily, but when a stormwater event happens, then this will be even further stressed. By installing and implementing green roofs, a certain amount of the stormwater is retained on the roofs of the buildings, where it is either slowed, which allows the sewage system to keep functioning as normal, or it is kept up on the roofs, where it eventually evaporates or is retained. This evaporation is likewise a benefit, which, as the aforementioned benefits, contribute to cooling of the city and less dry air.

**Social benefits (mental & physical health improved)** is a benefit that is mentioned in the literature but is perhaps a less commonly known benefit with stakeholders. It is, however, mentioned in literature such as *Greater London Authority (2008)* and *Københavns Kommune (2013)*.

**Improved health and well-being is important for happy citizens:**
Living in urban areas carry some disadvantages to a person's overall health, as there are several risk factors tied with urban life. Some of the more commonly known risks are air pollution, which is a severe problem in urban areas, due to heavy traffic and densely populated areas. Other risks include noise pollution, again this is connected to heavy traffic, construction work and in some areas, an active nightlife, and as mentioned in the first part of this subsection, the UHI-effect has a negative influence on health and well-being of citizens as well, with risks such as cancer or stress related diseases being increased (Rosenbak and

Jørgensen, 2009). Implementing green urban spaces, planting city trees and, of course, green roofs, all has the ability to contribute to both the physical and mental health and well-being of citizens, in a positive way. Green spaces and trees can store carbon, and “exhale” oxygen, which will contribute to cleaner air in cities and less air pollution. Likewise, green roofs in particular have a potential noise reducing capacity, which will have an effect on noise pollution. Other than having effects on different kinds of pollution, green urban spaces also contribute to overall better mental well-being, as people naturally like green areas, as these offers both recreational and relaxation purposes. Green spaces have the potential to attract more people to cities, which could contribute to some economic benefits, that could be invested in even more green urban areas and green roofs.

In the next paragraph, the state-of-the-art, and the texts chosen for this, will be examined. This is done with the intent of focusing on the documented advantages of green roofs, and how other researchers approach areas regarding the benefits gained from green roofs. The state-of-the art will examine some of the texts mentioning the four most prevalent benefits and contextualize these, which will serve as part of the examination of how green roof benefits are examined in academic literature. This paragraph is closely connected with the paragraph above.

# 4. State-of-the-Art

## 4.1. State-of-the-Art on the Benefits Gained from Green Roofs:

In this paragraph, four different texts focusing on certain benefits gained from green roofs will be summarized with the intent of, as have been described earlier on, illustrating how other researchers and the literature are working with the known benefits of green roofs. This will likewise serve as an illustration of how these benefits are put into different contexts, that count both geographical differences, political collaboration efforts and differences in climate change consequences. These texts are likewise some of the texts that mention some of the four most prevalent benefits as described above.

**In Zhao & Srebric (2012)**, an examination and assessment of how green roofs perform under winter conditions is undertaken. Zhao & Srebric argue that examinations with this particular focus are lacking, and is more or less neglected in academic literature, except for a small amount of examinations. These have, however, had their own shortcomings, more specifically that they do not regard snow as an influencing factor on heat transfer and insulation. The reason for including this text as a state-of-the-art text is that this project is concerned with cities, primarily located in the northern hemisphere (Berlin, Copenhagen, Stockholm, Rotterdam etc.). These cities experience cold, and sometimes snowy, weather which makes it important to consider the performance of green roofs under these conditions, when talking about benefits, barriers and the like. Before going into depth with their research, Zhao & Srebric gives a definition of what a green roof is, the elements it consists of and some of its functions. They define a green roof as; "*Green roofs (or ecoroofs), a sustainable technology used in green buildings, are special roofing systems that include layers of vegetation and growing media.*" (Zhao & Srebric, 2012; 1). It is claimed by Zhao & Srebric that green roofs are becoming more popular in sustainable building design, due to their potential benefits. The green roof industry grew at a rate of about 50% from the year 2001 to 2004, which is quite substantial. A possible reason for this growth might be the aforementioned potential benefits of green roofs. The roofs have the possibility to contribute to energy savings, environmental benefits and to comply with current and future building code requirements. Specific benefits include thermal protection, which may reduce the thermal load and in turn the energy demand of buildings, reduced stormwater runoff which is beneficial for water infrastructure in cities during storms, and green roofs can extend the lifetime of roofing membranes that reduce the costs of roof maintenance. These are some of

the more obvious benefits, but other benefits include added aesthetic appeal, improved microclimate, a reduction in greenhouse gas (GHG) emissions and a reduction of the UHI-effect in cities. After this walkthrough of the contractual composition of green roofs, and the possible benefits of these, Zhao & Srebric delve into their assessment of green roofs under winter conditions and the results of their findings. They describe the parameters for their examinations, where they have six test buildings, two of which had green roofs, one had only till the soil layer of a green roof, meaning no vegetation, two were reference roofs, meaning that they had no green roof elements, and one building contained the measuring equipment. Their examination contained two winter scenarios on which their assessment was based. Scenario one was a winter scenario with no snow, whereas scenario two was a winter scenario with snow. The results discussed in the text are regarding the energy loss during heating season. In the two scenarios, the soil roof and the reference roof vary in which type that performs the worst, with the soil roof performing better than the reference roof during snow, but worse when there is no snow. The green roof, however, performs the best in both scenarios, indicating that there are clear energy saving benefits to be found in having a green roof. It is stated by Zhao & Srebric that energy savings can amount to as much as 22,9% during winter when there is no snow, but these savings are reduced to “only” about 5-6% when there is snow involved. It is, however, a saving, nonetheless. From their research Zhao & Srebric concludes that there are benefits in having a green roof regarding energy savings, and that these benefits are not negated during the winter period as the green roof help preserve heat and thereby saving energy.

**Klein, Juhola & Landauer (2016)** carries out an analysis of how local authorities and private stakeholders are engaged in climate change adaptation. In their article they utilize the cities of Copenhagen and Helsinki as case cities, where they have established contact, and conducted interviews with multiple people affiliated with city planning. This text is not specifically about green roofs per se, but rather about how the local authorities along with the private stakeholders can be engaged in the climate change adaptation and which tools the state authorities can utilize in this regard. It is stated in the article that the local level and urban context, in regard to planning, have been recognised as being highly important when it comes to climate change adaptation. Likewise, policy documents have begun to highlight a need for private action in regard to mitigation. This is due to arguments claiming that the climate change has the possibility to overstrain the public capacity for adaptation, which makes it necessary for the involvement and inclusion of the private sector and citizens as well. In the article it is pointed out that “*Climate change adaptation is first and foremost locally based - at the municipal authorities, companies or individuals*.” (Klein, Juhola &

Landauer, 2016: 1056), but several studies have, however, so far indicated that the local adaptation is mostly dominated by the public sector in Europe. There is a lack of knowledge regarding how local authorities should foster involvement of private actors. Klein, Juhola & Landauer (2016) goes on to describe how shifting responsibilities to private stakeholders can be advantageous, especially if the private sector is to share in the risk, efficiency and flexibility in adaptation. However, the sharing of responsibilities also means that there will be an increase in participation and deliberation between stakeholders from the public and private sector. These responsibilities are, depending on which policy instrument authorities choose, mandated either by law (top-down), delegated by public authorities or self-initiated. The authors of the article go on to explain that soft policy instruments can encourage partnerships and participatory approaches by involving private actors (i.e. citizens or companies), which allow these stakeholders to have influence on the goals and to distribute responsibility. The opposite can be said for the harder or more top-down influenced instruments, in which the authorities define the goals and determine and allocate responsibility between stakeholders (public and private). The reason for this can be found in the author's distinction of adaptation measures as a public or private good, and that the authors claim that an interplay of the policy instruments and distribution of responsibilities, along with the public or private benefits can appeal to private stakeholders in different ways. This can in turn affect their capacity to adapt. As much of adaptation is regarding the flow and steering of processes, governance plays a role in how power and responsibilities are allocated, and different types of governance steering have different outcomes. A strong top-down steering with legally binding regulations as the chosen policy instrument mean that municipalities assign the responsibilities to the different stakeholders. If a bottom-up, participatory instrument is chosen, it opens for possibilities for citizens to engage more and influence adaptation planning, and who and where responsibility lies.

The analysis done by Klein, Juhola and Landauer (2016) have two main areas of focus, namely adaptation to increased precipitation and intense rainfall and adaptation to intensification of UHI-effects. In the article it is claimed that stormwater management has the highest priority amongst adaptation measures, in Copenhagen. There are two plans at the moment, where Sustainable Drainage Systems (SuDS) are perceived as the best fitting approach so far, where water is handled on the surface, so that it is not necessary to retrofit the older sewage systems. It is pointed out, however, that the SuDS and what is called the "Plan B" solutions, clashed with existing legislation and existing legal frameworks. To make these solutions possible, the authorities have had to make changes to the legislation, along with a change in how responsibilities are distributed between municipalities, Greater

Copenhagen Utility (HOFOR) and private actors. These changes have primarily municipal self-governing characteristics, which seems to indicate that this is how the authorities wants to handle adaptation measures. It is likewise pointed out that the owners of private properties, be it companies or citizens, have responsibility to implement and finance "adequate" protection against rising water levels, to 10 cm above ground level. This can, however, have some negative implications as the protection of one property can increase risk of flooding for another. Regarding the UHI-effects, it is pointed out in Klein, Juhola and Landauer (2016) that urban planning, i.e municipal self-governing, is the most important instrument in handling UHI-effects (e.g. by the contribution that green roofs can give if implemented on private properties). There are however also elements of governing by regulation as there are legal requirements, i.e. for the requirements of green roofs. In conclusion, Klein, Juhola and Landauer (2016) claims that local authorities are major players in both of the examined case cities of Copenhagen and Helsinki, with both cities making use of regulative instruments that shift the responsibilities towards the private sector. It is pointed out that with certain adaptation measures, a variety of policy instruments and the allocation of responsibilities, the municipalities can only create the framework for private stakeholders to take adaptation actions.

The text, "***Green roofs Copenhagen***", written by Københavns Kommune (2013), revolves around the benefits of green roofs, their material composition, and multiple examinations of project cases and local plans where green roofs have been implemented. They are examining the different policy approaches found in other cities around the world. According to Københavns Kommune (2013), green roofs can provide cities and citizens with a unique solution to sustainable climate adaptation, that have multiple benefits. It is pointed out that some of these benefits are; increased biodiversity, larger amounts of absorbed rainwater in sustainable ways, and a decrease in urban temperatures at the same time. As for absorption of stormwater, some of it evaporates, but green roofs have the potential to absorb between 50%-80% of the annual precipitation. If there is heavy precipitation the roofs function as a delay mechanism, which means that the water that will end up in the sewage system is led there gradually, so that capacity is not exceeded. The UHI-effect is lessened by the fact that the black, heat absorbing surface areas of normal roofs are replaced by green roofs which reduce temperatures with a couple of degrees. It also has the added benefits of improving indoor environment during the summer as the indoor temperature is affected as well. Københavns Kommune (2013) have, in their text, established a step by step guide on criteria for successful implementation for green roofs, which can be seen on Figure 6.

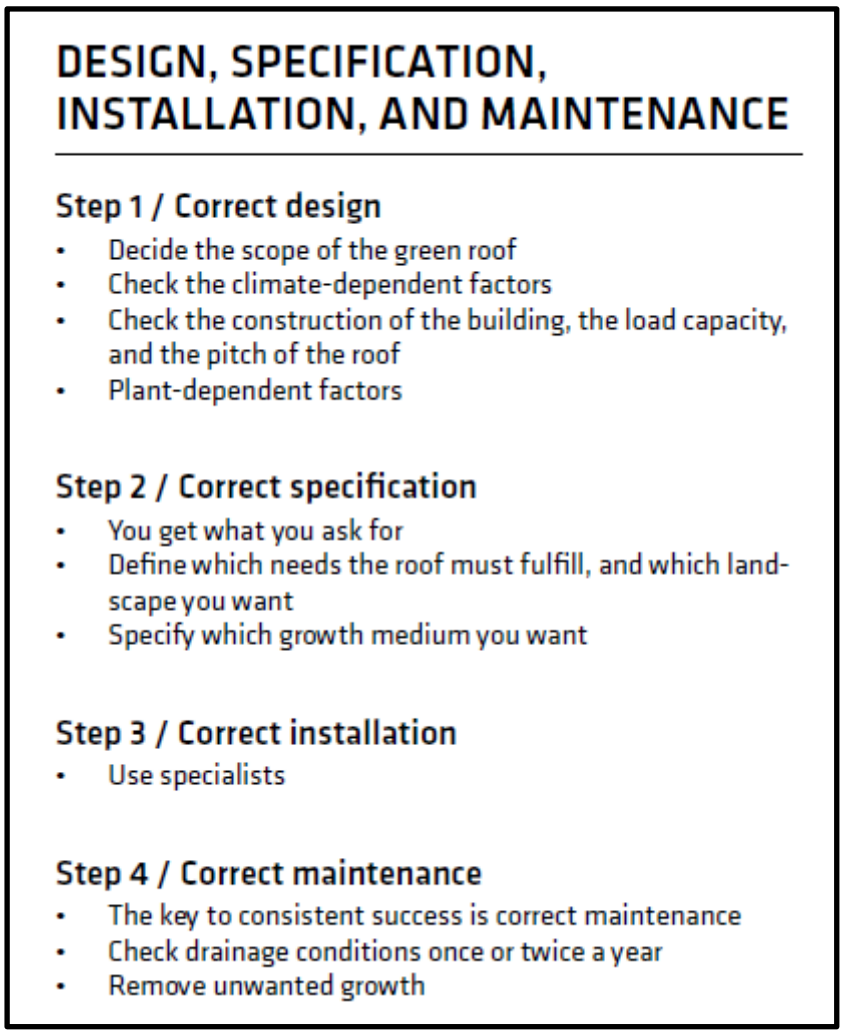


*Figure 6: The four design steps for successful green roof implementation (Københavns Kommune, 2013; 8)*

In 2009, when Copenhagen hosted COP15, green roofs met intensified focus, and since then green roofs have become an integrated part in different guidelines for sustainable construction works, with green roofs being mandated on all municipal buildings in Copenhagen. Since 2010, green roofs have been mandated in most new local plans, and estimations and calculations based on the approved plans with mandatory green roofs opens up for more than 200.000 m² of roof area with green roofs to be installed. In Copenhagen, there are more than 40 green roofs, and in the text "*Green Roofs Copenhagen*", 13 cases are examined with different types of green roofs, placed on residential, commercial and public buildings, with descriptions of which type of roof being used, how large an area it covers etc. A common denominator for most of the roofs is that it is Copenhagen Municipality that is the planning authority. The next part of the text focuses on the implemented plans at Kalvebod Brygge West, which is a commercial area where

focus is on stormwater being absorbed, collected or reused, with holding tanks put in place to contain or delay the water.

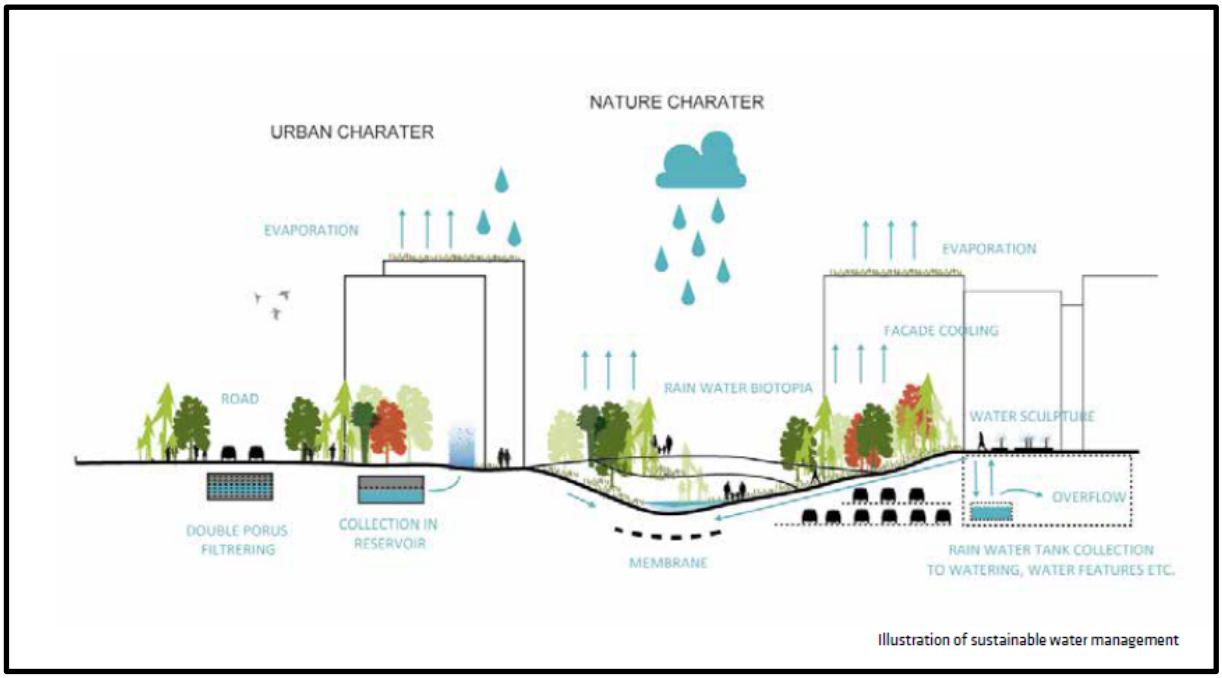


*Figure 7 - An illustration of sustainable water management (Københavns Kommune, 2013; 35).*

Figure 7 shows how the sustainable water management at Kalvebod Brygge West functions theoretically. This place is, however, not the only place where green roofs are implemented, as four new “cutting edge” local plans are in the works for different areas of Copenhagen. These areas are, Carlsberg, Århusgadekvarteret, Skelbækgade and Grønttorvsområdet. What these areas have in common is that water is meant to be absorbed, collected and utilized in many different ways, benefitting the citizens and private actors in the areas. Some of the areas will utilize the collected water for recreational purposes and some will reuse the water in the buildings in some way or another. This indicates that there are policies in place to secure future implementation of green roofs in Copenhagen. The text does, however, go a step further and describes the situation in other different countries such as Australia, Canada, China, England, Germany, Singapore, Switzerland and the US. In these countries there are some legislative, policy instruments in place to implement green roofs in some capacity or other. For the relevancy of this thesis, only England and Germany's descriptions will be examined. In England, it is primarily in London that there are requirements for green roofs, and where it is technically possible, Cold Roofs, in new buildings in London’s Central Activity zone. This zone consists of the City of London, Westminster, Camden, Islington, Hackney, Tower Hamlets, Southwark, Lambeth and Kensington and Chelsea. An ambition of

100.000 m² new green roofs in 2012 were proposed. In Germany some 48 cities are providing financial support for green roofs, and approximately 35% of all cities have integrated green roofs into building regulations. In Germany, at the time of the text being published, around 86 million m² of green roof have been established, which amounts to around 14% of the total roof area in Germany. There has been clear opportunity to set requirements for green roofs since 1998, and these have been widely used. Noteworthy cities are Düsseldorf, Berlin, Stuttgart and Munich, with especially Stuttgart being a frontrunner in terms of green roof implementation. In Stuttgart more than two million m² of green roof has been implemented. It started in 1986 with financial support for green roofs, and all new roofs that has a slope below 12 degrees is required to have a green roof. There are financial incentives in the fact that 50% of the cost is covered, up to a maximum of 17,9 euro/m². Another interesting perspective is that of Berlin, where they use biofactor and indirect taxes, as regulation tools to promote green roofs.

# 5. Methodology

In this paragraph the different methodological considerations that the authors have made, will be described. In this paragraph, the research design of the thesis, along with the theoretical perspective and methods approach will follow, with an elaboration on how the methods was applied in the end of this paragraph.

## 5.1. Research Design

In the following section, the research design of this thesis will be explained and described in order to create some insight and transparency regarding how each part of the thesis contributes to answer the research question posed by the authors. Both the connection between the theory and methods will be examined, as well as how the data from each of these can contribute in answering the research question.

In this thesis, the authors would like to examine how cities can enhance urban resilience through the utilization of an ecosystem-based approach, where green roofs are implemented as the solution to deal with a multitude of challenges pertaining to climate change. Likewise, through this examination, the authors would also like to examine how a framework consisting of best practice approaches to implementation of green roofs, can contribute to the enhancement of urban resilience. The authors wish to then propose a framework as the “product” of this thesis, based on the entire research process and collected data. The desire to examine these issues is to be found in an interest to explore how cities deal with climate change challenges and how to adapt to a changing world. Cities experience the consequences of climate changes, more so than countries as a whole, as the consequences affect the residents of cities and have potential high costs for them. It is thereby important to examine which solutions that are available for cities to utilize in order to deal with the consequences of climate change. One of the ways to deal with these issues, is to enhance the urban resilience of cities, as this helps them to withstand the external threats posed to them.

How the authors would like to examine the issues is by utilizing a combination of theory and applied methods that both create an approach to examine topics, through the theory. To actually conduct the examination, the specific tools in the methods, are utilized. The theory chosen in this thesis is a governance theory, more specifically ‘Polycentric Governance’. The different parts of the theory will be described in the next section regarding theoretical

considerations and the specific concepts of the theory. However, in its core essence, a Polycentric Governance perspective allows the conductor of a research to view multiple different cross-scale actors. As they are each their own decision-making center it can enable unique constellations of collaborations that enhance the success of implementation of i.e. a technology or legislation. In addition, the theoretical application is capable of potentially reducing the risk of failure through sharing of knowledge and experiences, and to create a system of redundancy which enables multiple actors to fulfill the same role in the system. All of this will be described in detail in the next section. When the theoretical perspective has been established, it allows for the researcher to choose a set of data collection methods. These methods can then be utilized to gather data that can be analyzed through the theoretical perspective in order to being able to give an answer to the research question. In this thesis, a qualitative approach has been chosen, as the methods belonging to this approach allows researchers to delve deeper into the meanings and background of certain statements, which allows the researchers to gain a unique insight into something that cannot be quantified. The authors utilize qualitative methods in order to examine the specific tools and approaches utilized by different actors in the cities, and to see how they might fit into a Polycentric Governance system. Climate adaptation is context specific, and as a result, the context must be understood and examined by asking specific questions. Due to this, the qualitative approach was deemed fitting.

At the very beginning of this thesis, the authors were aware of the fact that green roofs were a part of some city's climate adaptation strategies, and also of the existence of green roof solutions. On the background of this knowledge, the authors wondered why this solution have not been utilized further as a climate adaptation technology, which justifies the choice of an abductive research approach. In addition, the authors have chosen an iterative approach to data processing. The iterative approach has allowed for continuous adjustment of approaches in order to improve the way data is gathered. This too allowed the authors to exploit the abductive approach, as single cities have been examined, but if the examination proved to be missing some aspects, or that something needed to be changed, the iterative working method allowed for that to be done. The abductive approach was used to examine specific cities and whether they had some best practice examples, which could then be put into a generalized framework that was not context specific to any specific city. It was through this approach that the theory of Polycentric Governance seemed to be fitting, as preliminary research suggested that not one single actor was behind the implementation of green roofs.

In the next section, the description of the theory of Polycentric Governance is given, along with a view of the different core concepts utilized from this theory and how the theory fits into the context of this thesis area of examination.

# 5.2. Theoretical Perspective

## 5.2.1. Introduction to Polycentric Governance:

In this thesis, a lot of work has gone into the choice of the theoretical standpoint, through which the empirical data will be analyzed. After thorough considerations and a lot of research, the authors made the choice of using the theoretical notions of Governance theory. More specifically, the notion of Polycentric Governance, as described in Feldman (2016), Carlisle and Gruby (2019) with additional knowledge from Tarko (2015) and Simonsen et al. (n.d.). In the following section the theoretical concepts will be examined, explained and put into context, regarding the topic of this thesis, with the intent of utilizing these specific concepts later on in the analysis section.

## 5.2.2. Key Concepts in Polycentric Governance:

In this subsection, a description of the different key concepts found in Polycentric Governance, which are relevant for the expansion of Green Roof technologies, will be given. This is done with the intent of giving the reader an overview and an understanding of the different concepts which are relevant in the context of this thesis, and which will be included in the analysis of the empirical data of the thesis. It should be noted that, the following concepts, are not listed in any prioritized order, other than the concept of *Polycentricity*, which is quite essential for the entire theory, which will be listed as the first concept.

***Polycentricity*** as a concept is widely accepted and defined as; "[...] *a social system of many decision centers having limited and autonomous prerogatives and operating under an overarching set of rules*" (Tarko, 2015; 1). In addition to this, it is also widely accepted that the decision-making centers are most likely in close proximity to one another, with the different jurisdictions being able to work in close collaboration with each other (Carlisle and Gruby, 2017). To further explain the definition above, *Polycentricity* is a system, in which, multiple actors get together in a collaborative network that works in agreement with an overarching set of rules, which applies to every actor within the system. These rules have been agreed upon by majority rule, and they make the collaborative efforts easier to manage, as everyone works under the same limitations but also has the same opportunities (Carlisle and Gruby, 2019; Tarko, 2015; Simonsen et al., n.d.). *Polycentricity* stands in contrast to *Monocentricity*, which is where there is only one decision-making authority. If

decision-making power is consolidated with one actor functioning in one jurisdictional scale, decisions might fail to have the desired impacts on other scales of the system (Carlisle and gruby, 2019; Feldmand, 2016; Tarko, 2015).

This leads to a second key concept of Polycentric Governance, which is the concept of ***Semi-autonomous decision-making and Cross-scale jurisdictions*.** This concept has already been touched upon a little in the first concept, but a further explanation in needed in order to understand the concept fully. The actors who are acting as the different decision-making centers, should, according to the concept of Polycentric Governance, work at different jurisdictional scales, in both higher and lower levels. This is done to ensure that issues are dealt with in a fitting perspective, and at the according scale (Feldman, 2016). This ensures that the best possible solutions to fit the issues are found. These solutions should also be found in accordance with the rules set for the collaborative work, which should ensure that every actor has a framework to follow when dealing with the different issues they are faced with (Carlisle and Gruby, 2019). This framework of rules also contributes to the aspect of semi-autonomy, as the actors can make some decisions on their own and deal with issues pertaining to their scale, but it can also be limiting them in some regard, as they have to follow these rules and not work outside the proposed framework. This is the semi-autonomous aspect of the concept of Polycentric Governance, which leads to the next concept that can be said to be connected to the semi-autonomous aspect.

***Response Diversity*** as a concept revolves around the different actors that make up the decision-making centers in a Polycentric Governance system. As these actors have backgrounds and move in different scales and jurisdictions, their reactions to change, be it political or economic change etc. will be different than the way other actors react. This should, in theory, cause the entire Polycentric Governance system to be more persistent, more adaptable and resilient to change, as different actors, who have overlapping functions and interests, have different strengths (Simonsen et al., n.d.). Simonsen et al. (n.d.) explains the concept described above as follows;

"*Within a governance system, a variety of organisational forms such as government departments, NGOs and community groups can overlap in function and provide a diversity of responses, because organisations with different sizes, cultures, funding mechanisms and internal structures are likely to respond differently to economic and political changes*" (Simonsen et al., n.d.; 4)

The strength of a multi-actor system, that each operate on a different scale, seems fit to deal with many different issues, as the entire system is much more capable to handle external changes and variables such as changes to society and the Polycentric Governance system itself. It is, however, not only through *Response Diversity* that Polycentric Governance systems can obtain resilience against external factors, as there is an added quality in the fact that the actors can have overlapping functions. This relates to another concept that is closely connected to *Response Diversity.*

***Redundancy and Mitigation of Risk*** is a concept of Polycentric Governance that, as mentioned above, is closely related to *Response Diversity*. The relation between the two concepts is found in the actors that maintain overlapping functions in the Polycentric Governance system. *Redundancy* is in all fairness, a quite simple concept, but one that is still an important aspect of Polycentric Governance systems, as this concept contributes to the success of the solutions implemented by the decision-making actors. The concept is that the decision-making actors can, and possibly do, have overlapping functions and tasks, that makes the entire system less prone to failure, due to the fact that if one part fails, another that oversee the same functions can take over, without much disruption to the entirety of the system (Carlisle and Gruby, 2019; Simonsen et al., n.d.). As it is written in Simonsen et al. (n.d.), *Redundancy* is the embodiment of the saying "*don't put all your eggs in one basket*". Another aspect of *Redundancy* is ***Mitigation of Risk***. These concepts are interconnected as mitigation of risk is derived from an already existing system of redundancy. Carlisle and Gruby (2019) illustrates how risks are mitigated through the *Redundancy* of decision-making actors and their overlapping functions by the following example.

"[...] *every policy innovation has a probability of failure of 1/10. If the region were regulated by a single governing agency, one out of ten policy changes would be failures for the entire region. If designing rules were delegated to three genuinely independent authorities, each of these authorities would still face a failure rate of one out of ten. The probability that a failure would simultaneously occur along the entire coast, however, would be reduced from 1/10 to 1/10³ or 1/1000.*" (Carlisle and Gruby, 2019; 944-945).

This example serves to illustrate that, by including several different authorities, jurisdictions and decision-making actors, the risk of failure to the entire system is mitigated the more actors that have overlapping functions. The risk of failure for the individual part of the system is always the same, but the overlapping functions can, as earlier described, reduce the

chance of failure so that another actor can step in where failure has occurred. In this way, the entire system becomes more resilient towards failures, which strengthens the success rate of Polycentric Governance systems.

In the same way, the concept of ***Safe-to-fail interventions*** can be mentioned. This concept is similar to *Redundancy* in a way, but instead of actors serving to manage the same functions, *Safe-to-fail interventions* is more concerned with policies. It is claimed by advocates of Polycentric Governance systems, that due to the many monitoring possibilities of the different decision-making centers in such a system, it opens for possibilities for early warnings of the success or failure of an implemented policy (Feldmand, 2016). *Safe-to-fail interventions* are, in essence, policies that can quickly be replaced or changed, if they prove to be unable to deal with the issues they were meant to and be changed to "newer more adaptive innovations" (Feldman, 2016).

***Adaptive Capacity*** is, as the name suggests, the Polycentric Governance systems capacity to adapt to new or existing issues that may cause the system to fail. The *Adaptive Capacity* is likewise expressed as the ability to predict or anticipate changes, and to be able to get the system adapted to these changes. The ability to adapt can either be done through the change of processes in the system, and if this is not sufficient, a change to the actual structural elements of the Polycentric Governance system can be made, in order to respond to the anticipated changes. This can also be done by the creation of entirely new institutions in the system (Carlisle and Gruby, 2019). Because of the *Adaptive Capacity* of Polycentric Governance systems, they are thought to better be able to adapt and approach issues and changes than other more centralized types of governance (Carlisle and Gruby, 2019). It is claimed that the adaptability of Polycentric Governance systems, stem from the facilitation of experimental approaches and solutions, that encourage the different actors to learn and make experiences for themselves, which can benefit the system with adapting at later points. This happens through innovation that can help the system in changing in order to adapt and overcome challenges (Carlisle and Gruby, 2019). The aspect of learning and making use of former experiences is likewise one of the more commonly mentioned benefits of Polycentric Governance, as the decision-making actors can draw from earlier experiences made by other actors in the system to learn from their mistakes or successes.

***Incentives Compatibility*** is a concept that is regarding the alignment between rules and incentives. Tarko (2015) points out that if the rules of a system are considered useful and fair

by the actors subjected to them, and if the rules are transparent, then there is a potential for incentives compatibility. This concept is essential for Polycentric Governance Systems, as the presence of incentives compatibility determines whether a system is Polycentric or not (Tarko, 2015). This is true even if multiple decision-making centres are present. For actors, this concept entails that, there are rules that need to be followed, but by following these rules, there are also incentives that make it worthwhile to do so.

### 5.2.3. The Advantages of Polycentric Governance:

In this subsection, the concept of Polycentric Governance and the notions contained therein, will be examined and explained, with the intent of contextualizing the different notions in regard to this thesis and the topic in question, namely Urban resilience and Green roofs. Polycentric Governance revolves around the notion that, instead of centralised centers of decision-making, the decision-making centers should be multiple and build on several different semiautonomous stakeholders (Carlisle and Gruby, 2019). In Feldman (2016) this is elaborated upon, as it is said that the decision-making centers should be physically adjacent jurisdictions, where rules and policies are negotiated to solve common problems and to create persistent solutions. Polycentric Governance has been utilized in working with what Feldman (2016) calls management of Converging Knowledge, Technologies and Society (CKTS). Polycentricity as a concept is the case of multiple decision-making centers, which span multiple levels of both space and authorities (i.e local, state and national levels). These decision-making centers have some degree of autonomy, which is why Carlisle and Gruby (2019) make use of the term “semiautonomous”. This is quite important as the jurisdictions at the different levels are best suited to approach and handle issues and problems befitting their scope. This means that the local jurisdictions should be best suited to handle issues pertaining to the local levels, i.e neighborhoods or local communities, whereas the national jurisdictions are better suited to handle issues with a national scope. Noteworthy studies of Polycentric Governance have been focused on the use and distribution of “common-pool” resources such as freshwater areas, forests, fisheries and public safety (Feldman, 2016). It is likewise pointed out in Carlisle and Gruby (2019) that Polycentric Governance seems to be a good institutional fit for natural resource systems. This helps to support the author's choice of the theory in this thesis, as it seems quite fitting in regard to managing natural resources and “common-pool” resources, which Green roofs could be classified as. An elaboration of the point of Polycentric Governance being an especially good fit for natural resources is made in Carlisle and Gruby (2019), where they list three points for functional Polycentric Governance systems;

> "[...] *(i) polycentric governance systems are better able to adapt when faced with social and environmental change; (ii) they provide good institutional fit for complex natural resource systems; and (iii) they mitigate the risk of institutional failure and resource losses on account of their redundant teams of decision makers employing diverse or redundant institutions.*"
>
> (Carlisle and Gruby, 2019; 929).

Aside from being some of the advantages of Polycentric Governance, in terms of management of natural resources, the points also underline why the authors see the theory as a good fit for the subject of this thesis. Other advantages pertaining to Polycentric Governance, especially in relation to CKTS, is the potential for furthering a multitude of different aspects relating to CKTS. Some of the more interesting potentials when seen in relation to this thesis is the potential for enhancement of environmental sustainability and fostering improvements in the quality of life (i.e creating new jobs, broadening new energy options and furthering the longevity of humans mental and physical health).

The next advantage to be examined, needs to be put into perspective before it can be related to Polycentric Governance. Another often used approach in CKTS management, which is used when trying to overcome barriers, is being referred to as "Convergence ecosystems". Examples of these convergence ecosystems can be seen in cooperative networks such as Silicon Valley, the Semiconductor Research Corporation and several different regional science and technology initiatives (Feldman, 2016). These improvised cooperative networks that make up convergence ecosystems, allow for collaboration through institutional innovations which permit free movement and exchange of ideas and experiences, with the intent of generating sustainable innovation. The reasoning behind the former described sustainable innovation is to be able to use these ideas and innovation in viable and practical applications. This approach enables better identification of barriers and obstacles, and how to better and more efficiently overcome these barriers, without unnecessary efforts. How does this relate to the advantages and concept of Polycentric Governance then? It does so due to the fact that the Convergence Ecosystems display very distinct characteristics often found in Polycentric Governance. Especially two characteristics are quite explicit, with the first one being that the improvised collaborations in Convergence Ecosystems are based on rules of exchange and governance, which has been negotiated between the actors. An example of this would be how patents, licenses as well as costs and

earnings can be shared between the actors in the Convergence Ecosystem, and how this has been negotiated in advance. The second characteristic is that the collaborative networks also consist of actors that find themselves in close proximity to each other, which may allow for the development of conjoint platforms where research or entrepreneurial efforts can take place (Feldman, 2016). The Convergence Ecosystems are in this respect very much akin to Polycentric Governance, and the advantages found in the Convergence ecosystems must therefore also be present in Polycentric Governance. The authors acknowledge this connection and has kept it in mind when working with the concept of Polycentric Governance. Other advantages relating to collaborative networks include the minimization of risks when making use of these Polycentric decision-making centers and collaborative networks. By drawing on the former experiences and trials and errors that other actors in the networks have made, there is a minimized risk that the errors made will repeat themselves. This is possible due to the knowledge and experience sharing, which allows for other actors in the network who are facing a barrier, to look at former experiences and approaches in overcoming the barriers. This enables increased willingness to take risks and to create or implement new solutions, as the Polycentric networks contribute with a “security net” which should be able to minimize the risks at the different spatial and authoritarian levels of the collaboration network (Feldman, 2016; Carlisle and Gruby, 2019).

As have been established, Polycentric Governance share similar traits to the Convergence Ecosystems, but where the similarities end, Polycentric Governance goes beyond the Convergence Ecosystems in terms of possibilities. In Feldman (2016) it is claimed that Polycentric Governance may be able to open a platform for wider and broader collaboration, as well as widening the discussions and to standardize and unite the practices of the actors. This will allow for them to adopt “best practice” approaches for dealing with the management of risk, the fostering of innovation and the encouragement of all stakeholders, in an effective manner. One of the approaches Polycentric Governance make use of in creating a platform that enables actors to adopt best practice and promote wider discussions, is that, Polycentric Governance helps to promote what Feldman (2016) calls ad hoc institutional arrangements. These ad hoc arrangements permit the actors to participate in bottom-up, multi-actor governance, where it is possible to share in the risks and opportunities and to cooperatively use both physical and virtual intellectual space. Polycentric Governance acknowledge the importance of this multi-actor, bottom-up approach in facilitating the collaborative work of the different actors that are to be found within an institutional framework that is locally accessible, and one which have a high degree of legitimacy. It likewise acknowledges the

importance of access to local knowledge and information pertaining to this, along with a capacity to changing conditions and opportunities (Feldman, 2016).

Polycentric Governance has, as examined above, a quite significant amount of advantages, many, if not all, which can be related to the topic of examination in this thesis, Green Roofs and Urban Resilience. This theory allows for multiple actors to join in collaborative efforts that may enable increased innovation, focus on the local level, and mitigate potential risk factors, by making use of experiences made by other actors. As the actors in these collaborative frameworks are also “semiautonomous”, it allows them to view the issues they face, through their own perspective, and to deal with the issues at their own level and scope. This seems beneficial in regard to the expansion of green roofs and urban resilience, as this is sometimes very localized in terms of where green roofs are to be established, and by whom.

As with any theory, however, there is also some challenges and barriers in Polycentric Governance itself, which are important to be aware of. In the next subsection these challenges and barriers will be examined in the same manner as the advantages above, in order to give the reader a deeper understanding of the theory, and what the authors have had to keep in mind during the writing process. The exploration of advantages and barriers have been carried out in order for the authors to better be aware of potential pitfalls in the use of the theory, so that these could be avoided, and the best possible results of the analysis could be achieved.

### 5.2.4. Challenges and Barriers of Polycentric Governance:

As mentioned above, Polycentric Governance have some inherent advantages, which seem to be a good fit for CKTS issues, which, as earlier mentioned, the authors perceive green roofs and urban resilience to be part of. It does, however, also have some inherent challenges, especially if the theory should be an optimal fit for CKTS issues and how to manage these. In this subsection, an examination of these challenges will take place, in order to create awareness of the potential pitfalls in the theory, and how these can be avoided.

First it should be noted that Polycentric Governance, does not necessarily perform any better than any other forms of Governance. It does, as many other different theories, however, work well in specific contexts and examinations of certain fields, such as CKTS.

Secondly there are some challenges and pitfalls which are inherent to the proposed structure of Polycentric Governance. What is meant with this statement, is that the close proximity jurisdictions, that functions as these “semiautonomous” decision-making centers which are at the core of Polycentric Governance systems, can also contribute to some challenges. In Carlisle and Gruby (2019), it is claimed that the Polycentric Governance systems/networks can be very complex, which adds some potential pitfalls, as it can be quite costly with the high coordination that is required in order to form the decision-making centers. This is especially relevant if the actors in these decision-making centers are geographically dispersed (Carlisle and Gruby, 2019). Likewise, there are some potential accountability issues with Polycentric Governance, as the dispersed decision-making centers make it more difficult to hold any one decision-making entity accountable (Ibid.). This does not mean, however, that people are not willing to trust and give credit to the constellations of decision-making actors partaking in Polycentric Governance systems. This trust is not given out freely, however, as people expect a trade of sorts, with them giving their trust and credit to the decision-making actors, with the expectation and demands of knowledge. This knowledge that is demanded is usually pertaining to the risk factors of certain technologies, information regarding the costs and benefits, and the different available options (i.e different types of green roofs, pros and cons of each type, and the different maintenance costs of each of the different roof types) (Feldman, 2016). The importance of this type of knowledge is, that it allows for stakeholders to make informed decisions, based on the knowledge that has been made available to them, which in turn opens for the possibility for increased stakeholder participation in governance efforts throughout the entire process. To ensure that the stakeholders have access to the information they need, Feldman (2016) claims that especially two types of major infrastructure is needed, telecommunications and social media, as these allow for open and inclusive governance. This is, however, also a potential area where challenges and barriers can arise that can harm the Polycentric Governance efforts. The challenges in question pertain themselves to the issue that less developed societies may lack sufficient access to these types of infrastructure, and also lack the knowledge of how to use them properly. The framing of these challenges might seem as though it would be mostly relevant in, what is in daily speech referred to as, developing countries. In the countries located in these regions, access to telecommunications and social media, might not be as widespread as in countries located in other regions (i.e the northern hemisphere).

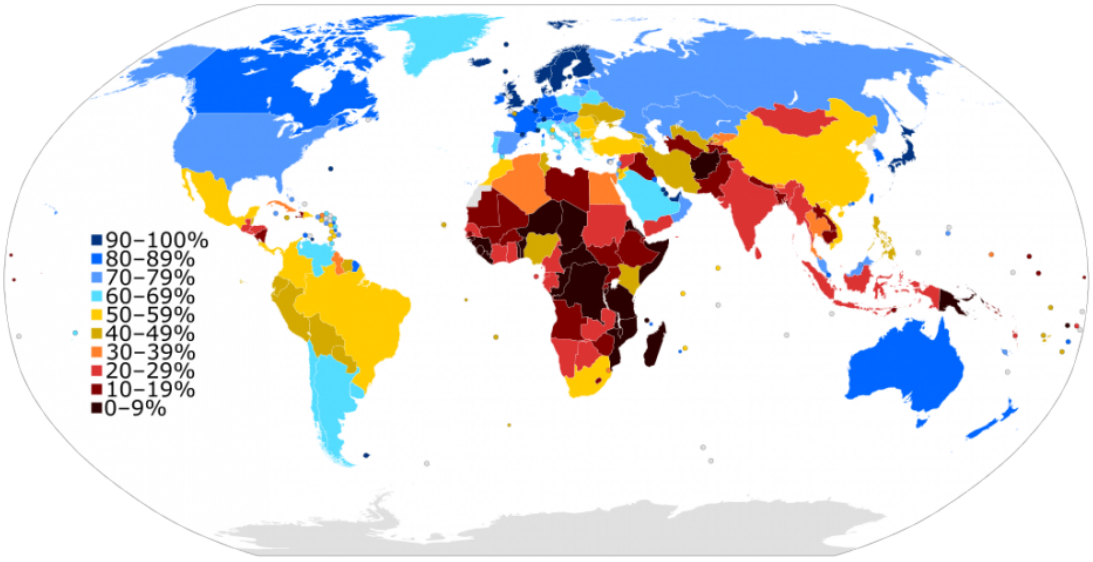


*Figure 8 - Illustration showing percentages of people with access to the internet in all parts of the world (Stub and Stub, 2018)*

As illustrated in Figure 8, regions such as Africa, Asia and South America lack behind in terms of people who has access to the internet. The challenges are very apparent in these regions, but an area where the challenges of lack of telecommunications and social media might also play a significant role, is with the elderly population, even in highly developed countries with wide access to the internet (Givskov, 2017). As Feldman (2016) claims poor access to telecommunications infrastructure can be an inhibiting factor for inclusive and open Governance. This is something that is worthwhile to consider when trying to do the best possible efforts towards participation in Polycentric Governance. Participation and the facilitation of participation is important aspects in most cases of any type of Governance, but it is especially important in Polycentric Governance, as it is not always clear as to how, this type of Governance, can facilitate participatory engagement (Feldman, 2016). This is where the multilevel, cross-scale perspective of Polycentric Governance is put into use, as it is claimed by literature regarding Polycentric Governance, that the ability to draw upon the cross-jurisdictional experiences is an asset that can be helpful when working with the challenges of participation engagement (Ibid.). It is likewise pointed out in the literature, that the local level is indeed extraordinarily important in Polycentric Governance as this helps in determining the local needs, when managing common-pool resources. In Feldman (2016) three infrastructure key points for best possible participation in Polycentric Governance, that lessens the issues of it not always being clear as to how participation can be facilitated, are given. The three key points are; "*(1) support for stakeholder dialogue, (2) sound design for*

*public engagement processes, and (3) support for a wide range of participatory tools*." (Feldman, 2016; 884). As important as access and usage of telecommunications and social media has been claimed to be, the three key points opens for just as important engagement measures which pertains to the physical meetings of stakeholders. It is claimed that it is inevitable that the stakeholders participating and engaging themselves will have to conduct face-to-face dialogue at some point. This is due to the fact that there is a need for structured discussions between the participating stakeholders and the different decision-making actors, which can help guide the overall process. This is underlined by the fact that effective Polycentric Governance is often based on ad hoc, decentralized, and often improvised means of collaboration (Ibid.). Effective Polycentric Governance can, therefore, be created in these face-to-face forums where all the stakeholders and decision-making actors are present, as these forums might allow for improvised collaborations, that can contribute to effective Polycentric Governance.

Some final challenges pertaining to the use of Polycentric Governance, can be said to be connected to the inherent framework of Polycentric Governance and the many different cross-scale collaborations and decision-making centers with all the actors. There are some inherent challenges in terms of the use of redundancy and experimental approaches, as it can be difficult to balance the cost of involving the different jurisdictions and their members, and their different interests. It is something to keep in mind when working with Polycentric Governance, as part of what makes up the framework of the theory, is also the cause of possible challenges, which needs to be dealt with if they arise (Simonsen et al., n.d.). The last challenges, of which there are two, can also be said to be related to the framework of Polycentric Governance systems. There are challenges in negotiating trade-offs between the different stakeholders and actors, with each their own “agenda” or interests, which can be a determining factor for the choices they take and the actions they want to see realized. This challenge regarding the trade-offs continue into the final challenge, which is what Simonsen et al. (n.d.) has chosen to call “scale-shopping”. Political conflicts are sure to arise in a constellation such as can be found in a Polycentric Governance system, as there are potential for skewed benefits, based on the political agenda of the system. Scale-shopping can arise when some actors and/or stakeholders find that their interests or own agenda does not fit into the agenda of part of the Polycentric Governance system. The unsatisfied parties can, if the issues are not dealt with, choose to approach a different decision-making center in another part of the Governance system, on a different scale, which might be more favourable towards their interests (Ibid.). This has the potential to hurt the political processes

of the Polycentric Governance systems, which are part of the foundation of the framework to begin with.

# 5.3. Methods

## 5.3.1. Introduction to Methods:

During the data collection for this master thesis, several methods related to a qualitative research approach have been utilized. These methods were utilized in order to gain knowledge on the topic of green roofs and how an ecosystem-based approach such as this can contribute to more resilient and climate adapted cities. As mentioned at an earlier point of this thesis, the research and writing process was conducted during the COVID-19 pandemic of 2020. This severely hindered and obstructed what the authors would classify as “traditional” data collection, and the methods and the approaches associated with these had to be adapted to the situation of the world at the time. The methods are clearly adapted towards a more online-focused approach, with research being conducted primarily on the internet through desk research and netnography, and interviews being conducted either by phone or through online calls via chat/messaging applications such as Zoom or Microsoft Teams. To accompany the Desk research and Netnographic data collection, Document Analysis and Discourse Analysis were chosen as they seemed fitting. Arguments as to why, will of course be given in the following section, detailing the choice for each method and how it has been utilized to work with the data in this thesis.

## 5.3.2. Desk Research and Netnography:

Desk Research or as it is sometimes otherwise called, secondary research or literature review, is the natural starting point for most researchers wanting to examine a certain area or topic. It is the practice of examining and analysing sources of data such as books, archival data, journals, academic reports or databases on the internet, with the intent of gaining knowledge upon the desired area of examination. To do desk research is to “stand on the shoulders of giants” as it is sometimes phrased. Researchers further their own knowledge and research by utilizing existing valid data to support and accompany their own (*Curtis and Curtis, 2017*). It is on this basis that it is claimed to be the natural starting point for researchers. By utilizing secondary research at the early stages of the research process, researchers have the opportunity to get a wider understanding of the area of examination and to view the general trends on the topic of interest (*Liedtka, Ogilvie and Brozenske, 2019*). This is likewise underlined by the fact that by using this type of research, researchers have the opportunity to position themselves and create their own perspective, which can

sometimes be quite helpful in order to understand the secondary research data even better (*Curtis, 2018*). In the case of this thesis, the authors aim to position themselves and their research through the use of the "*State-of-the-art*", in which literature on the topic of green roofs, albeit with different points of focus, are read and examined, in order to find gaps in the existing literature. Through this examination of the gaps, the authors of this thesis are able to position themselves and their research so that it is able to fill the gaps and create relevant research for the future. In the positioning of this thesis, the authors have followed four points made by Curtis (2018), which helps researchers to position themselves in the vast ocean of existing research. These points are as follows;

1. *Read widely* - Read the existing literature that relate to your own area of research and read as much as time and resources allow.
2. *Develop a chronology, a timeline, of when the material was published* - By keeping the read materials in a chronology, it helps the author to see patterns and timelines of specific points of debate, issues or events.
3. *Distinguish between differing perspectives* - As different academic as well as non-academic literature will have different opinions and make contradictory claims. It is important to be able to distinguish between these contradicting opinions and claims even though it is not always obvious.
4. *Distinguish between differing actors and interests* - This last point is done when all the other points have been done, as an understanding of the different material have been developed, and it should be possible for the researcher to differentiate between actors and their interests. This is done to identify the actors who are involved in creating and framing your area of research.

(*Curtis, 2018; 6*).

A common point made in much of current literature regarding desk research, is that, in contrast to 20 years ago where research were done in libraries and archives, research today, is conducted through the use of search engines and databases on the internet (*Curtis and Curtis, 2017; Curtis, 2018; Liedtka, Ogilvie and Brozenske, 2019*). The authors of this thesis too have conducted much research through the use of search engines such as Google, and academic databases, such as the Aalborg University Library database (primo) and the vast amount of databases available for students, such as SAGE Research Methods, SAGE Journals, ScienceDirect (Elsevier) and Taylor and Francis online. Beside the online data research, the authors have also made use of the physical Aalborg University Library

and borrowed books related to green roofs, green infrastructure and ecosystem-based approaches.

As much of the research in this thesis has been conducted on the internet due to the aforementioned COVID-19 circumstances, the authors opted to utilize not only Desk Research, but also Netnography as a data collection method. As Netnography studies are concerned with the examination and research of communities, social aspects and culture online, it was deemed relevant and fitting to conduct in tandem with the Desk Research. Netnography would allow the authors to examine the "communities" and social aspects of green roofs and matters related to this, by examining texts, databases and blogposts all pertaining to green roof technologies. **Netnography** is, much like its "analog" sibling, Ethnography, a method which is complimented quite nicely by a multitude of other methods (Kozinets, 2010; Rivera et al., 2017). These methods include amongst others, interviews, which has also been used as a method for data collection in this thesis. Netnography allows researchers, by use of observation and participation, to gain knowledge of certain communities' social interactions. In traditional Ethnography that would mean to go to a specific place, and partake in whatever actions that can possibly take place, and/or observe how the community members interact with each other and the "object" or "subject" that they have built their community around (Kozinets, 2010). In the case of this thesis, the authors propose that green roofs have their own "community" with their own social interactions. This "community" are the people that endorse the development, establishment and implementation of green roofs as a technology or other stakeholders who are somehow involved in expanding the use of this technology. The authors view this community as consisting of both private and public stakeholders, researchers and green technology enthusiasts, which all write, discuss and partake in events relating to this technology. As this community is quite vast, it gives the authors plenty of opportunities to research the materials that are readily available on the internet regarding green roofs.
As e-mails, forum posts, blogs and specific sites devoted to a certain topic, are all part of the communication the community share (Rivera et al., 2017) there is plenty of information, which has been examined as part of the data collection of this thesis. Rheingold (1993) defines online communities and what people do in them as;

> "*exchange pleasantries and argue, engage in intellectual discourse, conduct commerce, exchange knowledge, share emotional support, make plans, brainstorm, gossip, feud, fall in love, find friends and lose them, play games, flirt, create a little*

*high art and a lot of idle talk.*"

(*Rheingold, 1993; 4*)

Based on this quote, the authors would argue that it is fair to state that, online communities, is where life happens, just as it would in "real life". Online communities may contain all the same complexities and interactions as communities that are not found online, and therefore, these communities are most likely also carried out outside of the internet. This makes the examination of the communities relating to green roofs, even though it is conducted online, no less valid than if it was conducted by venturing out into the world.

In utilizing these two methods, Desk Research and Netnography, the authors believe that it will help to both position this research in the "knowledge gaps" of existing research, and to understand why the communities relating to green roof technologies, endorse this technology and how they are working with implementing this in climate adaptation measures. When the relevant data and literature has been identified and examined, and the issues has been clearly identified, the next step of the data collection should be to analyse the found literature and documents. To this avail, the authors of this thesis made use of Document Analysis.

### 5.3.3. Document Analysis:

Document analysis is, like the rest of the chosen methods, a primarily qualitative research approach. It is the systematic procedure of analyzing documents and evidence that can contribute to answers for specific research questions (Frey, 2018). Because of this, the method was deemed extraordinarily fitting to work with, in combination with the other methods used in the data collection in the work with this thesis. Another positive aspect is that document analysis is inherently well suited for iterative work (Ibid.), which has been utilized in most of the data collection efforts, as described in the research design of this thesis. Document analysis as a method in its most basic form can be used to analyze documents of all types, but in doing so, it is important as researcher to be aware of several important points. One of these points is that all documents have been created and exist in a specific context, which means that the texts have been influenced by social, economic and cultural aspects of their time. This is important to remember as it affects the way the texts should be understood and interpreted (Ibid.). Throughout the data collection work, the authors have been very much aware of this, and have made many efforts to ensure that the

texts were interpreted in a “critical” light, and that the results were not taken at face value. If Desk Research and Netnography can be used to gain a good overview and a general understanding of a research area, then the Document analysis is a look into the specifics of this research area. Even so, there is still a distinction made between primary and secondary data in Document analysis, both of which has been analyzed in the data collection in this thesis. To provide a quick overview for the reader, the elements that constitute primary and secondary data in a Document analysis context are that, primary data consist of first-hand accounts, such as documents detailing the minutes of a board meeting, personal e-mails, policies and newspaper articles. Secondary data on the other hand consist of what could be classified as “regular” academic texts, or texts that have been developed as a result of an analysis, in which the data has been interpreted. Secondary data consist of book chapters, research articles, dissertations and webpages, to name a few (Ibid.). In the table below (table 3), an example of how documents can be sampled and analyzed is included. This illustrates how Document analysis can be utilized in specifying research and to give an overview of the literature chosen.

| Documents selected | Data analysed |
|---|---|
| Community Participation in Projects Funded by the Jamaica Social Investment Fund: 'Making Your Project More Participatory' (JSIF, n.d.) | Importance of equitable citizen participation in decision-making processes |
| *Millennium Development Goals: A Compact among Nations to End Human Poverty—Human Development Report 2003* (UNDP, 2003) | Human Development Index and related data |
| Jamaica Social Investment Fund's Annual Report 2002–2003 (JSIF, 2003) | List of approved subprojects |
| Jamaica's *Survey of Living Conditions* (STATINJA/PIOJ, 1998) | Relationship between poverty and sanitary facilities, specifically the use of latrines |
| Letter from a High School Guidance Counsellor to the Assistant Youth Coordinator at a local Mediation Center (11 April 2003) | Data on Peer Mediation Program in schools, a JSIF-financed subproject |
| *A Review of Children's Homes and Places of Safety* (Ministry of Health, May 2003) | Contextual data for the research on a girls home (a refuge for young, female wards of the state), which was supported by the Social Fund |
| Update on the National Poverty Eradication Programme 2001–2002 (JSIF, n.d.) | Data on Jamaica's Social Fund as an anti-poverty strategy |
| 'A Week that was Strong' (*The Gleaner*, 4 December 1999) | Role of the St. Elizabeth Homecoming Foundation, a local subproject sponsor, which organised Homecoming Week activities |
| *World Development Report 2003: Sustainable Development in a Dynamic Economy* (The World Bank, 2003) | Demographic and economic statistics |

*Table 3: Illustration of sampling of documents and analysis of these (Bowen, 2009; 36)*

One final aspect worth mentioning, is the fact, that there are many advantages in doing document analysis, some of which are even more relevant when research in the field has not been possible. However, there is also some disadvantages by using documents as data, such as lack of detail, as texts, have been created to fit in a certain context. Other disadvantages include low retrievability as text can sometimes not be retrieved or have been blocked for one reason or another, and lastly, text might be the victim of what Bowen (2009) calls biased selectivity. Biased selectivity seems to align with lack of detail in some regards, as some texts might have been curated to align with i.e. corporate policies, organisational strategies or the like. The authors include these disadvantages as they are worth noting, and to clarify that this is something that has been kept in mind. However, the authors believe that by being transparent when encountering these disadvantages, and when working with document analysis in general, this is something than can be circumvented.

As mentioned before, Document analysis has been used in tandem with Desk research and netnography, as the preliminary data collection methods. The methods have given a general picture of the area of examination, and this has in turn been analyzed more in-depth, with a more specific focus in order to gain more specific knowledge on the topic of green roofs. This knowledge has then been utilized in the work with the last data collection method, Interviews, which will be described in the next subsection.

### 5.3.4. Interviews and Transcription:

Interviews were chosen as a method to collect qualitative data. The authors would like to argue that, even though very relevant data can be gathered from exhaustively analysing texts and documents, it is important to interview people with knowledge on the topic in question. The importance of interviews is, that the knowledge gained helps to understand matters that is not immediately clear when reading.

Kvale and Brinkmann (2015) asks a rhetorical question in their text; "*If you want to know, how people understand their world and their life, then, why not talk to them?"* (Kvale & Brinkmann, 2015; 17). This underlines the argument put forth by the authors of this thesis, that interviews help to understand matters that is not quite clearly understood by just reading texts. Interviews as a qualitative research method revolve around the *subjects* understanding of the world and their view of the world. The *subjects* are, however, subject to the discourses, power relations and ideologies of the world, that might affect them, even if its unknowingly (Ibid.). It is then, just like almost all other methods, imperative that the interviewer has this in mind, especially when analyzing the answers obtained from the interviewee. The authors would like to remind the reader that the subjects of green roofs are still debated heavily around the world, and that a "*regular roof vs. green roof"* discussion is still ongoing, as proponents of either argue that their solution are the best. Due to this ongoing discussion, it is deemed even more important to be aware of the personal values that people have, and what the discourses are at the moment of the interview. The type of interview the authors deemed the most fitting was the semi-structured interview. The semi-structured interview does, as many might know, resemble an everyday conversation more than an actual interview. It does, however, follow an interview guide which gives the interview structure which makes it easier for the interviewer to get answers to all his/her questions. The reason that it is semi-structured, however, is that even though an interview guide is followed, there is ample room for follow-up questions, and to follow the flow of the

interview if interesting topics should emerge (Kvale and Brinkmann, 2015; Bryman, 2012). This almost always seems to be the case. Relating to the qualitative semi-structured interview, are some phenomenological viewpoints, some of which are quite relevant for the examination done in this thesis. These viewpoints include, but are not limited to; *Lifeworld, Meaning, Qualitative, Descriptive, Specificity* and *Conscious Naivety* (Kvale and Brinkmann, 2015; 50-51). These viewpoints all relate to understanding the subject's point of view, and why they see the world as they do. They also relate to the nature of the questions asked, as these should be descriptive of nature such as they allow the interviewee to give the most detailed answers as possible and be as specific as possible to not get generic/general answers or opinions. These are available in texts and are not of interest in an interview setting. A categorization of the individual interviewee will be given in the section regarding the interview persons, i.e. expert in the field, stakeholder (public/private) and legislators. In a later section the interview guide used in this thesis will be explained, and how these viewpoints have been incorporated in the questions will be clarified.

#### 5.3.4.1. Transcriptions:

When processing the answers from the interviews the authors have chosen to work with the method of transcription, which is commonly coupled with interviews. This method allows for closer analysis of the oral interview, by changing it into writing. Transcriptions are, however, a very time-consuming method, as it takes approximately 4-5 hours to transcribe a 1 hour interview (Brinkmann, 2013). As the authors have not had to go out into the field to do research, more time could be allocated to the transcription, so this was not that big an issue. There are considerations to be made regarding how the transcription should transpire, i.e. words to exclude/include, how the data should be interpreted etc. These considerations will be described in another section, but the authors made a clear strategy for transcription before beginning the work, which was done to ensure an identical approach for each author in terms of transcription. This approach is underlined in Kvale and Brinkmann (2015), as it is crucial for the researcher to be able to be transparent regarding the transcription process and how the results from the analysis of it came to fruition.

Interviews and transcriptions have been the last step in the data processing, with the other chosen methods narrowing the area of examination, and making the search more specific. After the document analysis, it was possible for the authors to develop questions which

could yield answers to questions, which were still missing after reading the included literature.

In the next section the applied methods and how the authors chose to work with each of the methods will be described. In this section a description of how desk research has been conducted, along with the netnography study, and how the document analysis of the literature found in the aforementioned methods has been analyzed. The interview guide, with the questions will be shown, along with a schematic overview in where the chosen interviewees are represented, and why they are relevant for this thesis. The transcription strategy will likewise be described, with the perspective of how each of the categories relating to each specific topic was used to categorize the gathered data to use in the analysis.

## 5.4. Applied Methods

### 5.4.1. Introduction:

This paragraph contains a description of each of the applied methods chosen for the data collection process of this thesis. First, a reflection of the validity and reliability of qualitative studies will be given. Following that, a walkthrough of each of the applied methods, along with the work processes, will be described in order to create transparency regarding how data was collected and categorized in this thesis.

### 5.4.2. The Validity and Reliability of the Collected Data and the Qualitative Studies:

As is it important to be transparent when conducting research and collecting data, the authors would like to dedicate this section to a short reflection on both the validity and reliability of the applied methods and the collected data. It is important for the readers to know what kind of data that can be expected to be utilized in this thesis, how it was collected, and how valid and reliable the data is if any future replication should be relevant.

Regarding the **validity** of this thesis, a qualitative approach has been utilized throughout the data collection process which allows the researcher to “dive into the mechanisms beyond”

the data. By doing this, it is meant that the researcher can look at the background of different statements or examine the reasons why data is being the way it is, and to try and understand why it is so. This is favorable when trying to understand the causes and effects of certain matters, and when trying to find solutions to specific issues, as the answers may be in the underlying meanings and opinions. By approaching research and data collection in a qualitative manner, it will, however, be quite difficult, if not impossible, to recreate the exact results in another study. Some researchers criticize the validity of qualitative studies, claiming that small case-study based research is not sufficient enough in terms of generating any usable knowledge. Other researchers, however, state that it is necessary to analyze a specific phenomenon in its contextual uniqueness in order to understand the mechanisms behind (Olsen & Pedersen, 2015). As such, the qualitative research approach can be compared to a snapshot in time, which illustrates and interprets a specific moment in time. This moment in time may not be replicated, as situations change, technologies and societies evolve, and circumstances may be non-comparable just a few days from the submission of this thesis, and it is impossible to prevent this from happening (Bryman, 2012). In a sense, by conducting the research for this thesis, the knowledge that is produced will contribute to the aforementioned change, as this will allow for new reflections and possibly new solutions to be created.

This does not, however, mean that the source data is not valid or reliable at the time of conducting research for this thesis. With regard to the **reliability** of this thesis, the respondents chosen for interviews, along with state-of-the-art literature gives an insight into the current snapshot of time, and the current situation, which can then be built upon. Reliable respondents and text have been chosen to the best of the authors' abilities, which means that the respondents all have ties to green roofs in some way or another, and is currently still moving in the sphere of implementing green infrastructure. This might, however, affect the answers pertaining to critical or negative aspects of green roofs as the people working with them might be biased. To work with this issue, the authors has made sure to add reflective critical questions for the respondents which makes the respondents reflect on the possible negative aspects of green roofs. Interview data is, however, often regarded as being almost, if not completely, impossible to replicate, as they are related to some sort of social setting (Ibid.).

Both the validity and reliability of qualitative studies is very important to consider (Olsen and Pedersen, 2015), and by doing so, reflections of how the data has implications on the current societal situation can be made.

### 5.4.3. Introduction to the Applied Methods:

As described above, this section is regarding the applied methods that the authors of this thesis chose to work with. A detailed description of how work with each of the methods were conducted will also be given. This section serves as an insight to give the reader clarity and to create transparency in terms of the authors working methods. The description of each of the applied methods will follow the same structure as in the methods section, so give some resemblance of coherence, as these two sections are closely related. The structure is as follows, with desk research and Netnography coming first, with document analysis following suit. Then lastly a description of how the interviews has been conducted, and a couple of different tables and schemes that serves to present the different interviewees, as well as the interview guide used for the conducted interviews. In connection to this, the transcription strategy will be the very last thing described in this section.

### 5.4.4. Desk Research:

As described in the methods section regarding desk research, the method is often regarded as the natural starting point for any researcher (Curtis and Curtis, 2017). The authors of this thesis support this belief, as it seems quite natural to survey the field of research that one aims to delve deeper into. This whole thesis began with a common interest from both authors to be wanting to examine water in the cities, climate adaptation and water sensitive urban design (WSUD) solutions that might contribute to a larger quantity of climate adaptation. From a quick scouring of the AAU University library, it was determined that by focusing on WSUD solutions, both the interest in water in the cities, as well as solutions for climate adaptation could be met. After this gathering of the topics under one “umbrella”, the research efforts then went into learning more about different WSUD solutions, their capabilities and how widespread the use of each of the solutions were. As both authors had some preliminary knowledge on the topic, through the curriculum of the Sustainable Cities-programme, Desk research into the topic helped to nourish this knowledge. It also made it possible to see common trends and patterns in the literature as mentioned by Liedtka, Ogilvie and Brozenske (2019). Through this research process, it became apparent that Green roofs were quite an interesting technology, that seemed to have gained some renewed traction in recent years, albeit not being a new type of technology by any means, as

described in the introduction. The primary approach to desk research was as mentioned in the methods section, to use the internet and the many useful resources that can be found there. While researching on the internet, the resources used by the authors included the search engine Google, which were quite useful at discovering leads of where to search next. The results on Google could be authors and book titles pertaining to the search queries made by the authors, which could give inspiration to which authors might be interesting to examine further. The vast majority of research has, however, been conducted in the Aalborg University Library, as students have access to a plethora of scientific databases. These included, but were not limited to, SAGE Research Methods, SAGE Journals, ScienceDirect (Elsevier) and Taylor and Francis online, as well as the University library database called Primo. Primo serves as the main hub of the library, which can find texts located in other databases on the internet. To research the topic of Green roofs the authors chose to use search queries such as; “Green Roofs”, “Green Roof Technology”, “Green Roof climate”, “Green Roof policies”, “Green Roof benefits”, “Green Roof barriers”, “Green Roof urban resilience” with many more being used. The common theme for the search queries were, however, that almost all of them contained the word green roof, as this was the main interest of the authors research. The authors use of desk research as a method has been mainly iterative, which is inherently a part of desk research itself, as research leading to new knowledge, will alter the search queries, and the focus of research and narrow it down. This will in turn lead to new knowledge and narrow the search even further. This describes the approach also utilized by the authors, as this approach was deemed to be one of the better ones to gain increased knowledge, while also narrowing down the scope of one's research.

### 5.4.5. Netnography:

In connection with the use of desk research, the authors of this thesis also made use of the method Netnography. It should, however, be noted that even though it is a separate method, it has been used very closely together with desk research, as the authors believed it would make sense to research the field, and at the same time examine and research the possible different “communities” that were encountered through the research process. As described in the methods section, the communities in this context is, by the authors, regarded as the people, public or private, organizations, authorities, companies etc. that subscribe to the idea of green roofs being a valid solution to climate adaptation measures. And the opposite of course, with proponents of green roofs being part of their own community as well. The use of Netnography has not been as “explicit” as some of the other methods, as this method has been primarily used to gain knowledge about communities, and how the authors could

perceive the different stakeholders subscribing to the ideas that fit their view of green roofs as communities that share a vision, and who cooperate towards a common goal. How the authors have worked with Netnography, has been through the desk research, to find leads or concrete advocacy groups or opponents of green roofs, which could then be examined through either their webpages (if available), or through published materials expressing their stance on the subject. Through the examination of these advocacy or opponent groups of green roofs, the authors had the chance to gain insight into the landscape of green roofs. In this regard, it was possible to see which aspects of green roofs as a technology that was the topic of discussion at the time of writing this thesis. It was likewise possible to gather a picture of how each “side” of the discussion (proponents/opponents) went about pushing their agenda though the means available to them. This gave some insight into how each side used their available resources, and who/what they considered allies or tools to promote their views. One perspective that could be derived from these examinations were that advocacy groups and proponents of green roofs, often perceived politicians and legislators as some sort of ally or tool to promote the use of green roofs, since these actors has the power to make legislation pertaining the subject. On the other hand, opponents of green roofs seem less concerned with politicians and legislators and seem more focused on making sure that the “challenges” of green roofs are presented so that people know them. They try to use these challenges as tools to perhaps promote alternative climate adaptation solutions that cost less or has some documented and relatable benefits. These were some of the observations made when looking a bit more into the communities that are found within the sphere of green roofs and climate adaptation technologies.

### 5.4.6. Document Analysis:

After the scope had been narrowed through the use of Desk research and, in part, Netnography, the authors took on the challenge of finding relevant literature pertaining to the scope of this thesis that is Green roofs and how this technology can contribute to urban resilience. Subsequently the work began with reading the different texts, classifying them, process them in order to figure out the context in which they were written, and how the message to be conveyed could be interpreted. The authors have especially been inspired by the table from Bowen (2009) and decided to make use of it in the sampling and categorization of the chosen literature to create a better and more structured representation of the findings. The literature has been, as in accordance with Bowen (2009), put into the table (Table 3), with title and author in the left side of the table, and a summarization of the

overall focus of the text in the right side. The visual categorization of this work is not presented in this thesis. It can, however, be assured that this approach has been used in order to have a schematic overview of the read texts, that have been utilized as a reference work where the authors could quickly become reminded of the content of each text. After the finalization of this table, work began on sorting the chosen texts into categories, which was determined by the text's overall focus. For instance, texts that were more focused on the stormwater retention of green roofs were sorted under this category, whereas texts more focused on insulation capacities of green roofs were sorted under another category. The reasoning behind this choice of approach lies in the fact that it will become easier to identify patterns and trends in the analyzed literature, which in turn might help to position the work done in this thesis. When it is known what other research have focused on, then it is the belief of the authors of this thesis, that a more accurate positioning of this work can be done, with the intent of filling the gaps that exist in the existing literature. How the authors worked with this issue has been through a careful analysis of the abstract along with the introductory parts of each text, in order to gain general knowledge that could be helpful in determining the motive of the text, and what the author of the text set out to examine, and why they did so. Examples of this could be texts that aims to compare green roofs with conventional "grey" roofs (grey roofs refer to the fact that no vegetation is growing on the roof). When encountering texts with this focus, the authors have carefully examined the reasoning behind the comparison, as multiple motives can lie behind the choice. Some of these motives has been found to be a comparison with the intent of simply just comparing the pros and cons of both types of roof, in order to allow for stakeholders to make their own informed decisions. Other comparisons are made in order to promote one of the proposed roof types, by highlighting benefits in one type of roof, and the challenges coming with the implementation of the other type. These types of texts can contain useful information, but it is even more important to be cautious to not take the information at face value and attempt to be reflective about it. The authors of this thesis believe that such cautionary approaches have been made, and that each and every text has been scrutinized with "critical glasses" in order to gain the most useful knowledge. It is, however, important to be self-critical as well, and to be transparent, which is why the authors deem it important to also reflect on the scope of this thesis, and the results it will produce. It is the wish of the authors to examine how technologies such as green roofs can contribute to increased urban resilience. In choosing to examine this specific scope, the authors have made a conscious choice to assume that green roofs and other similar technologies have the possibility to contribute to urban resilience. This must mean that the authors have some pre-existing thought regarding that

green roofs must have some benefits that grey roofs do not, if they are able to contribute to urban resilience. By adopting this stance on green roofs, the authors own research and subsequent literature search might have been affected and “colored” by the pre-existing thoughts, which might have made the research a bit biased towards green roofs. The authors do, however, believe that this can, and has been alleviated, at least a little, by not snubbing the opinions made in critical texts of green roofs, but considering them as the foundation for future improvements of green roof technologies, so that the critical aspects might be removed. By doing document analysis, it has, however, been possible for the authors to gain insights into both the pros and cons of green roofs, and subsequently being able to include both perspectives into the research of this thesis. By being aware of this, it is seen as a strength to any research process.

### 5.4.7. Interviews:

Conducting the interviews throughout the data collection process of this thesis, have been in the nature of a semi-structured approach, which the authors believe have been quite beneficial for the in-depth insight of the green roof subject. The semi-structured nature of the interviews, and the interview guide, has allowed for changes to be made, in order to tailor the questions to ‘match’ any specific interviewee and their context, while still keeping the original ‘basic’ structure and questions to have some recurring pattern to return to. The questions for the interview guide was proposed based on the knowledge gained from the other utilized methods, desk research, Netnography and document analysis, as well as the authors own wondering about certain matters. The interview guide was formulated in both English and Danish, as interviewees from many different countries was included. As the authors of this thesis speak Danish as their native tongue and the fact that a Danish perspective was interesting to have when wanting to compare with the rest of the world, a Danish guide had to be created alongside the English one for the international interviewees. Both of the standard interview guides can be found in the appendix to this thesis (Appendix 9). To give a brief summarization of the questions included in the interview guide, the questions are mainly concerned with the potential benefits and barriers pertaining to the implementation of green roofs. In connection to these questions, there is also a focus on the legislative frameworks in each of the cities where the interviewees are located, and how they believe that more green roofs could be implemented. At the bottom of the interview guide, a scheme is located in which the interviewees can assess the different capacities of their city. The capacities include, but are not limited to, legislative capacity, learning capacity and social capacity. This is included in the interview guide as the authors were collaborating with

a British master student in the data gathering process. The British student asked if this scheme could be provided to the interviewees that the authors of this thesis reached out to, and it was agreed that it was to be included. In return, the British master student has tried to include some questions pertaining to green roofs in his interview guide, so that the data can be shared at a later point, and more data could be collected.

In the following part of this subsection, a description of the table containing an overview of the people that was found relevant to contact, can be found. A table was made in an excel-sheet to keep track of and have an easy overview of the chosen interviewees who was found interesting to contact. The table was made in collaboration with the aforementioned British student, George Parsons, and the contacts at Sweco Denmark and Sweco Netherlands. The table contains both interviewees contacted by the authors of this thesis as well as George Parsons, as the intention form the beginning was to be able to share the collected data. The name of the contacts along with their job roles was written, and contact information used to contact them was also written in a separate box in the table. For GDPR-compliance purposes, the table will not be shared in this thesis. The people who were responsible for contacting the person were noted next to the aforementioned information, and a status box containing a status of whether contact has been established or not is also present in the table. To illustrate the progress made on contacting the different people, it was decided to use colors, specifically red, green and orange, to show the status. Green represents a person has been contacted and has answered, orange means that the person has been contacted, but has yet to reply, and red means that the person was contacted but was unavailable for some reason or another. Another reason for using this table to collect and show the contacts was that it allowed the authors and the other people in the collaborative work to follow up on contacts, meaning that if one party did not have success with their contact, the other parties could follow up with some of the other contacts. It was also beneficial to have this table, and to contact possible interviewees this way, as it allowed the authors and the British student to cover a larger area of data, with contacts from multiple cities being included. When the interviews had been conducted, and often recorded if the interviewee consented, the audio recording was then transcribed.

In a following subsection, a description of how the transcriptions transpired, the choices taken and how the information and data will be categorized will be given. Before that, however, a list of the respondents with whom interviews has been conducted will be given.

### 5.4.8. List of respondents:

The following section will present a list of the respondents with whom contact has been established. The list contains the name of the respondent, which city they “represent”, their job role and why they were deemed relevant and interesting to talk to. This list only contains the respondents who participated in an interview.

- Lykke Leonardsen, Municipality of Copenhagen

**Lykke Leonardsen** is based in Copenhagen, Denmark, where she is currently fulfilling the role as Program Manager for Green City Solutions (Grønne Byløsninger). Leonardsen has worked with city planning for some time and have vast knowledge on the way the municipality of Copenhagen is organized, regarding climate change adaptation. Leonardsen was chosen as a respondent due to her vast knowledge regarding climate adaptation and also due to her role as a former city planner and current program manager for the Green City Solutions. The mentioned program, which is a networking initiative aimed at sharing and distributing knowledge between municipalities, has both a national and international reach, which gives Leonardsen some insights into foreign approaches as well.

- Christina Salmhofer, Stockholm Municipality

**Christina Salmhofer** is based in Stockholm, Sweden, where she is working as a Sustainability Strategist at the municipality of Stockholm. Salmhofer is working on the Stockholm Royal Seaport (SRS) project, which is a new and huge urban development project in the city of Stockholm. Salmhofer was chosen as a respondent as she had made some interesting contributions to some literature regarding sustainability initiatives at SRS, where it was assumed that we could benefit from her insight regarding the initiatives from Stockholm. Salmhofer was also chosen as she had vast knowledge regarding the SRS project, and it was found interesting which sustainability tools that was available when dealing with a construction project of such magnitude. Finally, the SRS make requirements to the use of green roofs, which the authors were curious to learn more about.

- Rebecca Gohlke & Fiona Wolff, Bundesverband GebäudeGrün e.V (BüGG)

**Rebecca Gohlke & Fiona Wolff** are both based in Berlin, Germany, where they represent the BüGG, which is a lobby association lobbying green roofs to interested parties, such as

cities, universities and different organizations. Gohlke and Wolff were not chosen specifically, as initial contact was established with the BüGG, through a general e-mail request. Subsequently, the organisation internally decided who was going to answer the questions, which resulted in a combination of answers from Gohlke and Wolff. The reason that BüGG was contacted, was because the authors believed that a professional organisation and lobby group for green roofs, must be very aware of different perspectives regarding the subject of green roofs.

- Stephan Brenneisen, Zurich University of Applied Sciences & City of Basel

**Stephan Brenneisen** is a professor at Zurich University of Applied Sciences in Switzerland and is also a green roof consultant for the city of Basel. Brenneisen is working with a research group that focus on green roofs, and also as a consultant on green roofs, qua his many years of both working with, and researching green roofs. Brenneisen was chosen as a respondent, as he co-authored some interesting literature on the expansion of green roofs in Basel, and because of his immense experience in the field, which was of interest as well. Likewise, other literature pointed to the city of Basel as being a frontrunner in terms of implementation of green roofs, which made Brenneisen even more interesting as he was thought to be able to share valuable insights regarding the approaches that made Basel so successful in implementing green roofs.

- Jörg Breuning, Green Roof Technology

**Jörg Breuning** is a green roof consultant, working within his own company, located in Baltimore, USA. Breuning is working as a consultant on green roofs consulting for stakeholders and other interested parties. Breuning originally lived and worked with green roofs in Stuttgart, Germany, which also allowed him to give some perspectives regarding the initiatives from Stuttgart. Breuning was chosen as a respondent as he is considered a very experienced person, with over 30 years of practical experience of working with green roofs. The combined US/German perspectives were meant to provide some interesting reflections on the geographically determined approaches to green roof implementation.

- Gustav Nässlander & Tanja Hasselmark Mason, Scandinavian Green Infrastructure Association

**Gustav Nässlander & Tanja Hasselmark Mason** are both representatives from Scandinavian Green Infrastructure Association (SGIA), located in Malmö, Sweden. Nässlander and Mason answered the interview questions separately, but as they represent the same organisation, they are combined in this list. SGIA was chosen as a possible respondent, as they have networks across Scandinavia, and also because they provided the possibility to give insights into multiple Scandinavian countries, however mostly the perspective from Sweden and Malmö/Stockholm. As SGIA have many different networks, they have vast knowledge on the current development regarding green roofs, and the different tools and approaches to implement these in urban areas.

Other possible respondents have been contacted, but due to the COVID-19 situation, many were occupied, and others chose not to reply at all. Some respondents were sent follow-up requests as they were deemed very interesting, but most that did not reply the first time, did not reply the second time either. In total, the authors wrote e-mail requests to 18 persons.

### 5.4.9. Transcription Strategy:

The following subsection contains the description of the approach taken by the authors regarding the transcription strategy. The strategy emphasizes both the choice of words to leave in or keep, as well as how data has been categorized in each transcription.

Each of the conducted interviews were recorded with the intention of later transcription. Before each of the interviews, the interviewees were asked if they would consent to the interview being recorded, with all of them agreeing. If some had declined, however, then the interview would have proceeded, but notes would have to suffice instead. Transcriptions are perceived by the authors as the most accurate way of revisiting the interview, as it is a recording of the words spoken and actions taken if it was recorded on video. As it was not possible to meet with the interviewees in person, both due to the geographical circumstances of the interviewees and authors, but also due to the COVID-19 situation, which resulted in the fact that all interviews were conducted using one of the many online applications available. The applications most commonly used during the interviews were Skype for Business, Microsoft Teams, or Zoom. The application Discord was also tested on one occasion, but as this is a less known application, it was decided that one of the three aforementioned solutions were to prefer in future interviews. When the recorded audio files were processed, a deliberate choice of keeping in most of the uhm, uh, hmm word was taken. Though these did not contribute to the overall purpose the transcription, they did

however contribute to a better sounding flow, which was preferred. The first couple of interviews were transcribed manually, using the service oTranscribe, which have some useful shortcuts that makes it easier and faster to transcribe, such as pause/play on the esc key, forward and backwards on F1 and F2, and timestamps on CTRL+J (for windows users). For the last couple of interviews that needed transcribing, the authors chose to change methods after discovering the service Otter.ai, which is an automatic transcription software. This service has the same functions as oTranscribe, but it can generate a quite accurate transcription by itself if an audio file is uploaded. As transcriptions are very time consuming, with the general rule of thumb being 5-6 hours of transcription for each hour of recorded audio, using Otter.ai was much preferred, as the additional work was primarily to correct the gravest of mistakes in the transcription. The time saved by using this software could in return be redirected to complete other and less time-consuming objectives within this thesis. In addition, it should be noted that every quote that should be used in the thesis itself has been thoroughly replayed and reviewed, in order to reconstruct and make sure that the words were as accurate as possible. A timestamp was added each time the speaker changed in the audio recording as this gave the authors, as well as possible readers, a chance to jump into the audio recording at the exact moment something interesting might appear. After each of the transcriptions had been written, the data would be categorized. To this effort, a system consisting of color coding connected with different categories, proposed by the authors, was created, in order to take a more systematic approach in the analysis of the data, as well as making it easier to work with the collected empirical material. This system consists of 6 categories, each with a corresponding color. For a practical example of this, it is recommended to view the appendixes containing the transcriptions (Appendix 1-7). The intention of this approach was to construct a framework for the analysis, in which the different categories are present, and where the corresponding data can be included.

In the following paragraph, the analysis of the collected empirical data will be undertaken. The data consists of the conducted interviews, read literature, transcription categorizations and the theoretical perspective of Polycentric Governance.

# 6. Analysis

This paragraph contains the analysis of this thesis, where the empirical data will be examined and analyzed. The framework for the analysis is the four sub-questions to the research question of this thesis:

- *What are the most significant barriers and drivers regarding the implementation of green roofs in different cities?*

- *Which tools are being utilized when green roofs are implemented, both private and public, and which incentives do they encourage?*

- *What is the role of cross-scale collaborations and networks, and how do these affect the expansion of green roofs?*

- *How can a framework based on best practice solutions contribute to enhance urban resilience through the utilization of green roofs?*

These four sub-questions have, in order to create a more structured overview, been split up into six different categories. These six categories are, *barriers, advantages, tools, , networks & synergies, technological aspects* and *urban resilience,* with the latter being included in the discussion for the framework creation. In aggregate, these six categories will answer the four sub-questions. In each of the six categories a template has been created, which will be repeated throughout the different categories. This template is made up of the different cities from where the respondents are basing their perspectives. Each of the respondent's answers to the category in question will be examined and analyzed before moving on to the next one. Throughout the analysis and the work with the six categories, the theoretical perspective of Polycentric Governance, and the described concepts will be included regularly. It should be noted that, when references to the appendixes throughout this analysis is made, specific time stamps will be used when quotes are utilized. Likewise, if the answers in the appendix was responded through an e-mail, the time stamp will be replaced with a reference to the specific question that is being answered. To exemplify, Appendix X; XX:XX or Appendix X: QX, where the Q refers to the question.

# 6.1. Barriers and Challenges Pertaining to Green Roof solutions

This subsection of the first sub-question is regarding the possible barriers and challenges that is pertaining to the implementation of green roof solutions. As described in the introduction to the analysis paragraph, this subsection will follow the template that has been made. The answers given by the Danish respondent will be analyzed first. Following will be the Swedish, German and swiss respondents, with the respondent from Baltimore in the US ending this subsection. Following the analysis of each sub-question, a collective sub conclusion will be given.

## 6.1.1. The Danish Perspective on the Barriers and Challenges for the Implementation of Green Roofs:

This first part of the analysis regarding the first sub-question is concerned with the potential barriers and challenges related to the implementation of green roof solutions. In this subsection, the challenges and barriers from the Danish perspective will be analyzed upon, with data included from the interview with a respondent from the city of Copenhagen.

### 6.1.1.1. The Existing Building Mass and New Construction Costs:

At a first glance, there is an obvious barrier for the implementation of green roofs in Copenhagen, as well as in many other older European cities. The existing building mass of the city is composed by older buildings, some even dating back a couple hundred years. These buildings and their roof constructions simply cannot support a green roof, due to the weight. This is an issue, and since the majority of buildings in central Copenhagen is older, it makes it almost impossible to implement green roofs on existing buildings, at least with the state of current green roof technologies (Appendix 1). This does not, however, mean that green roofs cannot be constructed in Copenhagen. In new constructions it is possible to construct green roofs, as flat roofs are often built, instead of sloped roofs. It is then possible for the authorities to demand, by requirement, that green roofs should be constructed on some of these new buildings. This is done in multiple ways, but one of the most common ones are through the utilization of local plans of an area (Ibid.). This cannot be realized on all new buildings, however, and sometimes the developers and the contractors object to having to construct a green roof on top of the new building. This is due to the perceived high cost of green roofs:

> "*So I would imagine that there were a lot of developers of those who build in the North Harbor and the South Harbor and on Amager [...] who will be frustrated with the more demands we make, the more expensive it will be for them, and the less profit they get"*
>
> (Appendix 1; 27:47).

As green roofs are more expensive than regular roofs, it will be more costly for developers, which they naturally have no interest in. If there are no requirements for green roofs, then they are likely to object and choose not to construct one. The barrier in this regard is both the higher cost of a green roof, but also the lack of tougher requirements that can ensure that green roofs are being built. There is, however, a need to find a balance between the requirements for green roofs and the added cost of constructing these types of roofs, as it is claimed that it is already quite expensive to build in Copenhagen (Ibid.). Even a 0,5% increase in the costs might cause issues, as there is a lot of focus on building more cheaply in Copenhagen, as the prices of renting and buying are extremely high as it currently is (Ibid.). Due to this focus, green roofs and the added cost of establishing these cannot be justified, and they are not being built to an extent as they could be. This is an issue that needs to be dealt with if it should be attractive for developers and contractors to focus more on green roofs on new constructions.

#### 6.1.1.2. Lack of Financial Incentives and Common Standards:

A possible method of making green roofs more attractive could be through the use of financial incentives. This would make the green roofs more competitive in terms of pricing when compared to regular roofs, if the developers could get some of the costs refunded one way or another. At the moment, however, there are not many financial incentives in Copenhagen in regard to green roofs, neither for developers or private actors (Ibid.).

> "[...] *there are no financial incentives for this, you do not get support or anything else for green roofs*"
>
> (Appendix 1; 09:09)

As it seems, green roofs are not established in Copenhagen due to any sort of financial incentives, which can contribute to green roofs being a challenging sell to customers concerned with making a profit, e.g. developers and contractors. There is then, a need for

other incentives to make green roof solutions attractive. What these are will be explored in the advantages section later on.

Another issue that can be a source of some disruptions in regard to making demands on green roofs or not, is that there is a lack of common standards in Denmark in general, and in the municipality of Copenhagen. Some years ago, there were talks about making it mandatory that green roofs should be included in local plans. These discussions met quite a lot of resistance, which resulted in issues that lead to the current situation, where every new local plan must be evaluated in order to determine if they want to put in requirements for green roofs or not (Ibid.). This means that every local plan is different, and that there are no common standards, in terms of implementation of green roofs at least, for planners and municipalities to follow when creating new local plans. This might be a potential for some issues, as the lack of common standards and guidelines could possibly mean that the municipalities need to allocate resources on finding the best approach each time, instead of just being able to use already determined frames. In this regard, it could be beneficial to look at it in a Polycentric Governance perspective, where the overarching system of rules would make up the framework for municipalities to follow, which would function as guidelines when making new local plans. This would allow for the possibility to make requirements based on the overarching system of rules, so that these requirements all had the same foundation, and shared some common traits.

#### 6.1.1.3. Regional Collaboration and Common Frameworks:

In the same regard it was mentioned by the respondent from Copenhagen that there is a general lack of regional collaboration and coordination, which leads to a lack of common frameworks, quite similar to the lack of common standards in making local plans. Regional coordination is stated to be very important when working with climate adaptation measures, and at the moment, there is a lack of this type of collaboration in Denmark, which is a challenge. Why it is a challenge, is because of the fact that it is the regional authorities that actually has the authority to do something, and when they lack coordination, it can be a barrier for successful climate adaptation, also meaning green roofs (Ibid.). An example of why the regional perspective is so important was given by the respondent from Copenhagen;

> "*So if in Copenhagen we decide to make coastal protection to secure us against a 1000-year event, while in Tårnby they decide that probably only a 100-year event is necessary, then the water can just run in through the back door to Copenhagen, right?*"
>
> (Appendix 1; 49:03)

This example serves to underline the importance of collaborative coordination between the authorities, as it can have large consequences for one region if another is not matching the efforts. To put this into the perspective of green roofs, a scenario could be that the city of Copenhagen implemented a lot of green roofs which would allow the sewage systems to be operated with a larger capacity due to the retention benefits provided by green roofs. But if some of the neighboring municipalities and cities do nothing, or choose to implement solutions with much lower capacity, then all of their excess stormwater could potentially flow towards Copenhagen, and cause issues with the sewage systems within this urban area. To avoid these issues, Polycentric Governance, and the concepts of this theory, would be a possible solution. As mentioned above in regard to the lack of common standards, planning through a Polycentric Governance system, and its overarching system of rules, would allow for a common framework for both, municipalities, regions and local planners to follow. As the entities that find themselves in a Polycentric Governance system are mostly semi-autonomous, they would be allowed to make solutions that fit their context, but through the overarching system of rules, they should make sure to at least follow the same guidelines for i.e retention capacity. Then it would be up to the individual entity to choose the solutions that fit the best into their context. A Polycentric Governance systems approach would also have the added benefit that there would be a better and more healthy collaboration and

coordination between the regions, just as long as they are part of the system. This might be a potential way of overcoming the barrier, and Greater Copenhagen Utility might be an example of how this approach could function in practice, due to their cross-jurisdictional ownership and collaborations. This point will, however, be explored even further at a later point in the discussion.

#### 6.1.1.4. Utility Companies and an Apparent Lack of Visible Consequences of Climate Change:

It was pointed out by the respondent from Copenhagen, that some of the barriers and challenges that inhibits the expansion of green roofs, are related to the utility companies. The utility companies can potentially benefit from their already established refund-initiative of the stormwater connection fee, which will be elaborated further in the advantages section. The utility companies achieve some of the benefit, as they do not necessarily need to install new sewage or drainage pipes, which can be quite expensive, as long a s stormwater is managed on applicants' own cadastral. They are, however, seemingly not utilizing this opportunity. This is even despite the fact that a new law was passed some years ago, that split the responsibilities between the utility companies and the municipality of Copenhagen. This law made it possible for the utility companies to be able to finance everything regarding water, whereas the municipality could finance everything about embellishment and functionality of parks for instance. This law has made the utilities able to easier implement solutions such as green roofs, as it is related to water management, but even still they are not quite so enthusiastic about these types of solutions (Appendix 1). It was mentioned that their preferred method of climate adaption and water retention was to make basins instead, which might be cheaper. Another example of why there is hesitation regarding green roofing solutions in Copenhagen, is the fact that it can be challenging to determine whether or not a single heat wave or rain event are associated with the consequences of climate change. This statement should, however, not be misinterpreted in a way that it appears as if people do not believe in climate change or deny that changes are happening. It does, however, mean that Copenhagen has been spared the more extreme consequences, and due to this, there is a perception that solutions such as green roofs, might not be as necessary to implement yet (Ibid.).

> "[...] *and the fact that we are not experiencing someone who says that this is a completely necessary solution or a necessary thing, as actions to solve either Urban heat island or water, is the biggest barrier*"

(Appendix 1; 37:56)

When the proposed solution is a solution to issues that are not perceived as being issues yet, then it is quite difficult to get support to change requirements and laws that would make green roofs a requirement on all new constructions. The need to work with this challenge is quite important, and how it could be done, might be to look elsewhere to neighboring countries and cities where they have similar issues. Then the consequences would be a bit more visible, and perhaps this could be enough to change the perception that people have.

### 6.1.2. The Swedish Perspective on the Barriers and Challenges for the Implementation of Green Roofs:

This subsection is regarding the Swedish perspective on the barriers that inhibit the implementation of green roofs. More specifically it focuses on the barriers in Stockholm, as this is where the respondent was located.

#### 6.1.2.1. Implementation of Green Roofs in New Urban Areas and Legislative Efforts:

Like Copenhagen, Stockholm is also an older European city with many old buildings that simply does not support the implementation of green roofing solutions. However, in new urban areas that are being constructed, specifically in the SRS, the authorities have made demands that green roofs are implemented if technically possible (Appendix 2). This has created a huge increase in green roofs in SRS. In the rest of Stockholm, however, the increase has not been as large. The respondent contributes this to a fundamental lack of knowledge regarding green roofs, which slows the development quite extensively. The lack of knowledge is found within the actors of the construction industry, the potential operators of green roofs, and in terms of maintenance. There are slowly being implemented demands for green roofs in all of Stockholm, but this development is not fast, but it is a step in the right direction. There is, however, also issues with legislating on solutions such as green roofs, that needs to be taken into account. The respondent from Stockholm had an interesting perspective regarding legislative action, and that it is not enough to just create any type of legislation as;

> "*Everything depends on how the legislation would be formulated. If the requirements are too low, measures would not be efficient and development could be slowed.*"
>
> (Appendix 2; Q8)

This means that, if legislation created to support the rise in implemented green roofs, is not strict enough, then it will contribute to unwanted effects of actually slowing the development, instead of enhancing it. In order to deal with this issue, the concept of cross-scale jurisdictions would be interesting to include. Experiences made from working with SRS could, as is is the case, be drawn upon, and the actions that helped to push for requirements on green roofs in new constructions, would be transferable from a more “local” perspective, to a larger regional perspective. This would quite possibly contribute to the creation of legislation that was fitting the context and was not too lax so that the development would not be affected negatively.

#### 6.1.2.2. Uncertainty Regarding the Technical Capacity of Green Roofs and the Climate:

Another barrier pointed out by the respondent, was that uncertainty regarding the future, is something that can affect people's willingness to invest in green roofs, as well as decision makers’ will to require green roofs. Several questions regarding the uncertainty was posed by the respondent;

> “*However, it is always difficult to know when you have done enough. As it is difficult to predict the future. How much warmer or wetter will it be? How fast will the climate change? What time perspective should we have in planning?*”
>
> (Appendix 2; Q2)

These questions underline that it can be difficult to know whether the solutions chosen actually does meet the requirements for future climate change consequences. This point has ties into the point made by the Danish respondent, who mentioned that it is difficult to act when you have not seen the consequences yet. In the same regard, it might be difficult to choose which solutions you should invest in, and there will highly be a doubt if the chosen solution then was the best choice. This is a barrier that is not so easily overcome, but it might be one that can be solved by using the experiences made by others and to create a system like Polycentric Governance, where risk mitigation is a core concept, that should be able to contain the worst risks if done correctly. As the future climate might change the weather patterns in Stockholm and Sweden in general, it creates uncertainties. The fact is, that the current weather in Stockholm is already quite hostile towards green vegetation. Elaborated by the respondent, it was stated that the climate in Sweden, and most of Scandinavia, can be considered a barrier, as the winters are very cold, but the summers can

be equally warm. This creates a span between two polarizing conditions, both of which plants and green vegetation does not thrive in. Due to this, concerns regarding green roofing as a climate adaptation solution needs an increased effort and research to examine which types of plants that are the best fit, and which can survive both extremes of the “weather scale”. The respondent pointed out, that because of this, a solution might be to remove the plants from the roofs regularly when the weather was too extreme, but this would increase the cost significantly, which is already a huge barrier (Appendix 2). This was something that needed to be examined quite extensively. The issue is likely to be transferred to a Danish context as well, given the similarities in climate.

#### 6.1.2.3. Certification Schemes and Green Roofs:

Many places and cities use building certification schemes such as DGNB, LEED and BREEAM, which encourage sustainable building through a point awarding system that can lead to a building getting a certain certification. These have the potential to encourage the implementation of green roofs by awarding developers and building owners with points that play into their final score and certification ranking. There are, however, some pitfalls in using these building certification schemes, as it is the developer that chooses freely which aspects they should focus on, and which points they want to get. The issue with this, and why this is a barrier for green roofs, is that, since green roofs are perceived to be an expensive solution, developers and contractors might choose to go with other solutions or implementations that awards the same amount of points as greens roofs do. If there are no requirements to implement a green roof on a building, then there is a risk that certification schemes would push green roofs even further away due to their cost (Appendix 2). Building certification schemes are in themselves also not cheap, so to comply with some of these in the first place is an investment, which might make another big investment in i.e. green roofs less attractive if not implemented in the first place.

### 6.1.3. The German Perspective on the Barriers and Challenges for the Implementation of Green Roofs:

This subsection revolves around the responses gained from the respondents of Berlin. The respondent(s) were an advocacy and lobby group for everyone who has an interest in green roofs, green facades and interior greening. As this respondents’ aim is to promote green roofs and all the benefits and positive aspects of these solutions, they did not delve into many barriers. They did, however, mention some, which are what will be examined in this subsection. Aside from the respondent’s own claims, some claims will be expanded upon by

other respondents who also had some insight into the state of green roof implementation in Germany. As the respondent replied by e-mail, due to the COVID-19 situation, the answers were not as comprehensive as other respondent answers.

#### 6.1.3.1. The High Cost of the Roofs Keep People Disinterested:

The respondent from Berlin mentioned as one of their only barrier or challenges more likely, to be that the price of green roofs is still too high. This makes people not wanting to buy them, as they would rather spend their money on other solutions (Appendix 3). This is the same issues as many other places, that green roofs are perceived as expensive. There is, however, an interesting comparison of conflicting opinions to be made, which can be delved more into in the discussion. The essence of the conflicting opinions, however, is that green roofs are perceived as being quite expensive, to an amount that makes them unattractive as solutions for many, but two of the respondents, claims that the price has almost been cut in half, especially in Germany. The two respondents claim that green roofs are not as expensive as they have been, and that they are nearly at the same level as regular roofs (Appendix 4; Appendix 5). The respondent from Berlin did not mention any other barriers, but it must be assumed that they are facing some of the same challenges as both Denmark and Sweden, albeit that Germany are one of the front runners regarding green solutions. A barrier that was pointed out by the respondent from Switzerland, who had some insight into the state of matters in Germany as well, pointed out that people do not seem to be very interested in green roof solutions. The reason behind this is tied together with the maintenance fee that is often seen in connection with green roofs. Even though some people are able to get subsidies for green roofs, they do not wish to receive them, because they are told by green roof companies, that they need to maintain the roofs during their expected lifetime, and that this is an expense for the owner of the roof (Appendix 4). As it will be examined later, there are some possible ways of going around this issue, but currently, these are some of the barriers that are found some places in Germany, and Berlin amongst other cities.

## 6.1.4. The Swiss Perspective on the Barriers and Challenges for the Implementation of Green Roofs:

In this subsection, the answers received from the Swiss respondent, are examined and analyzed upon. As the respondent has spent much time researching and working with green roofs, both in Switzerland and other places around Europe, some of the answers have a general perspective, and are not exclusive to Basel and Switzerland.

### 6.1.4.1. The General Aspects of Green Roofing Solutions and Lack of Knowledge:

As mentioned before, the price of green roofs is quite high, or are at least perceived to be. This is also underlined by the respondent from Basel, who claims that they have been able to reduce the price of green roofs to an extent, that is almost identical to that of ordinary roofs. The respondent does, however, recognize the issue being a barrier in many other cities (Appendix 4). A barrier that they are still encountering in Basel and Switzerland is the lack of knowledge regarding green roofs, and how to maintain them. It is argued that the cost of maintaining a green roof deter people from wanting to establish them in the first place. This is even if they are "gifted" a green roof, meaning that the costs of establishing a green roof is covered for them. Then the owners of the roofs are told that they need to remember to maintain it, and what the cost of this maintenance is. Confusion rules, as people are given dubious instruction manuals on how to maintain their roof, which makes things much more complicated than they really are, according to the respondent (Appendix 4).

> "[...] *then you have a manual that says that you have to go twice a year and weed everything that is not in the plan, that is not sedum, you have to weed it out. And this is for me strange, because every weed or whatever plant that is coming spontaneous is not a technical problem, so just leave that space how it is developing, that should be the goal and* [...] *you should, from my perspective tell the people, be relaxed, this is not a garden.*"
>
> (Appendix 4; 28:14).

Based on this quote, the roof owners should not get so hung up in whether they should be removing the weeds or not. There is of course the aspect of multifunctionality in some green roofs, but for a basic green roof, it does not have to be too complicated. As the respondent points out, the roof is not a garden, and the weeds do not affect the technical capacity of the roof, so there is no need to spend money on maintaining it as often as the roofing companies

might want the owners to do. The barriers are, in a sense, almost that too much information is given to the roof owners, or that they become misguided in several cases. This ties together with a claim from the respondent, that people often choose to get more expensive, but underperforming green roofs, due to their lack of knowledge. The roof owners are told a lot of information from the green roof companies that make the roofs, and it is all a bit too complicated according to the respondent. This is an example of where a Polycentric Governance perspective could play a relevant role. Through Polycentric Governance systems, public participation could be facilitated, with representatives from many different scales bringing knowledge that can contribute to successful green roof implementation. Through this facilitation of public participation and knowledge sharing, the roof owners could learn more about green roofs, and make more educated decisions, which perhaps, would lead to a bigger implementation of green roofs, that are not only cheaper, but also perform above average, and in addition requires a minimum of maintenance.

#### 6.1.4.2. Green Roofing Companies, the Value of Green Roofs, and the Debate Between Green Technologies:

In continuation of the previous statements regarding the perceived complexity of green roofs, the green roofing companies that manufacture the roofs, are in themselves a barrier for increased implementation. They are so, due to their “branding” strategies, which aim at making green roofs seem like an innovative clever solution, that can bring a lot of benefits with their implementation. They are, however, as mentioned above, phrasing this technology in a too complicated way for the potential consumers to understand, which drive them away from the technology.

There is, however, a market for green technologies which the green roof companies are trying to enter and profit from. In connection to this there is also another market, which is regarding the future maintenance of the green roofs, which the companies are also trying to make money from (Appendix 4). There is, of course, nothing wrong in trying to make a profit on creating solutions to climate adaptation issues, but it seems counterintuitive to make the use of the created solutions so complicated for the average customer, that they would rather not use it. Another barrier for green roofs is, that, unlike many other green solutions, green roofs does not, as such, produce any clear or immediate financial value, despite perhaps an, for some, aesthetically pleasing look, and a guarantee that they can retain some water. Unlike PV panels, that give a clear value in the form of energy, that the owner can either consume, or sell depending on the quantity of energy produced, green roofs do not produce

any corporeal value, at least not in its basic design (Green roofs for growing food exist, but these are not often used for climate adaptation purposes). This causes potential clients to make a choice between two solutions, and when one produces tangible value, and the other does not, it is quite obvious which of the two options many would prefer (Appendix 4). This has resulted in the emerge of a “debate” between PV panels and green roofs, when trying to allocate a use for roofing space. The respondent claims that there is an industry-driven attempt to get PV panels placed on roofs. It is technically possible to combine the two solutions, by raising the PV panels above the green roof, but it adds to the cost, and as it has been mentioned before several times, an added cost is not something that is welcomed with open arms by many. The people wanting PV panels on the roofs also have a different view on green technologies and sustainability, a view in which biodiversity, water retention and other benefits from green roofs, are not so important. This causes the green roofs to be less attractive. In Switzerland, they have building codes which state that you must build a green roof on new or renovated buildings. However, if PV panels are installed instead, then the building code declares that then it is not required to install a green roof (Ibid.). The respondent from Basel is however a firm believer that this is not the optimal solution, and that the building codes should instead declare that a combination should be installed, if PV panels are to be placed on the roofs (Appendix 4; 37:18). These barriers seem quite difficult to work around, but through the utilization of Polycentric Governance systems and the concepts within, it should be noted that, safe-to-fail interventions could play a role in working with the building code. If safe-to-fail interventions were put in place in a Polycentric Governance system in Basel, and it showed that the building codes were not working in terms of implementing green roofs combined with other technologies, it would be possible to change the building code and the approach, in order to work towards a combined use of green technologies, that does not exclude one another. In the same regard, the adaptive capacity of a Polycentric Governance system could play an important role, as the system, by utilizing two different green technologies, can adapt to even more environmental issues that are likely to appear in the future. Through a combination of these two technologies, it opens for possible experimentation of how these two technologies can benefit each other, which in turn will lead to experiences that can be utilized by other actors in the future.

#### 6.1.4.3. Calculation Tools and Future Issues Regarding Decommissioning:

In the opinion of the respondent from Basel, calculation tools, such as building certification schemes, and tools that calculate the value of i.e. green roofs based on predetermined assumptions are not very good to use (Appendix 4). The respondent mentions the same issues with building certification schemes as some of the former respondents has also pointed out. They argue that they have the risk of making green roofs a less attractive choice, if there are other, easier and cheaper options that contribute with the same amount of points. In Basel they do not want to use these solutions, as the respondent argues;

> "*Yeah, unfortunately what then the benefit for somebody in Germany is that you can bring green roofs into account in that calculation. Yeah, so say green roof has like 50% of the value lack of green space on the ground. And for example, in Switzerland, you're not allowed to do that* [...] *We don't want that somebody can come and say green roof is compensating something on the ground.*"
>
> (Appendix 4: 66:21)

What the respondent argues is, that by using these types of calculations, which are measuring on the wrong parameters, such as green roofs having a 50% lack of value compared to ground based green spaces (presumably because of their recreational aspects), you end up making the wrong arguments for the solution. In Basel they rather choose to not work with any calculation tools of this nature. It is the belief of the respondent that it is a waste of resources for cities to keep talking about best practice, the values of a green roof and the costs. Instead, resources should be directed towards creating new legislation and laws that support the implementation of more green roofs.

A final barrier mentioned by the Basel respondent, is a barrier that is not yet relevant, but it is surely one that will be relevant in the coming years, when older green roofs are going to be decommissioned. As plastic materials are often used in the composition of a green roof, there are worries that when time comes for them to be decommissioned, they will contribute to a bigger issue with what to do with the plastic elements. The barrier in this is that the negative effects of the plastic waste, might subtract from the environmental benefits the roof contributes to throughout its lifetime (Ibid.). Similar issues are seen with other green technologies, such as wind turbines, and how the glass fiber waste should be handled when a wind turbine is decommissioned. How this barrier is going to be solved is up for debate,

but it will require that more research goes into how green roofs can be created easier and cheaper without using plastic components.

### 6.1.5. The Baltimore and Stuttgart Perspective on the Barriers and Challenges for the Implementation of Green Roofs:

This is the last of the respondent's answers regarding the barriers for implementation of green roofs. This respondent's perspective is both as a citizen in the city of Baltimore in the US, but also as a native German, and perspectives from his hometown of Stuttgart. The respondent tries, at times to be very general in the statements given, but specific examples from Baltimore and Germany are given quite often.

#### 6.1.5.1. Lack of Knowledge Regarding Plants and General Aspects and Educational Aspects of Green Roofs:

Many of the barriers that the respondent from Baltimore claim affect the implementation of green roofs, are regarding lack of knowledge about many aspects of green roofs. The respondent made sure to emphasize the importance of having the factually correct knowledge about green roofs and the vegetation that grows on the roofs in particular. When this knowledge is missing, it results in suboptimal green roof solutions that end up costing more in maintenance than is necessary, which strengthens the existing notion of green roofs being an expensive solution (Appendix 5). The Baltimore respondent is a proponent of trees as opposed to other plants, as trees has the potential to store larger amounts of $CO_2$ than other plants. Another reason why the respondent think trees should be preferred compared to other plants, is that when the plants die during winter, there is a tendency to cut them down, which releases their stored $CO_2$ into the atmosphere again. This defeats the purpose of planting green vegetation, and as such, trees seem like the better solution. There is, however, issues with trees as well, as they weigh significantly more than plants, and therefore they are not optimal to use on roofs (Ibid.). Trees do, however, need a minimal amount of attention and maintenance, which makes them interesting to use in other solutions. Another barrier linked to the lack of knowledge, and increased maintenance costs is the fact that people lack the knowledge regarding the optimal air to water ratio needed to sustain plant growth. When the water to air ratio is imperfect, then the plants will die out, and then a need for new plants arise. This defeats the purpose of a green roof by always planting new plants, as maintenance costs rise, and the plants do not live long enough to contribute to the benefits of a green roof (Ibid.). The respondent mentions that lack of education regarding nature, contributes to a "fear" of nature that results in anything that resembles

“wild” nature is removed and/or controlled. This plays into former claims by other respondents that green roofs sometimes are over maintained, when they could just be left to their own, and maintained only a couple of times per year. The respondent argues that one specific type of green roof, food roofs (a green roof used for agricultural purposes), is more of a gimmick than anything else, as the quantity of food it can deliver is quite small. These types of roofs do, however, open up for great educational aspects in terms of education school children of where and how food is grown (Ibid.). Public participation as a concept would be a method to facilitate and include people in possible workshops and information meetings, that might contribute to increased knowledge regarding all the things a green roof need. If experts with knowledge in the field was invited to share their knowledge it would be beneficial to the generation of knowledge.

#### 6.1.5.2. Artificial Irrigation and Building Certification Schemes:

Artificial irrigation is mentioned by the respondent as being one of the biggest issues with green roofs currently, especially in the US. Artificial irrigation is an issue, as it contradicts all the sustainable perspectives, through i.e. the inputs of large amounts of water, along with plants growing where they should not be able to grow amongst. Besides that, there is also the aspect of water being transported to places where water should not be present. The respondent pointed to examples such as Las Vegas, where there is a huge consumption of water just to keep their green spaces green. The same can be said for cruise ships, where their green roofs are nursed artificially, so that they are green no matter where in the world the ship is, be it Alaska or Dubai (Appendix 5). This is, according to the respondent, pointless and it goes against anything that green roofs should represent. This opinion is shared by the respondent from Basel too. The amount of money that is used to maintain green roofs of cruise ships amount to around 10.000$/month, which is a tremendous amount (Ibid.). The respondent claims that green roofs such as these will never pay back in an environmental sense. According to the respondent it makes no sense to use such high amounts of money to keep green roofs alive, it just makes them more expensive to operate than they need to. An interesting perspective was also pointed out, which was that the massive use of artificial irrigation, defeats the very purpose of green roofs in terms of stormwater retention capabilities. If the green roofs are irrigated during the day, then they are already at full water capacity as the soil is fully saturated with water to keep the plants green. When it starts to rain, however, the roofs have no retention capacity, and the stormwater is not retained by the green roofs. This means, that because of people's needs to have a green roof that are always green and healthy looking, one of the biggest

advantages of green roofs, are negated. This is an issue that is especially prevalent in the US according to the respondent. Another aspect the respondent mentioned as being more or less pointless was the use of Building certification schemes and green roofs to award points for a certification. There are high costs associated with getting these building certification schemes, and if owners of green roofs only get the green roofs to get points in a certification scheme, it would make much more sense to use the money to make more green roofs (Ibid.). The respondent argues that it is too expensive to get these certification schemes at least when they are used in connection with green roofs, as they just add to the cost;

> "*And I know a lot of clients, they say I build it, this and this and this way, this would be approximately elite silver, but I'm not going for the certification because otherwise I would then pay another hundred thousand dollar.*"
>
> (Appendix 5; 75:08).

There are other issues with the building certification schemes, or to be more precise, issues with the approach that users of these schemes have, in order to gain access easy and cheap points. Some of these issues can possibly relate to green roofs, but also other technologies and solutions. The respondent pointed out that examples of companies, that was made aware of the possibility to gain points in schemes such as the LEED-scheme, when using recycled materials such as plastic. This might be relevant in terms of green roofs as these use plastic components in their composition, and if these are made of recycled plastic, more points may be awarded in certification schemes. The issues are, however, that companies that produce the plastic materials have, unfortunately, been known to shred their new products and use the shredded material to produce "recycled" products (Ibid.). If such materials are used as components in green roofs, it defeats the purpose as a green technology, as the "double" production of "recycled" plastic, will contribute to even more waste and emission of greenhouse gasses.

#### 6.1.5.3. Business Aspects of Green Roofs, Legislative Actions and Technical Aspects of Vegetation:

Other areas in which barriers exist for green roofs are in the nature of the business aspects of green roof solutions, and the companies that manufacture these solutions. As mentioned in some of the former subsections, the green roof companies are, by some of the respondents, businesses like any other businesses, and they are trying to make money by selling a product and services relating to this product (Appendix 5). The green roof

companies do, however, in their effort to make their products and to make a profit, make their solutions too complicated and hard to understand for their customers, which in turn, scare potential customers away. The customers are fearing that, due to some complex partnerships with certain green roof manufacturers, they can dictate what products the people who wishes to establish a green roof are forced to use (Appendix 5).

> "*I need to add new waterproofing, then I go to a waterproofing guy or manufacturer, and ask him Okay, can I put a green roof on it? And then he will say, yes, you can, but only our system.*"
>
> (Appendix 5; 37:14)

This example serves to illustrate how the green roofing companies are trying to lock down their customers choices by only allowing the use of certain products within certain systems. This functions as a barrier for owners of green roofs that want a more customized/tailored option, and it contributes to additional costs for roof owners, as once they have bought a product from a certain manufacturer, apparently is forced to only buy other products and services from the same manufacturer. This results in the fact that, these manufacturers have a monopoly on the products the roof owner can use, which makes them able to raise the prices on their products and services (Ibid.). It is likewise pointed out by the respondent, that most green roof products, in the US at least, are primarily made to satisfy the stakeholders and to make profit. Why this is an issue, is that it often leads to plastic being used as a component in green roofs, as plastic is a very cheap product, that enables green roof companies to make profit. This enforces the issues of plastic being a future barrier, as this plastic needs to be decommissioned at some point in the future. The respondent also pointed to some barriers regarding legislative action on green roofs, and how it can be quite difficult to take legislative action and make tough laws that enable the implementation of green roofs. The respondent argued that, cities are considering whether they should make tougher legislation on green roofs in an attempt to increase the utilization of such solutions, but they are hesitant as differences in legislation across different cities can cause some issues. An example was given by the respondent, that highlighted this issue of some cities having legislation and others that do not;

> "*At a certain point, it cannot be the case that Maryland requires a green roof or a new warehouse and Pennsylvania, that's only 50 miles away, they don't require that, because then the investment goes to Pennsylvania. No, of course it costs them less.*"

(Appendix 5; 37:14)

This example was given in relation to big companies such grocery shopping giants, and them wanting to construct new warehouses. If there is legislation that requires that they establish green roofs on the new warehouse in one area, but that the same legislation is not present in another area, then the companies will, of course, choose the area where they can get the cheapest investment. Green roofs add to the cost of a warehouse, and if they can avoid this cost, they will (Ibid.). This can serve as an example of what can happen if there is no coordination between actors, with no common guidelines, and why Polycentric Governance systems can be useful in order to work with overcoming these issues. If this example was put into the perspective of Polycentric Governance systems, and the two cities were included as entities in the system, they would have had some overall rules that they should follow, preventing companies from escaping such demands. These rules could be that every new warehouse should have at least some green technology constructed on/in it. Then the different entities would be able to decide for themselves which green solution that would be relevant for them, but it would nonetheless contribute with some green solutions. This would also mean that the risk of failure of some of these chosen solutions would be even less, as the entities could draw on the experiences of others, and if every new warehouse got a green solution, some redundancy would be created. This would mean that even if the solution chosen did not perform as anticipated, all the other implemented solutions could make up for the one that did not work. If safe-to-fail interventions were to be included as well, then it would be possible to quickly change the rules and policies if it was discovered that some approaches worked better than others, in order to ensure the best possible solutions were chosen. This would in the end contribute to large companies choosing their new location, not based on the amount of money they can save on their investment, but rather where the optimal location for their business is, which is another point made by the respondent from Baltimore (Ibid.). One last barrier that the Baltimore respondent wished to point out was that there are a lot of current approaches to green roofs that are essentially wrong, which cause the roofs to underperform. In the end it damages the image of the green roofs and raises their maintenance cost even though it should be necessary. This barrier relates to the “instant gratification” that roof owners want to have, when getting a green roof. The roof owners do not want to wait 2 years for the plants to have grown naturally, so instead, they choose plants that grow quick, and plants that are fed a lot of fertilizer or other growth boosters in order to get them green more quickly. The issue in center of this, is that in doing so, the plants grow unnaturally, and they grow under

suboptimal conditions, which makes them underperform and be more prone to failure (Ibid.). It also causes issues with lack of biodiversity on the green roofs, which is otherwise quite important for well-functioning green roofs, and urban resilience for that matter. According to the respondent from Baltimore, the “sedum standard” mix that is often used on green roofs, is a bad approach, as it has virtually no diversity. This makes the plants more prone to sickness which affects both the maintenance cost, but also the cost of getting new plants to replace the dying ones. The respondent claims that by having a lot of different plants, the gene pool of the green roof is diversified and strengthened, which increases the resilience of the roof;

> “*It’s just a little bit of wrong approach but so i’m always promoting a certain diversity within the green roof and within the that because then a system is getting much more resilient* [...] *You want to have this gene pool of a lot of different plants that there’s always something and adapting to the situation adopting also to climate change situations.*”
>
> (Appendix 5; 23:32)

This ties back together with some of the first points made by the respondent, that there is a need for more knowledge regarding plants, what they need and how to best keep them alive and thriving. By making this knowledge available, one of the biggest barriers, the cost of maintenance and replacement of dying plants might be lessened, and green roof solutions might be cheaper and more widespread implemented.

## 6.2. Advantages and Drivers

This second and final subsection of the first sub-question; "*What are the most significant barriers and drivers regarding the implementation of green roofs in different cities?*" is addressing the possible advantages and drivers within green roof implementation in the cities. This is done in order to present a more profound and nuanced picture of which benefits green roofs contribute with, as well as understand what drives the expansion of them in each individual city.

### 6.2.1. Copenhagen, Denmark

#### 6.2.1.1. Local Planning Incentives are used as a Driver for more Green Roofs:

In Copenhagen, it has been politically decided to implement green roofs in some new urban development projects. In practice, this is carried out through the use of local plans (Appendix 1; 16:47). In Carlsberg Byen, which is a rather new urban development project in the Danish capital, it is requested, that all rooftops on new building constructions - to the extent that it is possible - are made with green roofs, or with a slope that makes it suitable for Photovoltaics (PVs) to be applied (Københavns Kommune, 2009). Formulations such as the one mentioned in the local plan for Carlsberg Byen, does not, however, equal successful implementation of green roofs, as this way of expression and similar, opens the door to free interpretation (Jørgensen et al, 2015). An entrepreneur has, on one occasion, interpreted the formulation of the tender in a way that the roof was constructed with green roofing felt, and not a green roof with soil and vegetation elements as intentionally described by the authorities. The incident was brought to court where the entrepreneur came out victoriously (ibid.). Within the overarching system of rules of a Polycentric Governance system, adaptive measures are in this case requested by some professionals. As the above-mentioned incident suggests that safe-to-fail intervention needs to be considered in order to restructure and adapt the way green roofs are described in future (Danish) local plans, to minimize the risk of too concise and poorly determined frameworks.

Furthermore, Danish environmental legislation allows the district council and/or utility companies to dictate if stormwater should be handled on the cadastral/locally (Trafik-, Bygge- og Boligstyrelsen, 2017). Leonardsen points to the fact that construction companies or other contractors are able to achieve financial savings in the form of a stormwater connection fee, when water is handled locally;

> *"[...] you can get half of the connection fees back per dwelling, if you establish solutions such as local drainage of rainwater, then you should be able to handle all the rainwater locally right? Up to a 10-year event"*
>
> (Appendix 1; 54:39)

To elaborate, current legislation in Copenhagen states that if someone wishes to assist in reducing their stress on the stormwater systems, they are offered the chance to get a discount if certain requirements are met. For instance, a minimum of 50% of the roof and surface area has to be able to handle the water on the cadastral, and then the discount is calculated accordingly (HOFOR, n.d.). It is also a prerequisite that the municipality approves a number of areas of the application before it is permitted. Subsequently, the utility company has to approve and assess the facility in order to approve the refund ibid.). The argument in center is, however, that companies and individuals are able to obtain financial savings if they invest in local drainage systems such as green roofs. This is a benefit for the utility companies as well;

> "[...] *This is because they can save some expansion of the sewage-system. But it has to be in some areas where it makes sense to them where they have a capacity need*"
>
> (Appendix 1; 18:14)

The financial incentives seem to be a driver for both the utility company and the building contractors and other landowners in the municipality. The capacity of the urban stormwater system is directly linked to financial expenses of the utility company, Greater Copenhagen Utility (HOFOR), who are in control of the solutions and technologies that should handle the precipitation volume of the future. This can be a challenging affair, as it can be difficult to predict exactly how much water will fall at any time, as well as their frequency. It is therefore in the utility companies' interest to ensure that, especially the common sewerage facilities, are exposed to a reduced volume of water in the future, as new measures such as pipes or other adaptation measures, which can be funded by them, are expensive to install. If the building contractors was to benefit from the opportunity of saving money on the connection fee, as well as making the building more attractive to potential business clients or tenants, it could be potential drivers (Appendix 1). On the contrary, the utility company does not currently express any strong and enthusiastic opinion towards green roofs, but it is believed that an explicit pro-green roof opinion would be a strong driver for the expansion of green roofs in the city (Appendix 1; 31:03).

#### 6.2.1.2. Knowledge, Competencies and Modern Buildings Equals Positive Feedback Loops:

Though the number of green roofs in Copenhagen are relatively limited, compared to other cities, Leonardsen are confident that a change will happen concurrently with the increasingly larger knowledge base and expertise;

> *"I think it will come quite steadily, there will be more green roofs as the manufacturers also become better at constructing them, and they also get cheaper and cheaper, and especially maybe also easier solutions so that they do not weigh as much"*

(Appendix 1; 45:25)

Not only is the respondent convinced that the volume of green roof will increase in the future, she also believes that the solutions get less heavy, higher quality and cheaper as the knowledge and practical experience with the roofs are strengthened. Other respondents - especially the ones from the more successful cities - are sharing the same optimism, which will be elaborated further in the Baltimore/Stuttgart, Stockholm and Basel-cases later.

Modern and flat-roofed buildings can also be a driver for the expansion of green roofs in Copenhagen. As opposed to the already presented argument made in the section regarding barriers, much of the existing building mass in Copenhagen are simply not suitable for green roofs. In combination with the requests for green roofs to be written into the local plans of new urban development projects, and the fact that modern and flat-roofed buildings are more suitable for green roof implementation, it is argued that new buildings will possibly be constructed with a larger quantity of green roofs than currently (Appendix 1; 23:00).

### 6.2.2. Stockholm, Sweden

#### 6.2.2.1. Strong Legislative Force and an Experimental Approach

The urban development project, SRS, has been an example of how strong legislative initiatives can drive the development of green roofs. Their approaches and solutions have been recognized internationally, and in 2015, they were awarded with a C40 cities award for best sustainable urban development project.

Entrepreneurs who wants to build in the SRS are obliged by contract to include green roofs. The illustration and master plan of Värtahamnen - a part of the SRS - serves as a good

example of how the initiatives in this urban development project (Figure 9) impacts the green roof development in Stockholm. As green roofs have become a major asset in this urban development project, the significance of the legislative actions appears to be arguably successful (Appendix 2).

*Figure 9: A visual representation of part of the SRS-development project (Business Finland, 2018)*

Green roofs in SRS are required by a Green Space Index, which is a tool used in Stockholm to both measure and assist in the planning and implementation of ecosystem perspectives in urban development projects (Appendix 2, Q4; Stockholm Stad, 2019). In order to comply with the requirements within stormwater management, biological diversity and social aspects, a green roof is necessary for the developers to be allocated land (Appendix 2; Q4). Since 2010, green roofs have been required in the urban planning of SRS, while the demand has been introduced to the rest of Stockholm in 2019 (Appendix 2; Q12). As such, SRS can be considered an experimental urban development arena, that allows planning ideas and methods to be tested in a bounded area (Dubbeldam A+D, 2018). The experiences and findings from this experimental approach can be transferred to the rest of Stockholm or other projects in order to create new frameworks and policies for urban development and green roofs.

Finally, the respondent believes that legislation regarding green roofs could be a driver for expansion of green roofs in the city (Appendix 2; Q8). In addition - and with relation to the

Danish respondent - Salmhofer too addresses that a growing volume of green roofs increases the knowledge-base, which can minimize the costs of implementing green roofs (ibid.). However, the way legislation is formulated plays an essential role (ibid.). By looking at the examples given above, there are definitely some strong Polycentric Governance concepts that could be viable to connect with the approach utilized in SRS. One that is very clear is the overarching system of rules, which affects every actor with a stake in the area, as they have to follow the proposed guidelines and legislations regarding implementation of green roofs. There are, however, some semi-autonomy present, as the developers and green roof companies can collaborate in order to create the best possible implementation of green roofs, within the legislative frameworks. The experimental approach that seems to be used extensively in SRS bears some resemblance of safe-to-fail interventions, as experimental approaches are encouraged, but if these fails, the framework in which they are created can be changed, and likewise with the legislation. This is especially true as Stockholm municipality owns the land of Stockholm, which enables interesting approaches to legislative action. This does also, however, contribute to a somewhat less Polycentric approach, as the municipality can make demands without the inclusion of other actors. From the examples, however, they do, however, seem to include many different actors in the development.

#### 6.2.2.2. Stockholm Royal Seaport - a Branding Tool for Developers and Companies

According to the respondent, developers are using the installation of green roofs to enhance their public relations agenda, while at the same time being allowed to build on very attractive land;

> *“As the Stockholm Royal Seaport is a very attractive site, developers see the installation of green roofs and multifunctional court yards positive to be used for public relations.”*
>
> (Appendix 2; Q4)

The same companies also show responsibility when implementing green roofs, which could be a benefit in terms of land allocation done by the city Stockholm (Appendix 2; Q7). Another incentive for them to keep driving the green roof expansion further could be to hand out awards for green roofs (Appendix 2; Q9). By complying with the requirements for green roofs companies, despite being “forced” to implement these solutions, gain branding advantages,

as they can promote themselves as being greener, or being environmentally conscious. This could perhaps be utilized in other places, as the notion of being “green” has a positive connotation, and it is related to being conscious of emissions and waste issues.

### 6.2.3. Berlin, Germany

#### 6.2.3.1. Potential Drivers of Green Roofs in Berlin

In Berlin, a range of different tools and approaches are able to assist in the expansion of green roofs.

> *“Building certification schemes [...] can play a strengthening role of increasing the utilization of green roofs in cities”*
>
> (Appendix 3; Q10)

DGNB, which is a German building certification scheme with roots in how the Brundtland reports defined the aspects of sustainability (NCC, n.d.), can be utilized as a tool which could drive the expansion of green roofs in Berlin (Appendix 3; Q10). In the light of climate change, the respondent points to the fact that many people become more focused to the sustainable and climate-friendly lifestyle, also in construction. DGNB is a tool that can be utilized in order to ensure that people can benefit from sustainable solutions in construction, and that building contractors can use the certification as a marketing tool (ibid.). This can be related to the point given by the Swedish respondent, that developers have the opportunity to use green roofs as a branding tool in some regard. In addition, it is argued that land is a valuable commodity, and to use this in order to create climate adaptation solutions can challenging. Green roofs allow the stormwater management to be handled in a decentralized way, even in urban areas with high density (Appendix 3; Q13).

Another tool that can be utilized in order to expand green roofs is through a divided wastewater and stormwater fee. This would indirectly support the expansion of green roofs, as water from precipitation does not require the same treatment as wastewater from e.g. big manufacturing companies and the like (Appendix 3; Q17). How this could and should be carried out in practice is however not elaborated by the respondent. In this regard, it could be a potential area which could be included in a collaborative effort, with multiple stakeholders relating to these issues could be included, in order to find the best possible solution. By making sure that there is some aspect of incentives compatibility, it gives the

stakeholders incentives to partake in these collaborations, and to comply with a proposed set of rules that aim to enable a solution to be found in unison.

Finally, German national guidelines and legislation enables that green roofs can be used as a climate adaptation measure;

> "*According to the Federal Building Code, the requirements of climate protection and climate adaptation must be taken into account. On this basis, municipalities can define green roofs in their urban land use plans or determine green roofs statutes for the city area*"
>
> (Appendix 3; Q15)

Interpreting this though a polycentric governance perspective, the semi-autonomous decision-making perspective is fulfilled, as the overall national guidelines/framework for green roof implementation have been provided by the German national government. The cross-scale jurisdiction enables actors on a regional and municipal level to define and implement green roofs as part of their urban land use plans, and in this way, integrate them in the urban environment.

## 6.2.4. Basel, Switzerland

### 6.2.4.1. Energy Saving Fund and Legislation - a Key Driver for Green Roofs in Basel

One of the key drivers of green roofs in Basel is their energy saving fund-initiative, which is subsidized with approximately 9,5 million euro annually. The energy saving fund is funded through an additional tax on the energy bills from the citizens of Basel. The additional tax was adopted in a democratic way, and the additional tax represents approximately 4-5% of the total energy bill. The fund is ensuring that energy saving measures receive funding in order to minimize the energy consumption in Basel (Appendix 4; 05:24). Green roofs must be assumed to fall within this category because of their insulating attributes.

The outcome of the initiative became that all the roofing companies "*got in contact with that technology, and they found out it's pretty normal, instead of making a gravel roof, you just make a green roof*" (Appendix 4; 05:24). The municipality of Basel later introduced a building code which emphasize and stipulates the construction of green roofs in the city (Brenneisen

& Baumann, 2016). Design guidelines associated with the building codes and legislation in Basel stipulates that:

- *"The growing medium should be native regional soils — the regulation recommends consulting a horticulturalist;*
- *The growing medium should be at least 10 cm deep;*
- *Mounds 30 cm high and 3 m wide should be provided as habitat for invertebrates;*
- *Vegetation should be a mix of native plant species, characteristic to Basel;*
- *Green roofs on flat roofs over 1,000 square meters must involve consultation with the city's green roof expert during design and construction."*

*(ibid.)*

The above-mentioned building codes also applies to the retrofitting of already existing building mass in the city (Appendix 4; 16:46).

What is important to keep in mind is the fact that Basel is a city with a stable tax-income from certain professions (Appendix 4; 43:53). This enables cities like Basel to create initiatives such as their energy saving fund. Other cities might not have the same option because of system-differences or lack of political encouragement, which naturally will have an impact on the options other cities have available to promote the use of green roofs in the city (ibid.). The above-mentioned guidelines encourage collaborative efforts between different actors, relating to vegetation, construction of green roofs, and the construction of buildings. The guidelines could, in theory, be included as part of the guidelines in a Polycentric Governance System, in order to make sure that the appropriate actors and stakeholders are included, and to ensure that they are all given a mandate to contribute with their specialized knowledge. In this way, more successful solutions may be created, and the chance of them failing, should be lessened.

#### 6.2.4.2. Cooling of the City and Prices of Green Roofs is both Important Aspects

With reference to the significance of the UHI-effect, the respondent from Basel brought up the challenges regarding UHI in cities;

> "*2003, that was like in Europe, [...] the key event in Europe, where in Paris 10.000 people died, during the heatwave. They measured in... all over Switzerland it was 1.000 people in that time, that died additionally*"
>
> (Appendix 4; 31:15)

Preventing casualties during heat waves can also be a driver for expanding green roofs, as green roofs are capable of cooling the city and reduce the impact of urban heat islands, in times of high temperatures (Appendix 4; 30:25). If it is possible to bring the cooling obligation to the building owners, that would be a positive approach, as it could have the potential to contribute with even more green roofs, if knowledge regarding their cooling capabilities were more widely known (ibid.).

Furthermore, the prices on green roofs play an important aspect in the expansion of green roofs, as it has already described in the above-mentioned barriers. Basel have had success with reducing green roof pricing, as low-tech green roofs have been widely used in the city;

> "*And we brought that price, or we make low-tech green roofing, and we brought that price down to let's say, around 20 euros per square meters*."
>
> (Appendix 4; 05:24).

These numbers are compared to other market prices, which Brenneisen believes are incredibly high (ibid.). He further elaborates that the roofing companies were not exactly enthusiastic about the green roof law requirement, however, they did not oppose it either, as they might be able to profit from installing a green roof on their building. It is also a possibility that the green roof companies are able to earn a semi-stable income from the associated maintenance work on the roof. What is considered both a driver and a barrier in this regard, is the fact that green roofs require equally, if not only a small bit more maintenance than a gravel roof. The fact that many companies do not inform their clients of this, can serve as an example of how the private market actors are able to control the way green roofs are presented to the outside world.

The law in Basel, has become a common part of the building code, on the same level as for instance insulation and fire prevention standards has, which has made the implementation of green roofs just as normal as insulating and/or fireproofing a building. 2016 numbers suggest that the amount of green roof projects in Basel is "*1711 extensive green roof projects and 218 intensive green roofs"* (Brenneisen & Baumann, 2016). This too is a testimony to the fact that the low-tech green roof systems (extensive solutions) is by far the most preferred solution to implement on the roofs in Basel.

The green roofs also offer designers, architects and planners a chance to utilize the empty roof-spaces for recreational purposes - an interest which, according to Brenneisen, is rather popular across different professions. This is a potential driver, as i.e. architects might advocate for the implementation of green roofs in designs, as they find them interesting to work with, and perhaps will aim to influence their clients to consider these solutions.

#### 6.2.4.3. Green Roofs Challenged by PVs?

As conventional roofs often are referred to as areas with poorly utilized space, it makes sense to build green roofs on them, and in that way benefit from the utilization of this unexploited space. In Basel, where green roofs are required by law, the only thing that might challenge them from being implemented are PV's. According to Brenneisen, it is possible to get around the green roof requirement in Basel if you apply the district council for PV-installation instead of constructing a green roof. The main challenge lies in the fact that green roof does not provide any direct financial benefits for the owner, which, on the contrary, PVs do (Appendix 4; 37:18).
A proposed solution is, however, to make a combination of a green roof and a PV-roof, a so-called bio solar roof. Bio solar roofs require some extensive planning, as planners have to consider both the performance of the PV's, but at the same time make sure that the vegetation on the green roof contributes with the many benefits it entails (ibid.). In this regard, it would perhaps be beneficial to make use of cross-jurisdictional and cross-scale collaborations with the intent of enabling the sharing of knowledge and experiences made by others who have worked with similar issues before. Likewise, actors from different scales would be able to contribute with their experiences both from a municipal and regional perspective, to a more local and area perspective. This would allow the planning system to have some adaptive capacity, as the collection of knowledge and experiences would surely make the entire system better prepared to act to changes. This is, however, something that

would need to be examined further. The combined solution does, however, offer some interesting potentials and synergies, as cooling from green roofs are known to increase the performance of PV-panels (Zandersen et al., 2014).

#### 6.2.4.4. Smart-City Perspective (In the Netherlands)

The Swiss respondent referred to a solution provided by a Dutch company who makes green roofs. The mentioned solution makes use of technological innovation, capable of measuring and controlling the outflow of water retained from the rooftops - an approach which, according to the respondent, is gaining an increased amount of attention;

> *"Well what I see one challenge is coming more up with water management now a days is the good solutions qua what I saw in the Netherlands recently. That you shouldn't work with the water retention just with the substrate on the roof, you should design your outlet of the water, the runoff. It is much easier because you can block almost every... all the water that is coming out of the roof, with a very simple technology. It doesn't need 3000 square meters of these eggshell mats for example, this plastic stuff."*
>
> (Appendix 4: 52:05)

The name of the company is 'Metropolder' and can be implemented as a regional solution to stormwater management. What is interesting about their roof solutions is the fact that they utilize both the evapotranspiration processes of the vegetation on the roof, but at the same time also allow the outflow of water to the sewage systems of the city, to be controlled by their system, which measures how much water is stored in their roof through technology. As the system is equipped with an automatic retention control, it is capable of controlling the outflow of water to the sewage systems, and thereby reduce and, possibly, control the peak flow of water during a precipitation occurrence in the city (Metropolder, n.d.). In summary, this solution not only retain water, but also measures and control when it should be passed on to the sewage system. The above-mentioned solutions are very well aligned with Brenneisen's assertion which propose that locally based innovation and locally based incentives are seen as an advantage to give a positive spin on the implementation of green roofs.

## 6.2.5. Baltimore and Stuttgart, United States and Germany

### 6.2.5.1. Trees can be Essential in Climate Adaptation:

The German/US respondent made it very clear, that trees plays an essential role in climate adaptation, as trees are able to, among other things, store carbon dioxide in a very good way (Appendix 5: 06:04). As such, planting trees should always be considered as a tool to achieve a higher level of climate adaptation in the cities, as well as storing greenhouse gasses and mitigate the consequences of climate changes. It is an approach which requires minimum effort and the benefits are multiple; "*You can also extremely cool down the temperatures of city not only by the shade of the trees, but also by the evaporation of trees*" (Appendix 5: 11:28). As mentioned earlier in this thesis, trees can also be planted on top of green roofs, meaning that it is possible to bring the same benefits to the top of buildings, if correctly implemented (ibid.). If it is not possible to implement an intensive or semi-intensive green roof, alternatives can bring additional value to the city as well;

> "*So, for me a typical extensive green roof a shallow system is for me better than nothing. It is and it's also used as a stormwater management tool. So from this perspective it's a very inexpensive solution that reduces the stormwater runoff, but also creates some of the environmental benefits, not the same as trees, but getting close to that, and so it is good.*"
>
> (Appendix 5: 11:28)

The quote above testifies that any action with regard to climate adaptation is better than no action at all. The respondent further mentions the fact that in many places in the US, branding or publicity is a driver that currently expands the use of green roofs in the US, similar to the situation in SRS. More specifically, big companies as well as some local governments seize the opportunity to enhance their image by implementing green roofs on public buildings or large warehouses or headquarters (Appendix 5: 86:09). It is apparent that image and branding plays a large role on the US green roof market, as the respondent repeatedly referred to the fact that green roofs often are awarded for i.e. the design of the green roof and the like. In this way, it is possible to create awareness and some sort of competition in order to spread the message of the multiple benefits provided by green roofs in the urban environment (Appendix 5: 06:04). The people within a certain building, equipped with a green roof, (residential or in a work environment) can in addition exploit the value created by having green roofs.

#### 6.2.5.2. Innovative Legislation on Green Roofs could Potentially Expand the use

With reference to the image and branding points mentioned above, some interesting legislative suggestions were brought up. The respondent proposed that, if big companies, for instance new huge grocery shopping markets or new shopping centers were required to implement a green roof as a prerequisite for being allowed to become located in the area, they would probably do it, since they have an interest in being close to their customers (Appendix 5: 37:14). The city can, however, be cautious of making these demands, if no national framework or guidelines prevents the businesses from relocating their activities elsewhere because of the green roof requirement. This is why the respondent proposed that a set of national guidelines or a framework should ensure that all states, regions or municipalities etc. are using the same framework with the same requirements in order to ensure that businesses who wants to establish themselves in an urban area do not just move their activities to other cities or municipalities. This initiative could for instance be supported by a temporarily tax reduction, in order to present an incentive for the industries to construct buildings with green roofs (ibid.). The temporary tax reduction could, depending on the level of taxation potentially co-finance the green roof itself.
In terms of renovation projects of already existing building mass, it was proposed that, if required by law, there would be less objections towards it. The example above, of cities being cautious of making demands for green roofs, if they are aware of their neighboring cities having none, is something that could be alleviated by the inclusion of a Polycentric Governance Systems perspective. If the higher levels of government made guidelines and/or legislation, that requires green solutions to be implemented, then the local municipalities can implement the best fitting solutions in their city, without worrying if companies are moving to the neighboring city, due to the same guidelines needing to be followed.

Finally, the respondent brought another interesting fact about the expansion of green roofs in Germany to the interview. It shows that heavy investments in huge quantities of green roofs made the price drop from 50-60 euros per sq. meter to 25-30 euros per sq. meter, which helps to generate more interest in the solutions. This advocates some of the claims brought forward by other respondents who also mentioned that a massive investment in green roof solutions can bring the prices down on the solutions available on the market. The German example here serves as a practical example on this particular assertion.

#### 6.2.5.3. Building Certification Schemes

The respondent shares a strong belief in the fact that building certification schemes were important to be introduced in the US, as it puts more emphasis on environmentally friendly buildings and the sustainability agenda in general (Appendix 5: 75:08). He did however bring some criticism to the certification schemes, as also presented in the barriers, which is why he brought up an interesting proposal regarding the creation of a public/governmental certification programme, which could challenge them;

> *"I think there should be it could be some maybe a nonprofit associated or in close relationship with a city with cities with state or with the government, where people make very specific recommendations, how a building needs to be built to meet certain requirements and this information and the services are for free."*
>
> (Appendix 5: 75:08)

The services that this programme could potentially offer would be to assist the building contractors with all the sparring they needed in order to become successful with implementing a larger number of green roofs in the city, and with sustainability in general (ibid.). Inspectors would then make sure that the gap between plan and execution is coherent and realized, and in this way "audit" the implementation. As formerly mentioned, it was proposed that this service should be free, and that all people who needs sparring or advice within the topic could receive it. Thinking about this solution in a polycentric perspective, it would certainly bring more actors and stakeholders together in order to shape and realize persistent solutions in the urban environment.

It is however important to remain critical towards building certification schemes, as it is also argued in the barriers that for instance 'recycled' plastic components can be descended from instantly recycled virgin materials. An independent, non-profit certification scheme could possibly ensure that these incidents are averted, as they do not have any economic incentives to drive them towards environmentally unsustainable solutions, as the plastic example could be categorized.

## 6.2.6. Sub-Conclusion

As presented in the two sub-sections above, the first sub-question; "*What are the most significant barriers and drivers regarding the implementation of green roofs in different cities?"* will be answered. For the purpose of simplifying the process of answering this sub-question, the two factors (benefits and advantages) will be divided into two separate sub-conclusions, as was also the case for the analysis of the different parts of the sub-question. The two separate sub conclusions will serve to answer the entirety of the first sub-question regarding the drivers and barriers. First the sub conclusion of the barriers will be given, followed by the sub conclusion on the advantages and drivers.

### 6.2.6.1. Sub-Conclusion on the Barriers for Green Roof Implementation:

This following subsection will serve as a summary and sub conclusion to the points made in the analyzed responses on the barriers for green roofs. It will include perspectives from all the respondents, and a categorization will be made in order to keep the sub conclusion easy to navigate.

### 6.2.6.2. The High Cost of Green Roofs and the Cost of Maintenance:

A barrier that was pointed out by every respondent is the perceived high prices of green roofs, and perhaps especially the maintenance of these during the lifetime of the roof. As mentioned by several respondents, the prices for green roofs are not as high as they used to be, but they are still high enough so that it makes them a less interesting green solution. Even more so, the knowledge that the roofs need maintenance is another reason that people do not want green roofs, even if they can receive subsidies that pay for most of the roof, people do not want to maintain the roof, and pay those regular fees for something that they do not get a clear value from.

### 6.2.6.3. Lack of Clear Values and Issues Regarding Legislative Actions:

Another barrier that was pointed out, albeit not by many, was the issues concerning the clear lack of immediate and tangible values gained from green roofs, compared to i.e. PV Panels, that generate a very tangible value. This makes PV panels a more attractive choice, as it is easier to argue for the extra expense if there are clear values that make an "instant" return on the investment. Other barriers include legislative action, and how this, in most cases is the best approach to increase the implementation of green roofs. There is, however, issues with legislative actions, as these needs to be created in the right framework and context, and that it has the possibility of being too lax, which could have negative effects on the

implementation of green roofs. Tough legislation is needed, but it is needed everywhere and not just in some places, as this will disrupt competition aspects between cities with regard to the fact that some companies choosing to the cities that have less legislation, as it will be cheaper to invest there.

#### 6.2.6.4. Lack of Knowledge and Issues Regarding Instant Gratification:

The lack of knowledge regarding green roofs, and the different aspects of green roofs (the vegetation, the need for maintenance, or the lack thereof etc.) is pointed out by many respondents as being a huge barrier, one that both affects the implementation of green roofs, but also one that affects the perception of solutions such as these. The lack of knowledge inhibits roof owners' abilities to make informed choices on solutions such as green roofs, and it also contributes to a slow societal implementation of green roofs, as contractors, developers and planners also lack knowledge about these solutions. Efforts that go into increasing knowledge regarding these solutions and how to maintain them is needed in order to implement more green roofs successfully. The aspect of maintaining the roofs properly is also a point made by some of the respondents. They point out that the lack of knowledge leads to the roof owners following the "instruction manuals" on green roofs blindly, which causes them to maintain the roof more than necessary. It also makes them choose the wrong types of plants, and not think about biodiversity on the green roofs. One of the biggest issues with this barrier is the huge use of irrigation of green roofs, which defeats their water retention potential, which is why many of the green roofs are constructed in the first place.

#### 6.2.6.5. Lack of Consequences from Climate Change and Complicated Business Models:

A barrier for green roofs is that some places around the world have yet to experience huge consequences of climate change, which makes an investment into green roof solutions a hard sell. There is also an aspect of uncertainty regarding the future needs that makes an investment into a technology that may or may not meet these future needs a "gamble" that many are hesitant to make. Specific to Scandinavia, the weather cycles are pointed to as being a barrier, as summer and winter can be in each end of the weather scale, and many plants cannot survive these two extremes. The general business model of green roof companies is also argued as being too complex, which hurt the companies own businesses, and makes it less attractive to get a green roof. This is, however, something that needs to be examined further.

#### 6.2.6.6. Sub-Conclusion for the Advantages

Both Stockholm and Copenhagen refer to the importance of how legislation is formulated in order to reduce uncertainties and the risk of failure. As especially Copenhagen have been victims of some serious misinterpretation, a stronger focus on formulating legislation is needed in order to ensure that all involved actors in urban development projects is on the same page and are working towards the common goal. In addition, legislation and local incentives are considered as significant drivers, as municipal requirements for green roof implementation is a simple, but strong driver for green roofs in the city. Municipal requirements can for instance be tested within a smaller urban area before being upscaled and implemented in the rest of the city. To support these requirements, it could be beneficial to construct a set of common standards. For the part regarding legislation, it is important to bear in mind that it requires a strong political encouragement, as it is the people, chosen in a democratic way, who holds the power to realize this change.

Local incentives are in addition also an important aspect to consider when striving to achieve a larger implementation of green roofs. Examples of this can for instance be different funding initiatives realized through i.e. an additional (small) tax in which the resources are directly used to fund climate adaptation initiatives and other beneficial subjects for the good of the city. The funding can also be used to generate knowledge and solutions, which in their own nature could be a driver. In this perspective, smart city-solutions could be of benefit to many cities, as a data-driven background might create more persistent solutions on a long-term basis.
Another example could also be the decoupling of wastewater and stormwater fee, which would provide private actors with incentives to consider implementing green solutions on their private land, which could benefit themselves financially, but also the utility companies, as the stress on their sewage systems become reduced.

Furthermore, tools such as the Green Space Index used in Stockholm could be of assistance in terms of implementing a larger scope of polycentricity, as these tools presents an overall framework and common guidelines for the provider of a green roof.
Many respondents agree on the fact that the local governments should be the ones responsible making requirements for green roofs, as experiences shows that this is a successful way of expanding the use of green roofs. The local governments should, however, be relieved by some overall guidelines from a higher level (e.g. regional or national standards).

Several respondents agree that utilizing green roofs as a PR or branding tool could benefit many private actors, as well as assist in the further expansive use of green roofs. In the US, awards are often given to green roofs on buildings, which could potentially be an incentive to implement these. Building certification schemes could in this regard too be considered as a driver, as their focus on sustainability and environment can cause a larger volume of green roofs to emerge in the cities because of their point-awarding systems.

Finally, it is important to consider all the benefits of green roofs, and not only reduce their function to a climate adaptation technology. The many benefits of the green roofs can be considered as strong drivers in terms of many other perspectives, such as the reduction of the UHI-effect.

# 6.3. Legislative /Political tools

This subsection is going to analyze the sub-question, "*Which tools are being utilized when green roofs are implemented, both private and public, and which incentives do they encourage?*", and it is concerned with the analysis of the different tools that are available for decision-makers when trying to increase the utilization of green roofs and other green solutions. These are tools that each of the respondents have pointed towards, either being some that is widely used in general, or some that is more context specific to the place where the respondent is from. Few of the tools are theoretical, possible future tools, that do, however, seem to make sense when seen in the current landscape. As with the former subsections, this too follows the template of which cities are first and which are last.

## 6.3.1. Copenhagen, Denmark

### 6.3.1.1. Tools that are Utilized in Copenhagen to Support the Implementation of Green Roofs:

The respondent from Copenhagen pointed to many different tools that the municipalities can utilize in order to facilitate and support the growth of more green roofs in the city. Many of these tools revolve around the possibilities to make demands or requirements on green roofs, especially in new building and construction projects. There are, however, as already mentioned in the barriers section, not many possibilities for the implementation of green roofs on the existing building mass in Copenhagen, as the buildings simply do not support such constructions. Where the existing buildings do, however, support green roofs, the municipalities have the possibility to create some incentives for the building owners, to make it attractive for them to get a green roof (Appendix 1). Another benefit for building owners, and for the utility companies, is that the municipality of Copenhagen, can refund a part of the connection fee back to the utility companies and building owners. This can amount to as much as 17.000 DKK pr. house. This is a tool, as the refund can only happen if stormwater is handled on site locally at the houses, which encourage the implementation of solutions such as green roofs (ibid.). This is a bit conflicting with a statement made in the barriers section, that there currently are no financial incentives regarding green roofs. That might only be the half-truth, as this refund of the connection fee is not directly regarding green roofs, but it can, however, contribute to the implementation of one. Public participation efforts are, just as in many other aspects, also utilized as a tool in the implementation of green roof solutions and in climate change adaptation in general. The municipality has the opportunity

to include requirements on public inclusion through public participation actions, which can encourage and influence the development and implementation of green solutions, i.e. green roofs. The respondent had an example of how this had been done in practice through the development of climate adaptation in Copenhagen in the area of South Harbor (Sydhavnen). In one of the poorest areas in all of Copenhagen, a very successful climate adaptation project has been developed in very close collaboration with the local residents and the local housing associations. Because of the successful inclusion of the residents and the housing associations, there have been a large commitment towards the project, and it has caused the residents in the area to feel some responsibility towards the solutions developed and the area itself. Because of this responsibility, the respondent claims that there is no garbage or litter in the area, as the residents feel a sense of ownership and responsibility towards the area, as they were included in the work.

> "*So.. to me, the transformation into something better can take many shapes and forms, it can be about environmental sustainability, climate sustainability, but certainly also about the social sustainability, the social cohesion forces in the city which is extremely important.*"
>
> (Appendix 1; 58:17)

This quote aims to illustrate that, even though climate adaptation is primarily concerned with environmental and climate sustainability, making use of public participation which includes the local population and their ideas, can be highly beneficial. By including the local population, the social cohesion in the city is strengthened, which, as the respondent points out, is extremely important, as it provides responsibility and ownership of the different areas of the city. This in turn, makes the implemented solutions more accepted perhaps, as the population feels that they have contributed towards the realization of the solutions.

#### 6.3.1.2. Certifications, Legislation on Local Plans and Cross-Scale Implementation:

Building Certification schemes (DGNB, LEED, BREEAM etc.) are seen as tools that have a potential to contribute with an increase in the number of green roofs. There are, however, some issues with them, which has been explored in the barriers section. Municipalities do, however, have the option to develop their own tools that can function in a similar fashion as building certification schemes. In Copenhagen they have developed a greening tool (begrønnings værktøj). Such tools can be developed and used, where they value aspects such as biodiversity, stormwater retention etc. and where green roofs can be weighted

heavier than other solutions. These types of tools also have the added benefit of illuminating the fact that green is not just green, and that it can have multiple added benefits, which are not completely obvious (Appendix 1). As these tools are made for a specific context, they have the inherent function that the criteria that weigh the most can be the criteria that encourage the greenest solutions. The respondent claims that these types of tools, can function almost as certification tools in their own way (ibid.). A tool that is mentioned by many respondents, including the one from Copenhagen, is legislative action regarding green roofs. The respondent from Copenhagen specifically mentioned that it would be possible to make legislation on local plans on a national level. By making legislation on local plans on a national level, legislators would make sure that the same framework was followed by every municipality when they would propose and implement local plans. This was something that was also pointed out by the respondent, as it was argued that legislation made on the national level, in the end, was something that should be implemented by local authorities on a local level (ibid.). These legislations regarding the local plans and what they should include and require could make it possible to make demands for more green solutions in new constructions. Such changes have, according to the respondent, already been made to how local plans should be formulated and what they require in terms of green solutions. These changes to the requirements of local plans has made it so, that it has become easier to finance green solutions;

> "*So because we have opportunities to just enroll climate adaptation as part of the local plans, it is clear that opportunities have also been made to make it easier for municipalities to finance these things"*
>
> (Appendix 1; 49:03)

Because of the opportunities made possible by legislation on the national level, the municipalities can more easily include climate adaptation measures into the requirements of the local plans. In the same regard, there has been efforts made in order to also make it easier to finance these solutions, as it is easier to make requirements on, which means that the whole process is now better able to deal with climate adaptation measures. It is pointed out by the respondent, that this is a step in the right direction, but that, in the future, legislation might need to be even more strict, in order to get the development going even further (Appendix 1). The municipality of Copenhagen has, as pointed out by the respondent, changed legislation regarding the utility companies' possibilities to finance green solutions pertaining to water related issues. This was changed back in 2013, and the legislation

allowed for utility companies to finance everything that was pertaining to water, by splitting the responsibilities for water and beautification measures respectively, between the utility companies and the municipality. This has made the utility companies able to focus on water related issues, and allowed them to seek alternative solutions, such as green roofs, as they now have the ability to finance such solutions. These solutions must, however, be approved by the utility secretariat (forsyningssekretariatet), to see if the chosen solution meets all the different criteria and demands regarding the distribution of expenses (ibid.).

#### 6.3.1.3. Polycentric Governance and the Political Tools of Copenhagen:

The tools utilized in Copenhagen when working with green roofs and climate adaptation in general, fit well into a Polycentric Governance perspective. Many of the tools, especially the legislative tools, function on multiple cross-scale levels with national authorities taking legislative action which have the purpose of allowing different opportunities for the local authorities to demand and require green roofs and similar solutions. Especially regarding the local plans, it seems as though the national authorities make the framework for the local plans, but it is up to the local authorities to fill out these frameworks with their own solutions that fit into their context. The different authorities are perceived as being more or less semi-autonomous in their decision-making regarding the implementation of their chosen solutions due to the aforementioned local implementation of solutions fitting the nationally proposed frameworks.

The concept of incentives compatibility is also represented in Copenhagen, as there is a strong connection between the overall rules proposed by the national authorities, and the incentives for the local authorities to try and implement green solutions. Specifically, an example of this, would be the legislation regarding the local plans, that make requirements for green solutions such as green roofs. The local authorities have the responsibility to follow this legislation, and to try and implement green solutions according with the overall requirements. These overall requirements, do, however, come with an incentive, specifically that it will be easier to finance the implementation of green solutions. Then, the local authorities are incentivized to implement these types of solutions, as they can (more) easily find the financing for green solutions. The same can be said for the way that utility companies are also incentivized to try and implement green water management solutions, as they have been given the opportunity to also finance these solutions, through the utility secretariat, as long as they meet the requirements put forth by the secretariat, and the distribution of expenses.

Public participation is very commonly utilized in Copenhagen, and it is no different in the implementation of climate adaptation solutions. By utilizing public participation, it strengthens the social cohesion in the city, and it makes it possible to draw on the experiences from the included actors, and to share ideas before the actual implementation. This has the chance of strengthening the final solutions that are going to be implemented as they have been scrutinized and have been going through an iterative process to find the best possible solution. What Copenhagen might lack, regarding Polycentric Governance, is the aspect of redundancy, as it seems as though the different municipalities in Denmark have their own specialists in different areas, which makes it so that there are less actors that fulfill the same roles. An example would be the utility companies, where it is Greater Copenhagen Utility (HOFOR) that is working in the Greater Copenhagen area, as the single utility provider. In other areas outside Copenhagen, it might be NOVAFOS, and because that only one utility company is working in an area, the chance of failure, as there are no other actors that fulfil the same role in the area, is therefore potentially heightened.

### 6.3.2. Stockholm, Sweden

#### 6.3.2.1. Stockholm and Their Approach to Legislative Tools:

As was pointed out in the analysis of the tools used in Copenhagen, the tools utilized in Stockholm are very similar, but also quite different in some regards. Many of the tools that the respondent from Stockholm pointed out which is being utilized, are regarding legislative approaches to the implementation of green roofs. The municipality of Stockholm, specifically in the SRS, are making demands that require all new urban development projects to have a green roof. They have been doing this since 2010 in the SRS, and in the rest of Stockholm since 2019. The legislative approach in Stockholm differs from the approach used in Copenhagen, as the demands for green roofs are not presented in the form of local plans. The demands for green roofs are put in place by the municipality of Stockholm, and if any developers or contractors want to construct a new building, they should implement a green roof. If they do not comply, they are not allocated any land development projects (Appendix 2). This demand excludes the developers that do not want the expenses of establishing green roofs and benefit those that do. The reason that enables the municipality to make such demands, is, that the municipality of Stockholm, owns the land in Stockholm (ibid.). This enables them to make requirements that are to be followed when seeking to get some land allocated for a project. It is pointed out by the respondent, that this approach is quite unique to Stockholm, and it might not be possible in other places, as they possibly do not

own the land. It was argued by the respondent, that a detailed planning approach can solve many issues, but in the end, it is legislation that will ultimately be the best tool to deal with these issues, and to make requirements for the implementation of green (ibid.).

#### 6.3.2.2. The Green Space Index, Branding Opportunities and Requirements for Managing Stormwater:

Again, much like in Copenhagen, Stockholm also makes use of some sort of certification tool, which is specifically tailored towards getting more green implemented in urban development projects. The tool that they are using in Stockholm is called a Green Space Index, and, according to the respondent, it is used to set certain requirements for the implementation of green solutions in new construction work, which are to be complied with. The requirements of the Green Space Index include that a green roof *must* be implemented in order to fulfil the criteria. Other than that, it is possible to gain points from implementing other green solutions, much like DGNB, LEED, and BREEAM, and a certain number of points is required in order to meet the overall requirements of the Green Space Index (Appendix 2). This contributes to a building mass in Stockholm, which meets the minimum requirements of green solutions proposed by the municipality. A tool that was specifically mentioned by the respondent from Stockholm was regarding the PR and branding opportunities of getting a green roof or other green solution. This is a tool that is both available for the municipality, as well as private actors who choose to implement a green roof. By private actor, at least in this context, it is mostly companies and businesses that can benefit from this. The municipality can use their knowledge of the benefits of green roofs in order to spin the possibilities of implementing a green roof into something attractive for developers. They can likewise use the branding on their own municipal buildings and show that they are an environmentally conscious municipality. In terms of the private stakeholders, it was pointed out by the respondent, that getting a green roof was seen as a PR tool, which companies could use to brand and advertise themselves as being environmentally conscious and green (ibid.). This makes an investment in a green roof more attractive, as it is seen as a way of getting increased positive publicity. A last tool that the respondent pointed out, was the requirement made from the municipality that stormwater should be handled locally on site, as the stormwater in SRS is not allowed to flow into the sewage systems. This requirement is, however, only made in regard to new constructions, as the older building mass, along with the sewage systems would have to be retrofitted in order to make this functional. The utility companies are pointed out as being a possible actor regarding making the requirements of stormwater management done locally (ibid.).

#### 6.3.2.3. Polycentric Governance and the Tools of Stockholm:

At first glance, the approach utilized by the municipality of Stockholm, seems less Polycentric in their approach to decision-making and legislation, and more monocentric. There are, however, aspects of Polycentricity as their use of the Green Space Index creates a framework and requirements, which are to be followed. How they are followed, however, is for the developer to decide. There are also aspects of the concept of Incentives compatibility, as the municipality of Stockholm makes an effort in making sure that the values of green roofs are known, which allows companies to use green roofs as PR tools and branding tools, which are incentives for getting a green roof. There are, of course, also the fact that by requiring green roofs, there is an incentive to implement such solutions, in order to be considered in the land allocation. As Stockholm and Copenhagen are somewhat similar due to their close geographical proximity, it must be assumed that they share quite a few of the same aspects of Polycentric Governance, but it must also be assumed that they might lack some of the same aspects. It appears there is not a huge amount of redundancy in Stockholm either, as many of the public instances are specialized in fulfilling one role, such as the case with the utility companies. This makes it difficult for one sector of the public authorities, to take over the work of another without it causing issues. In all, the approach in Stockholm seems less open for collaborative efforts, and more focused on making demands and requirements that are to be followed. This do, however, play into the aspect mentioned by the respondent from Stockholm, that legislative action is perceived as being the best possible solution to these types of issues.

### 6.3.3. Berlin, Germany

#### 6.3.3.1. The use of Inclusivity Through Funding, Cross-Scale Support for Authorities and Legislative Actions:

In Berlin, the respondent's answers weighted the use of different programs, that supported the implementation of green roofs, quite high. This seems to be one of the primary tools used in Berlin, as incentives for the implementation of green roofs are created through the support of financial programs, which can give funding to projects (Appendix 3). These programs are also supported by the inclusion of green roofs in the zoning plans in Berlin. This allows for the city to combine all the advantages of green roofs and support developers with implementation of green roofs through support programs. By approaching the implementation of green roofs in this way, the city of Berlin tries to enable the developers and other actors to make the best possible implementation of green solutions, by giving

them as much assistance as possible. It is not only the private actors that receive help and incentives through supporting frameworks. The municipality of Berlin are responsible for the task of implementing green roofs and other climate adaptation measures. They are not alone in this endeavor, however, as both national and regional planning authorities in Germany try to support the municipalities through subsidies, making specialist knowledge available and by creating legal frameworks that enable better conditions for green solutions (ibid.). A statement given by the respondent from Berlin, gives an insight into the German approach to climate adaptation and the implementation of green roofs;

> "*At the national level, German legislation enables the implementation of green roofs as a measure for climate adaptation. According to the Federal Building Code, the requirements of climate protection and climate adaptation must be taken into account*"
>
> (Appendix 3; Q15)

At the national level, the German approach to the implementation of green roofs is enabling the local authorities to make requirements on green roofs and climate adaptation, as the German building code demands that solutions such as green roofs, must be taken into account when developing new constructions and urban areas.

#### 6.3.3.2. Polycentric Governance and the Tools of Berlin:

The approaches and tools used in Berlin very much resemble that of a Polycentric Governance system, as there are multiple actors on different scales that function semi-autonomously, inside a framework of rules proposed by the national authorities. Inside this framework, the regional and local authorities can create incentives and different support programs, that support the implementation of green roof and other climate change adaptation solutions. There is also some level of exchange of experiences and knowledge going on between the actors, as the national authorities can support the other levels with specialist knowledge that potentially increase the local chances of certain projects to succeed. This too is an example of a good incentives' compatibility, where the frameworks and rules allow for many different incentives through the many different support programs. There are some aspects of redundancy as the national, regional and local levels all are striving to support the implementation of green roofs, through various means. They do, however, all have the same goal, which might contribute to, at least the lower levels of

authority, being a bit redundant, with the regional levels might being able to step in if the local approaches should fail. This is, however, a little speculative from the authors part. In the next paragraph, the tools utilized in the city of Basel, in Switzerland, will be examined.

### 6.3.4. Basel, Switzerland

In the city of Basel in Switzerland, many of the tools that are utilized in order to implement green roofs, are connected with legislative action.

#### 6.3.4.1. Legislative Actions as the Framework Enabling other Tools:

In Basel, legislations have played, and still play an important role in the development and implementation of green roofs in the city. Laws are put into place, which create a framework that enables future approaches and tools that further increase the implementation of green roofs (Appendix 4). By making laws that support the development of green solutions, which also makes these solutions a requirement, it removes the need for discussion regarding if green roofs should be implemented or not;

> "*So then kind of we had no really arguments against green roofing, because the trade, the roofing contractors [...] they were not kind of enthusiasts, but they did say, that if there is a law, and instead of putting gravel on the roofs we just make it green now, it doesn't matter we just do it*."
>
> (Appendix 4; 08:18).

It is argued by the respondent that when green roofs are required by law, the companies, even though they are not thrilled, will work inside the legislative framework that is proposed and continue their work. When they do not have a choice then the companies and developers will most likely accept that this is the framework that they have to work inside and use time and resources on discussing things (Appendix 4).

Some of the legislation that has been made in Basel regarding green roofs, is that this technology has been made a requirement in the building code. This means that green roofs are to be implemented in buildings in the same way as insulation, structural building aspects and the like. By utilizing the building code as a tool for implementing green roofs, the respondent claims that planners are able to make decisions on the thickness of the substrate of the roofs, so that the stormwater retention needs are met (ibid.).

#### 6.3.4.2. National Legislation and Local Incentives:

The respondent from Basel argues that the national authorities have had no influence on Basel's decision to include green roofs in the building code in the city. He does, however, point to the fact that national laws can be made, regarding ecological compensation, which green roofs can be defined as. It is, however, up to the individual municipality or local community how to define, how they are going to work with these issues (ibid.). The local perspective is pointed to, as being one of the most important factors in the implementation of green roof solutions. The respondent points to an example of why the local perspective is extraordinarily important;

> "*I think as we discussed a bit before, I think it's pretty much important that we work on locally with that stuff. Because the impact is mostly also locally. [...] So they could say like, for the research, that could be an important role for the federal institutions, but the local actions, the planning actions, I'm sure that must be locally.*"
>
> (Appendix 4; 60:18)

The respondent claims that the local perspective is significant as it is crucial to implement solutions on a local level, as it is where the impacts are affecting the local communities. The respondent argues that because of this, local actions, and local planning must happen locally. The municipalities are pointed to as being one actor, capable of facilitate and support these approaches, which makes sense, since they are working at the local level in an authority perspective, and on a daily basis, all year around.

#### 6.3.4.3. Funding Initiatives, Taxes and Environmental Calculations as Political Tools:

Other tools that the municipality can make use of include the creation of funding initiatives, legislation on taxation and utilization of calculation tools. The respondent mentioned funding initiatives as being a quite useful tool, which can support the development of green roofs. The reason for funding initiatives being a good tool in terms of implementation and development of green roofs, is that funding initiatives can be created with very specific requirements, which can be supportive of green roofs (Appendix 4). Another benefit of using tools such as funding initiatives is that they can be used to create incentives, and to motivate people regarding reducing energy use, emissions and to encourage implementation of green roofs. The same goes for using taxation as tools for the development of green roofs. The respondent from Basel emphasized taxes also being used in order to create incentives for

the implementation of green roofs and other green solutions. Taxes make it possible to split subsidies between people, which can be used as an incentive.

> "[You] *have to steer some environmental costs, you take the money and part of the money you give it back and you distribute it to everybody. Everybody gets a bit, and the ones that creates more cost, environmental cost, they are not benefited of course. So you try to steer, that they get motivation to reduce it.*"
>
> (Appendix 4; 55:10)

As stated in the quote above, the respondent argues, that by utilizing funding initiatives and taxes, the authorities can try to steer the development in a direction that is deemed attractive (in a sustainability perspective), and the ones complying to this get some benefits. The ones that do not comply are, of course, not benefited by the fund and tax subsidies (Appendix 4). One last tool mentioned by the respondent was the possibility to use calculation tools, which has also been mentioned by many of the other respondents. These calculation tools do, however, have many different purposes and are shaped differently depending on the context they are utilized in. The respondent from Basel mentioned an example from Germany, but it was a tool which could be used elsewhere with the same effect. The mentioned tool was a calculation tool which is used to calculate the different impacts from different sources in constructions. Then, after the impact calculations, the requirements to minimize the calculated impacts is made, so that they comply with regulations (ibid.). The respondent argued that this would not be the best solutions in Basel, but that it is, however, something that might work in other places. Such tools bring benefits to the building owners as well as the authorities, as it makes it possible to deal with the most severe impacts, but besides that, it also illuminates where the building owners have issues, which makes them able to deal with them. As also addressed in the barriers, a possible solution to the issues pertaining calculation tools, however, could be to develop a tool such as the greening tool (begrønningsværktøj) in Copenhagen or the Green Space Index in Stockholm. These tools seemingly calculate the value of green roofs on their own criteria, and not whether it has more or less value than ground based green spaces. This can lead to a more objective assessment of green roofs, if it is carried out correctly. This tool could be even further enhanced by drawing on the experiences made by the multiple decision-making entities in a Polycentric Governance system, that all draw on experiences from their own level and scale, to fit their own context. By approaching the creation of a tool in this manner, it might be possible to create a tool that works on most if not all of the different scales.

#### 6.3.4.4. Polycentric Governance and the Tools of Basel:

In Basel, most of the work with implementing and developing green roofs is done on the local level, meaning the municipality, local actors, funding initiatives and taxation created to support a local framework. It does, however, make sense that the local level is very much an important level to focus on, especially in Basel, as the respondent argued that this is where the important decisions has the biggest effect. In relation to the overarching system of rules which is one of the concepts of Polycentric Governance, it can be said that Basel has been very successful in creating rules and regulations that support the development and implementation of green roofs quite successfully. Through the implementation of requirements for green roofs in the building code, the city of Basel has made a framework which support the development of green roofs in the best possible way. It is a rules system which also allows other green solutions to be implemented, but green roofs in particular are made very easy to implement.
Based on the authority's willingness to make regulations and legislations, it is almost safe to say that there is an aspect of safe-to-fail interventions in place in Basel, which allows the authorities to change their legislation and approaches if they are deemed less than optimal. This makes the city authorities able to make legislations that support even better development of green roofs.
In terms of redundancy, Basel seems to be lacking especially since they are mostly working on the local level. There are, however, possibilities that the many funding initiatives and taxation legislations have some innate redundancy, as if one funding initiative cannot support the desired solutions, there are very likely some other funding initiatives that caters to the specific needs. This makes the other funding initiatives, who cannot support the solutions, redundant, but at the same time, it may be the other way around for other solutions.

In the next subsection regarding the different tools utilized by the different cities, Baltimore and in some respect, Stuttgart will be examined.

### 6.3.5. Baltimore and Stuttgart, United States and Germany

As the respondent from Baltimore/Stuttgart was speaking mostly from his background of being a horticultural technician and having his own company, the tools mentioned by the respondent was less politically related and more general tools that the respondent thinks is useful and has seen work regarding green roofs.

#### 6.3.5.1. Political Moxie and Cross-Scale Collaborations:

The respondent pointed to what, in the respondent's perception, was one of the easiest tools to make use of in the implementation and development of green roofs. This tool is the political "moxie" so to speak, meaning that municipalities and the different authorities should simply just make legislation that supports the implementation of green roof solutions. The reason for this is, that the municipalities and authorities know that there are some benefits related to green roofs, and even if they do not know, how many, or exactly which benefits there is, they do know that the roofs cause no harm (Appendix 5). The respondent claimed that this approach was used in Stuttgart, as an approach for enabling more citizens to move to the city;

> "*But then they said, okay, but we want to have more people in the city and we want to have more houses, more parking lots or whatever it is, you know, and then they said, okay, if we put green roofs on our buildings, we know we retain we don't know exactly how much today we know they retain around 50% of the annual rainfall of the systems.*"
>
> (Appendix 5; 37:14)

This statement was given in relation to an example given by the respondent, pertaining to the situation in Stuttgart in the 1980's, where the city wanted to have more citizens move to the city. However, due to the capacity of the sewage system of the city, it was not possible, as legislation in the city set requirements for how much water that is allowed to be led into the sewers. More citizens mean more water, but if green roofs were implemented, they could build denser, and get more citizens to the city, as the roofs would retain some of the water that would otherwise go into the sewage system (Appendix 5). In this regard, it was the green roofs that was utilized as a tool in order to gain the desired outcome. It is, however, not only the political moxie that is seen as a tool that can contribute the increased development of green roofs, and the respondent pointed to several other tools, that allows for both authorities and private stakeholders to reap the benefits of an increased amount of green roof implementation. Collaboration amongst the private and public sector was pointed out at being especially beneficial, for both the private companies and public authorities. The respondent argued that, municipalities, along with private green roof companies, could have several benefits to gain, if they began to work together in a collaborative effort. An example was given, illustrating this claim, as the respondent mentioned that this was what Stuttgart had done in order to lower the cost of green roofs. By collaborating across the private and

public sector, the actors managed to bring down the cost of a green roof by more than 50% per sq. meter. (ibid.). This happened as a direct consequence of the authorities ambition to implement a large quantity of green roofs. As the municipalities and authorities wanted to implement over 1 million sq. meters of green roofing, the green roof suppliers saw an opportunity to get a steady flow of work orders, which enabled them to lower the price in order to make green roofs more attractive, and to make sure that their roofs was the ones chosen (ibid.). This creates a stable environment for the roofing companies, which might encourage them to take more risks, as they know that they have incoming orders in the next foreseeable future. In the same regard as collaborating across sectors, the respondent also pointed towards cross-city collaborations as being necessary in order to create the best possible solutions. The respondent valued cross-city collaborations, as the different cities have divergent perspectives and experiences with climate adaptation solutions and the implementation of these solutions, which could benefit each of the cities within the collaboration (ibid.). It is, however, not only through cross-city collaborations, that greater development and implementation of green roofs can occur. The respondent pointed towards the need for nationwide legislative frameworks, that enable and facilitate these collaborations;

> "*[...] the state levels they have to agree on certain environmental measurements. That are consistent without the entire nation. This is important. You don't want to give investors an opportunity to go somewhere else because they get a cheaper there. You know, the costs should be pretty much everywhere the same.*"
>
> (Appendix 5; 37:14)

The respondent argues, that before cross-city collaborations can have the desired effect, nationwide legislation should be implemented, which should function as a framework in which the collaborations can be facilitated. This is also said in relation to the issues regarding companies and investors choosing the path where they can get the most value for their investments. If one area does not require climate change solutions, then it will surely be cheaper to invest there, than in an area that do require these types of solutions. By collaborating within the nationally proposed frameworks, the cities can work together in finding the solutions that work the best in their geographical area, and the solutions that will benefit each of the cities.

#### 6.3.5.2. Taxation and “Green Credit Trading”:

As other respondents have also pointed towards, the respondent from Baltimore mentioned the use of taxation as a tool to incentivize and encourage the implementation of green solutions. The respondent proposed a taxation model that would have the purpose of billing the “environmental sinners”, meaning the companies, people or other, that had too high emissions, or ones that have not implemented any green initiatives. By making fewer green approaches more expensive, incentives for implementing green solutions, and reducing emissions would be beneficial, and encourage a change in behaviors (Appendix 5). A similar model was given by the respondent from Basel, in terms of the energy fund tax that they are currently using in the city (Appendix 4). Besides taxation, the respondent mentioned a possible future tool, where it was made possible to “trade” green amenities or “green credits” between different people.

> “[...] *it’s like an open market, you know, when you have in this area, and this could be defined on a specific area or something like that, if you have a lot of free measurements and you don’t need them, you can sell it to somebody else who needs them.*”
>
> (Appendix 5; 37:14)

Here, the respondent describes the idea behind the “trading” of green amenities or “green credits”, where the ones with more green solutions, would be able to sell these areas to other actors who perhaps have no space to have these solutions. Then, people, companies, or municipalities who want to implement green roofs, but have no buildings to build them on, would be able to buy a space on a roof, and implement their solution this way. It is a highly theoretical tool, but if something like this came into existence, then it would perhaps be able to encourage and incentivize the implementation of green roofs, by allowing people to make profit from trading away their flat roof space. This would allow for more green roofs being made on available surfaces (Appendix 5).

#### 6.3.5.3. Polycentric Governance and the Tools of Baltimore and Stuttgart:

Many of the tools that the respondent from Baltimore points towards, seem inherently polycentric in their nature, with many of the tools focusing on cross-level collaborations and overall frameworks for facilitation of these collaborations. The national level creates the overall framework (the overarching system of rules), in which the local level authorities, the municipalities, work and create solutions in collaboration with each other. At the local level,

there is also cross-sector collaboration between private and public stakeholders, which result in better solutions due to mutual collaboration in order to generate incentives and benefits. In this constellation of actors, incentive compatibility is very important, as the different rules created on the different levels, have to have some incentive built into them, in order to maintain a successful network of collaborations. In the respondent's answers, incentive compatibility is expressed by the national frameworks that encourage city municipalities or regions to collaborate in order to gain equal chances for companies to invest in their area, as also mentioned in the "advantages". Through the municipal collaborations, requirements for green solutions create incentives for the private actors, as they can gain potential benefits by implementing these solutions, and they are able to invest in land if they meet the requirements. If the different city authorities are aiming towards working in the nationally proposed framework and are trying to implement the same legislations and solutions, then it could lead to redundancy between the different authorities. If one municipality is less successful than their neighboring municipalities, then they are redundant in some manner, but then it leads back to the issues with companies going where they get most value from their invested money. If a municipality or city is not successful in implementing green solutions, they could contribute to an imbalance between the municipalities in an area. This is where safe-to-fail interventions would come into force, if the national frameworks could either be changed, or allowed for the local levels to quickly change their approaches and legislations in order to enable more successful solutions. The cross-city collaborations could contribute to this, if the cities could draw on the experiences and "best practice" examples from other cities.

### 6.3.6 Sub Conclusion on the Different Tools Utilized by Actors Working with Green Roofs:

The many different cities utilize many localized tools which are working in the context of the specific city. In Copenhagen tools relating to including utility companies are quite unique, and context specific and not mentioned by any other respondent. However, in terms of making specific requirements on green roofs, Stockholm and Basel are the ones that utilize this approach the most. It appears it has been a quite effective approach, which also removes the need for discussing if green roofs should be implemented or not. In Germany, Berlin more specifically, focus lies more in creating programs and funding, which aim to encourage and incentivize stakeholders into implementing green roofs. These programs support and facilitate easier development of green roofs, but questions regarding their effectiveness are raised by some respondents. It is, however, clear that monetary incentives

are somewhat effective, as many of the different cities in some way or another utilize subsidies or tax benefits to incentivize the implementation of green roofs. Sharing of knowledge between actors and cross-scale collaborations is also something that is mentioned universally between the respondents, as being valuable tools to ensure that the best possible solutions are reached, which raises the question of more focus on Polycentric systems would be quite beneficial in the context of green roofs.

## 6.4. Networks and synergies

This paragraph is concerned with the sub-question: "*What is the role of cross-scale collaborations and networks, and how do these affect the expansion of green roofs?*". Private and public actors play a major role in expanding the use of green roofs. Consequently, it is important to analyses the synergies and collaborations between the green roof actors in the city. Partnerships on different levels as well as individual efforts can both have a big impact on how green roofs are used and expanded. This paragraph will have a closer look at the partnerships and efforts formed on different levels and cities and put in a polycentric governance perspective to learn where cities have failed or succeeded to apply this form of governance and which potentials this might have. It will also be concerned with some of the synergies between green roofs and actors i.e. educational institutions etc. As in the previous sections, this paragraph is also divided into smaller subsections which emphasizes the different cities in focus of this thesis, though this topic were not the most discussed topic during any of the interviews or e-mail responses.

### 6.4.1. Copenhagen, Denmark

#### 6.4.1.1. Private Actors Develop the Green Roof Solutions and Build Knowledge:

As previously mentioned, actors within the private market are the ones who often provide green roof solutions to the building contractors or developers. In Denmark, the respondent believes that some of the private actors are able to develop solutions that are easy to use, and on the same time build knowledge upon green roofs - all which, in the end, potentially could result in market with receding prices for installing green roofs (Appendix 1: 19:32 & 45:25).

#### 6.4.1.2. Copenhagen Collaborates with C40 Cities:

Copenhagen collaborates with cities from all over the world in order to learn more about state-of-the-art innovations and technologies within the sustainability agenda. Some of the more profoundly mentioned collaborations is the ones with the other C40 membership cities of Amsterdam and New York:

> "*[...] Amsterdam and New York are the ones who have been really far ahead in trying some things in my opinion. They are also related to which cities we are cooperating with regularly, we have a lot of cooperation with both Amsterdam and New York*"
>
> (Appendix 1: 46:27)

According to Leonardsen, there are also some differences between how cities use green roofs, in New York, for instance, they work a lot with the UHI-effect:

*"And it is not really something that has started to fill so much at home, it has started to fill really much for example in a city like New York, they really struggle with getting too hot in the summer, they have nothing but flat roofs, and so they have decided to do research on green roofs and what they can, both in terms of lowering the temperature and all sorts of other things"*

(Appendix 1: 27:47)

Research and knowledge-sharing are important features between these cities, as for instance New York do a lot of research on green roof performance. The Technical University of Denmark (DTU) is currently the only Danish actor who have acquired test-facilities to bring data and knowledge about green roofs in a Danish context to the debate. The test-facility is, however, fairly new, and research within the green roof systems is an ongoing process. The justification for making such a test-facility is to ensure that the immediate benefits of green roofs also are being supported by scientific data, as it is argued that only a few of the statements about green roofs currently are supported by science (Jensen, 2018). What the scientists from DTU measure is performance in relation to stormwater, moisture and roof temperature (ibid.).

Knowledge generated from experiences in other cities is, according to the respondent, also extremely important in a Danish/Copenhagen context, as it can be transferred to other cities, such as Copenhagen:

*“it is very important, it is really important! So... we learn a lot by participating in networks, we share our knowledge through networks and so on, so it's extremely important. It's also the way you become aware of what solutions may .. if any other cities have made some smart solutions and try to find out how can we transfer them to a Copenhagen context and vice versa, so it's extremely important.”*

(Appendix 1: 47:12)

This of course also applies the other way around, and other cities are also learning a lot from the initiatives in Copenhagen (Appendix 1: 43:56), i.e. in relation to sustainable mobility planning and bicycles. As knowledge sharing and cross-scale collaborations are already a huge part of how cities and municipalities approach work with green roofs, it would make sense to adopt aspects from Polycentric Governance. Many respondents, Leonardsen included, underline the importance of collaborative efforts, as there are much to be learned from one another, across municipalities and cities, as well as between countries. By collectively sharing best practice examples, and supporting these with scientific data, there are many potential benefits to be had, especially regarding the success rate of the implemented solutions. By supporting knowledge with evidence-based research actors in a collaborative constellation have the opportunity to implement solutions in the most optimal way, that ensures the success of said solution. If only one actor is “fumbling” in the dark, trying to find solutions, it might be a costly endeavor, which is surely to be rejected. This illustrates the need for a collaborative effort, on multiple scales.

#### 6.4.1.3. Local Planning not Enough, Coordination with Other Regional Actors Needed

A key issue when it comes to stormwater management is that the local solutions and planning perspectives are not necessarily sufficient enough in terms of ensuring common or consensus driven action to a certain issue. Leonardsen pointed to the fact that climate change and energy related issues needs to be addressed regionally, and that local initiatives not always are sufficient enough, and that this perspective is highly relevant in terms of for instance, coastal protection:

*“[...] If in CPH we decide to make coastal protection to secure us against a 1000-year event, while in Tårnby they decide that probably only a 100-year event is necessary, then the water can just run in through the back door to Copenhagen right?”*

(Appendix 1: 49:03)

In this perspective, it is addressed that there exists a need for regional planning authorities who are able to create synergies and coherent inter-municipal planning, so the burden of several municipalities does not turn into a burden for any individual municipality or planning level (Appendix 1: 51:03). Common action and coordination between different levels would in this regard ensure a higher level of polycentric governance, with several actors being utilized in order to create common and persistent solutions for the city. This perspective does, of course, also apply to lower and more practical planning levels, such as the collaborations between municipalities and i.e. housing-associations who are also able to create common solutions to specific problems in a collaborative effort. In this regard mitigation of risk could potentially come into play, as inclusion of different actors on different scales, contribute with a decrease of the chance of failure. If more parts of a system are aware of issues, and are working collectively to stop them, the chances of failure are surely minimized. If a common goal is proposed, then even if one part of the system "fail" or cannot reach that goal, other parts of the system are working towards the same goal, which increase the chances for success significantly. Because of this, there is a need for many different actors, as have been mentioned multiple times, by respondents as well as the authors.

#### 6.4.1.4. Utility Companies in Center of the Stormwater Management in Copenhagen and Beyond

A lot of the work with stormwater management in Copenhagen are directly linked with the utility companies. Especially associated with risk management and calculations with regard to the hydraulic needs in the city (Appendix 1: 53:34). The role of the utility companies is to execute the requirements and demands proposed by the municipalities, so they are the ones to deliver solutions within the framework set by the municipalities (Appendix 1: 1:01:00).

In Copenhagen, they closely collaborate with the local utility company, Greater Copenhagen Utility (HOFOR), which is responsible for the stormwater management in the 8 Danish municipalities: Albertslund, Brøndby, Dragør, Herlev, Hvidovre, København (Copenhagen), Rødovre and Vallensbæk, which are all municipalities surrounding Copenhagen (HOFOR, 2017). Copenhagen Municipality also discuss solutions with another utility company, NOVAFOS, which is responsible for some 9 and more northerly located municipalities within the capital region of Denmark. This collaboration is essential in order to prevent that precipitation from one municipal land does not become the problem in another:

"*[...] It is clear that we do not work so much with NOVAFOS (Danish water Utility company) because they just do not cover the municipality of Copenhagen, but we do have a collaboration with them because a number of our solutions extend to other municipalities, and therefore we have a collaboration.*"

(Appendix 1: 59:54)

## 6.4.2. Stockholm, Sweden

### 6.4.2.1. A Strong Public-Private Partnership

The urban planners of SRS have been working closely together with the Swedish Meteorological and Hydrological Institute (SMHI) at the early planning stages, in order to implement their recommendations and expertise regarding climate adaptation in the urban development project. The purpose is and were to anticipate the effects of climate change such as increased rainfall, warmer climate and rising sea levels (Appendix 2: Q2). Specific examples include:

> "*Adapting buildings to future climate conditions and extreme weather events by installing green roofs and courtyards connected with ponds, open stormwater systems and urban greenery; adapting public land to future climate conditions and cloud bursts such as installing multifunctional parks and integrated stormwater system that purifies and delays stormwater before released to the sea; raising the levels of grounds where needed; setting aside land corridors to help species migrate*."

(Appendix 2: Q2)

As mentioned earlier in this thesis, developers also use the SRS as a testbed where they are able to try out new and innovative solutions, and possibly implement the lessons learnt into future projects (Appendix 2: Q4). This makes up an excellent arena of creativity, where both developers, urban planners, architects etc. can plan and test out new ideas that can potentially benefit the rest of the city, or elsewhere.
A capacity building programme have been initiated as well, in order to build knowledge and a larger understanding of climate adaptation measures in the urban area, to benefit multiple planning perspectives (ibid.). The city of Stockholm has, in addition, had large success with 'matching' developers with green roof suppliers, supporting a strong collaborative effort in

the development of green solutions (ibid.). In this regard, these city-initiatives can be considered as a platform who facilitates and work with both public and private stakeholders in order to create profound, persistent solutions to benefit the city on a long-term basis.

#### 6.4.2.2. A Need to Build Knowledge on Green Roofs and to get Inspired by Other Cities

Even though SRS is putting mass emphasis on the exploitation of green roofs, it is acknowledged that there is a lot to learn from other cities as well (Appendix 2: Q12). The respondent points to the fact that other cities request thicker green roofs (ibid.), assumable because they are able to retain a higher level of precipitation. Furthermore, and as also stated by the respondent from Copenhagen, there is a need to build knowledge of for instance, green roofs (Appendix 2: Q13). In Stockholm, they have experts within the topics of environment, health, city planning and development in different administrative bodies of the municipality but contact to external experts are too assisting the city administration within these topics (ibid.).

### 6.4.3. Berlin, Germany

As a professional association and lobby group for companies, cities, universities and organizations, BüGG is widely embracing different stakeholders (Appendix 3; Q1). The organization currently have 361 members who operates within different areas of green roofs, facades and interior greenery (ibid.). They describe their own role in networks as; "*Our tasks include the provision of a platform for exchange between science, industry and cities in the field of greening buildings in Germany"* (Appendix 3; Q12). It is further elaborated that this approach ensures that knowledge about the implementation of green roofs can be shared and uncertainties can be reduced through the level of new research and exchange of the knowledge within (ibid.).

In addition, BüGG collaborate with other German-speaking associations from Austria, Switzerland and other parts of Europe in order to exchange knowledge, contacts and practical working aid for members of the organization (Appendix 3; Q1).

Finally, the respondent describes that the interest in green roofs as a climate adaptation measure constantly increases in German cities (Appendix 3: Q11). Examples like in Munich, Stuttgart, Frankfurt a.m. and Hamburg are presented as cities who pursue green roof strategies (ibid.).

## 6.4.4. Basel, Switzerland

### 6.4.4.1. Legislation on Green roofs and Democratic Processes

Metaphorically using the adaptive measures of the COVID-19 pandemic in Switzerland, the respondent from Basel drew some parallels to the way that the local government of Basel have exploited the use of green roofs on a local level. With the power to change legislation, they did so and achieved a large expansion of green roofs in the city. This happened without any national guidelines available to them, but the citizens, however, accepted the transition and today they have the largest number of green roofs in the world, measured in sq. meters per. citizen. Clear incentives and guidelines have too been helpful in this achievement.

The respondent from Basel furthermore highlights the importance of networks and knowledge sharing, even on a small scale, such as the knowledge and data shared with the authors for the writing of this thesis:

> "*We have the networks and people are asking... you know you come to me to ask about this, it is also a networking. We distribute the knowledge this way, right?*"
>
> (Appendix 4: 57:15)

In this regard, it can be highlighted that the city of Basel, does not rely on cross-jurisdictional collaborations, but rather cross-scale collaborations within the city limits, between the municipality and stakeholders. By acknowledging the need for political willpower and willingness to act, the authorities in Basel has made some legislative choices that ensures the implementation of green roofs. They then have had the opportunity to turn their attention towards cross-scale collaborations between the authorities, knowledge institutions and stakeholders, and how to highlight the benefit of green roofs (Appendix 4). The approach in Basel is to enable open debates regarding why things are the way they are, and also in terms of green roofs and why they are needed;

> *"So we don't need to make it I would say like to make it create kind of a common sense or like, how it says like in this question, you know, if you have to make actions to bring people together, to bring stakeholders together, I think don't make it to complicated, you know, because I think we have this humanity thinking. That's part of our culture. Cause we argue with each other all the experts are talking to each other.*

> *We have close enough hopefully, all over you are more or less to politicians, you know, we have an impact on them. We have democracy, you know."*
>
> (Appendix 4; 67:39)

It is believed that by enabling an open democratic debate and relying on actors listening to each other and experts, that opponents can be persuaded, or at least, accept the democratic decision-making process, where majority rules. This is a very locally based focus, which has proven to be quite successful in terms of the implementation of green roofs in Basel, and an approach which other cities could perhaps adopt, to create more local ownership feelings.

## 6.4.5. Baltimore and Stuttgart, United States and Germany

### 6.4.5.1. Green Roofs, Education Systems and Governance

The Baltimore and Stuttgart respondent stressed that green roofs could potentially be of assistance when it comes to the education of children from kindergarten and above (Appendix 5; 37:14). Given some urban schools location and distance from nature, green roofs can be utilized as an excursion destination where the children can learn more about nature, environmental issues and vegetation. It also gives teachers the opportunity to share facts and awareness about climate changes and the way they impact the planet (Appendix 5).

> *"[...] in general, it is important to create an awareness in a very early stage of a new generation about vegetation and how vegetation grows and how vegetation doesn't grow. [...] It's about the cities, the cities, it's a concentrated area with a lot of problems or a lot of challenges. They have a lot of challenges. But a decision needs to be made within the, within a city and whatever decision they have in mind, then this needs to be brought up on a state or country level."*
>
> (Appendix 5: 37:14)

The respondent believe that it is important that decisions regarding city challenges are brought to a state or country level and addressed on a national scale, which suggest that a Polycentric Governance system would be preferred by the respondent, as the national level could help formulate guidelines for the other scales. As formerly mentioned in the barriers, companies would for instance construct their new warehouses in municipalities or areas that do not have any local legislation regarding green solutions (ibid.). If these networks and

inter-municipal/regional synergies do not exist, market competition could be disrupted and the number of green roofs could be reduced, making the local legislation redundant. Implementing national legislation on this matter would ensure that people do not question the implementation of green roofs in the city, as well as making cities grow much faster, because they would like to live in the city (ibid.):

> *"And with these decisions, they should basically go with other cities and then to the state level, and then basically to the highest level depending on... on to the government level, depending on how they are sorted. And then bringing that also from top down, that there is a green area ratio, for example, that you need to have a certain amount of green."*
>
> (Appendix 5: 37:14)

### 6.4.6. Sub conclusion

The following can be concluded regarding the role of cross-scale collaborations and different green roof technologies: Every respondent underlines the importance of networks as these contribute to essential knowledge regarding green roofs and similar technologies, which enable more successful utilization of said technologies.

The need for cross-scale and cross-jurisdictional collaborations is likewise pointed to as being of high value, as it is difficult for one jurisdiction or one actor to act alone, with lasting and meaningful results. Even in Basel, where the local authorities chose to act and make legislations without influence from a national level, the need for cross-scale collaboration within the city is invaluable. The support from the local actors and stakeholders and the creation of strong public-private partnerships, along with democratic debates, contribute to the chosen solutions and legislation to be valid if the majority supports it. It also helps in determining the best possible solution for a given context, especially a locally based one. This validation is also important in the cross-country collaborations, as best practice examples can serve as a guideline for other countries and cities in order to determine whether the desired solutions are valid or not. Networks and synergies are present in almost every aspect of climate adaptation and green roof implementation, and it will likely stay that way, as it is an efficient approach to increasing successful climate adaptation.

# 7. Discussion

In this chapter the discussion of this thesis will be conducted, and the different uncovered aspects from the analysis chapter will be included in order to discuss the findings and they can contribute to answering the research question proposed in the thesis. This chapter will include the fourth and last sub-question of the research questions, which is; "*How can a created framework based on best practice examples contribute to enhance urban resilience through utilization of green roofs?"*. The different tools and approaches which are utilized in the examined cities, along with the "best practice" examples from each of them will be included. Best practice is meant as the solutions and tools which the cities themselves point towards or the ones which many of the respondents point towards, i.e. knowledge sharing. When each of the approaches which can be included in the framework, has been discussed, a model of the framework will be presented in order to illustrate the collected work in the discussion.

## 7.1. How Can a Created Framework Based on Best Practice Examples Contribute to Enhance Urban Resilience Through Utilization of Green Roofs?

To answer this question, the different findings from the analysis chapter will be included, as described above, in order to discuss how they can be included in a framework which will be proposed by the authors. The reasoning behind this framework is to create a "tool" which, in theory, could be utilized by cities and other stakeholders when trying to implement green roofs and when working towards enhanced urban resilience. To create this framework the findings from the analysis and the entirety of this discussion, will be based on a Polycentric Governance systems "framework", where the different elements of the framework will be inserted. The reasoning for this is that Polycentric Governance Systems inherently contain elements of a framework, which will make the process of fitting the proposed framework to a Polycentric perspective easier. The different elements of the proposed network will be discussed, both in terms of how they could potentially contribute to enhanced urban resilience, but also in terms of how they would contribute to and be affected by the Polycentric Governance perspective. It should, however, be noted that this framework will not fit in to every scenario or context without some preliminary work going into determining the needs and contexts of a specific area. The reasoning behind this statement can be found in the fact that climate change and the consequences hereof, are not the same in every

country or city around the world, and differences are present, which makes the solutions challenging to fit every scenario. Some places deal with the climate change consequences of increased stormwater and precipitation, which causes some issues that the adaptation solutions will need to manage. Other places, however, have the completely opposite issues, and they are desperately trying to keep water within the cities, due to droughts, and extreme temperatures. In these areas, stormwater management solutions may or may not be relevant, but keeping as much water in the city, and direct it away from it, is a high priority.

### 7.1.1. Inclusion of Different Cross-Scale Actors and Cross-Sector networking:

When working with Polycentric Governance Systems, it is highly unlikely that the cross-scale perspective can be avoided, as it plays a significant role in these systems. Likewise, in the proposed framework, the inclusion of different cross-scale actors, as well as cross-sector networking between the public and private stakeholders is one of the main suggestions to be included. The inclusion of different actors and networks, both across different scales and sectors, but also across city boundaries, is addressed by almost all of the respondents in the interviews. This seemingly suggests that it is a very important aspect in terms of the expansion of green roofs, and one that the authors want to implement in the proposed framework as well. The inclusion of different actors is in a Polycentric Governance perspective beneficial, as it allows for the sought-after solutions to be implemented on the according scale, in the appropriate context. Seeing as many of the respondents point towards green roofs and the implementation of these to be very context specific (Appendix 4; Appendix 2; Appendix 5), it might be beneficial to utilize a framework that supports the inclusion of cross-scale collaborations and the inclusions of many different actors.
Examples of how this could function in practice can be gained from both Copenhagen and Stockholm. In Copenhagen, utility companies are mentioned as an actor which are very interesting to collaborate with, as they have the know-how and knowledge regarding water management, along with potential pitfalls in suggested solutions. They also has ties to other municipalities and planning levels, which makes them compliant with the polycentric governance perspective. As the reason for the inclusion of different actors is a mutual beneficial collaboration, the utility companies might also gain something from their participation networks, within this framework.
Furthermore, it was pointed out that there are already existing benefits for utility companies (at least in Copenhagen and Berlin) where private actors can receive a financial refund on their investments, if water is managed locally. It is highly likely, based on this example, and

examples from other cities, that other benefits could be gained, such as easier financing of green solutions, financial gains and more successful implementation of sustainable water management solutions (Appendix 1; Appendix 3; Appendix 4).

Another example that might be an indication of how inclusion and collaboration across sectors could function in practice is gained from Stockholm. In Stockholm, as pointed out in the analysis, the city authorities make requirements for green roofs to be implemented in the SRS (Appendix 2). This is, however, not the only approach they are utilizing, as they are trying to include other private stakeholders i.e. green roofing companies, and developers/contractors in the process. This is done with the intent of trying to "match" the different actors with each other, in order to find the best possible fit, and to make sure that the best solutions are found. This might be a contributing factor to their relatively large success, and with the municipality as facilitators for this process, it is ensured that all actors are included. It is also a good example of how the inclusion of different cross-scale/sector actors can contribute to better solutions being found.
Most of the respondents point towards cross-scale/sector collaborations as being beneficial, but some do, however, also point out some potential areas where issues might arise.
The respondent from Basel (Appendix 4) mentioned that national demands or legislations might have the unfortunate side effect of seeming "alienated" for the local population in the affected cities. Nationally proposed legislation can be considered as a proposal 'coming from far away', and does not fit into the local context of a city. In this regard, it might be beneficial to include both national, regional and local actors in a Polycentric framework, with the aim of ensuring that the national level makes guidelines instead of legislation, which, in return, would potentially allow the local authorities to form their own legislation fitted to their unique context.
As a potential approach for dealing with how the local scale can deal with the issues of making context specific solutions and legislation, the creation of knowledge databases could perhaps be a possible way of doing this. By having databases where data from different parts of the country could be stored and freely accessed by local authorities or other stakeholders, it would perhaps contribute to easier implementation. Stakeholders and local authorities would be able to draw on the knowledge and experiences stored in the knowledge databases, and choose between different experiences with green roofs, that fit the same context as the local authority is working within. This would have the added benefit of also allowing the data to be used in evaluation measures regarding which type of roof that is to prefer in a desired context. The local authorities could then be able to determine

whether the roofing solutions should be extensive or intensive, which added values they would like, and if the roof should be combined with i.e. PV panels etc.
This could be a potential for more customized solutions that perhaps would perform better in the desired context they are placed in, rather than standard all-round solutions.

### 7.1.2. Legislative Guidelines, Regional Laws and Local Incentives:

As suggested in the former section, national legislation should perhaps instead be replaced by national guidelines, which in turn could allow more regional focus on legislation, and locally based implementation of these legislations. It is suggested by the authors of this thesis, and by a respondent as well (Appendix 5), that a combination of national guidelines and local or regional legislation should be made. This is suggested as it would allow the local level to create legislation of how to live up to the national guidelines, and still be based on local incentives, and the inclusion of locally based actors. Another reason for this suggestion is to be found in the statement from the respondent, who states that different legislative landscapes might be a contributing factor that can askew competition between cities and companies. This too was described in the analysis, but essentially there is a concern that the difference in legislation might cause investment opportunities to be more profitable in areas where there is less legislation on green solutions. There is a subtle line between when national legislation is needed and when it is not, but generally the respondents point towards a bigger need for guidelines (Appendix 4; Appendix 5) on a national level, which is why the framework takes this into account. This fits well into a Polycentric framework as the overarching system of rules can be considered as the national guidelines, which could allow for green solutions to be a requirement in new urban development projects, but which solutions and approaches to be implemented would be up to the local level to figure out. There is, however, an interesting discussion to be had, regarding the flexibility and strictness of potential legislation in this regard. Some respondents (Appendix 2) points towards legislation and the need for it to be quite tough or strict, as less tough legislation might actually slow the development of green roofs. Other respondents (Appendix 4) makes the claim that too strict legislation might also cause issues, where the legislative approaches inhibit the combination of technologies, and therefore excludes some technologies and enables others. Again, there is a subtle line that needs to be addressed, but a compromise could be that legislation should be strict enough to make sure that there are no loopholes regarding the implementation green solutions, but flexible enough to allow for a change in approach if the best solutions are a combination of two technologies. An example of where this approach to legislation was mentioned by the respondent from Basel (Appendix 4),

where it was found challenging to combine both PV panels and green roofs, and the two technologies were essentially excluding one another. This happened due to legislation not being able to accommodate a combination of the two technologies, and PV panels were chosen more often than green roofs, due to their tangible benefits. In a Polycentric perspective, which this framework tries to imitate, a possible solution to this issue could be to make tough legislation on green solutions, but to make it flexible enough to accommodate a combination of technologies, which could happen through safe-to-fail interventions.
If such interventions were to be implemented, the subtle line between tough, but flexible legislation might be erased, as the interventions could make it possible to make changes in the legislation in order to make it more flexible in the areas where it is needed, while still preserving the strict legislation on implementation of green solutions. To return to the example, such an approach might benefit both technologies if they could be implemented in a combined fashion where it was possible, and not limited by legislation. Likewise, local plans or zoning, could be affected by the same issues and solutions, where the national level makes the guidelines for what should be included in the plans. Then, it is the local authorities, where the plans are to be executed, that decide what they should actually entail, more specifically, as long as it follows the proposed guidelines. It should, however, be considered if the demands for green roofs are expressed explicitly enough in the local plans, as less explicit demands might lead to some unfortunate interpretations. Once again, the example first mentioned in the analysis, of a contractor in Copenhagen, that took a very literal approach to the demands in the local plans. The contractor's interpretation of a green roof was to fit green felt on the roof, which, of course, did not comply with the intentional visions of the urban planners. But as it turned out later on, as there were no clear demands in terms of which type of green roof that was to be implemented, the contractor was victorious in court (Jørgensen et al, 2015). This example might open for a discussion regarding if there is a need for more strict building codes, that stipulate specific green roof characteristics in order to succeed with implementing green roofs. If the answers from the respondents are something to base assumptions on, then it might seem as though as this is most likely the way to go about implementing green roofs. Many of the respondents, as already mentioned, points towards stricter legislation, and some even mention building codes specifically as an approach to secure more green roofs.

### 7.1.3. Best Practice Tools Suggested by Respondents:

Besides building codes being regarded as an efficient tool, there are, as have been examined in the analysis, many different tools which could play a significant role in the proposed framework of best practice approaches. These tools are also tools that might be able to contribute to, and work within a Polycentric Governance system, engaging several different actors and approaches, spanning across different scales and sectors. Such a tool might be like the energy saving fund and tax, which they are currently working with in the city of Basel. Taxation and funding initiatives are tools that may include several different actors across multiple levels and scales. National, regional and local actors might be engaged in the creation and utilization of such tools, as cross-scale collaborative efforts might be beneficial in such a context i.e to determine funding options. It should, however, be mentioned that the respondent from Basel pointed out, that there were little to no influence or decision-making from the national authorities in Switzerland, in regard to the energy fund. This shows that there is a way to make such a tool function on a single scale, but as it stands at the moment, and as many of the respondents have already expressed, there is a need for the national authorities to provide an overall set of guidelines. One city might be able to create a successful implementation of such funding initiatives and taxes, but in order to really push the development forward, several different actors are needed, as pointed out by both the respondent from Copenhagen, Stockholm and Baltimore (Appendix 1; Appendix 2; Appendix 5). If several funding schemes exist, it is a possibility to create redundancy within the framework, which makes it more resilient to failures and external influences.

Tools such as taxation or funding through taxation might work in some places, but in Denmark for instance, it might be a more difficult tool to implement. The reason for this is that there are already very high taxation levels in Denmark, and increased taxation could perhaps receive resistance if an increase would be proposed. A place where it might be a possibility to implement increased taxation could be in the property tax, municipal tax or through green taxes, which is already in use today (Skou Andersen, 2006). Examples of green taxes are i.e wastewater discharge fees and the like. A separation of the stormwater management fees, and the wastewater discharge fee could also be a possible approach, which was suggested by the respondent from Berlin. If these fees are separated, then it could potentially lead to incentivizing management of stormwater on people's own cadastral (Appendix 3). A similar approach was likewise mentioned by the respondent from Copenhagen, where utility companies could provide a monetary compensation to private actors regarding the water connection fee, if stormwater was handled locally, instead of

being led to the sewage system (Appendix 1). These approaches seem as being able to create incentives both for private actors, but also for utility companies, which perhaps could foster a collaboration in order to maximize the benefits of these approaches. In a Polycentric perspective, the approach of utilizing taxation and funding is very similar to the use of national guidelines to demands of local plans. The national authorities could propose guidelines or a minimum taxation level to be complied with, and then it would be the local and regional authorities that would implement the best fitting solutions in practice.

Other tools which seem to fit well into the institutional fit of Polycentric Governance and how it deals with environmental issues and green solutions, are the building certification schemes. These schemes include DGNB, LEED and BREEAM, which are widely recognized, but also the created schemes from different cities such as the Green Space Index from Stockholm, and the Greening tool (begrønningsværktøj) from Copenhagen. The building certification schemes encourage general sustainable and environmentally focused construction, while the city schemes encourage very specific focuses on green solutions such as green roofs, both has their pros and cons.
Many respondents (Appendix 1; Appendix 2; Appendix 3) acknowledge that the building certification schemes can be beneficial in terms of the implementation of green roofs, as most of these award points for implementation of green roofs. There is, however, a downside to these building certification schemes, which was also explored in the analysis, which is, that there is a possible tendency for developers and contractors to “misuse” the schemes. By misuse, it must be understood, that the developers and contractors are utilizing the schemes as intended. They are, however, choosing to implement the solutions that are the easiest and cheapest to implement, and not the solutions that would be the best, considered from a sustainability point-of-view. It is somewhat understandable, as developers are trying to keep down the costs of their projects (Appendix 1) but at the same time, it does not further the development of green solutions.

This is perhaps where the city schemes (green space index and greening tools) have the potential to contribute to a further increase in the implementation of green roofs. As these city schemes have the possibility to be equipped specifically to work with green roofs or other green solutions, they might be a better fit in the proposed framework, as they can help develop and implement the desired solutions. At the same time, they might be able to change or adapt to changing scenarios or situations, which makes them more beneficial than the building certification schemes from a Polycentric point of view. If the city schemes can be

altered to fit ever changing scenarios of adaptation, then they fit well with the safe-to-fail interventions, and in some regards the adaptive capacity of a Polycentric Governance system.

Based on the answers from the respondents, the authors would like to argue for a combined use of the building certification schemes and the city schemes in the proposed network. The building certification schemes have a wider appeal, as they are widely recognized, and they encourage the implementation of sustainable solutions that go beyond that of green roofs. They might be able to function as a general framework for increased sustainability in the construction (if utilized as intended), while the city schemes being more focused on the actual implementation of certain green solutions. The city schemes can make demands for green roofs, which must be met in order to be allocated land for projects, such as it is the case in Stockholm (Appendix 2). The authors would also like to propose the idea of including a multitude of actors in knowledge sharing and research networks, with actors from both the authorities as well as experts on building schemes and contractors, as part of the proposed framework.
This would perhaps allow a Polycentric Governance System to further increase the use of certification schemes and city schemes on many different levels. It would also allow for a collaborative effort to finding “loopholes” in the certification schemes, which might inhibit the fundamental idea of sustainable construction by utilizing these. The reason for this statement is derived from some respondents which argued that some companies recycle new plastic products straight from the manufacturing line, in order to be able to classify them as “recycled” materials, to receive more points in a certification scheme or the like. By working together in a knowledge sharing and research network with actors and experts in the field, it might be possible to change requirements which would allow the loopholes to be closed. It can be argued that frameworks and guidelines that can help guide the development and understanding of how more sustainable approaches to implementing green solutions can be reached. Likewise, it is perhaps reasonable to argue that such frameworks and guidelines might also assist in the facilitation and support of funding programs and financial incentives for the development of green solutions.

It is pointed out by one of the respondents (Appendix 4) that creating and having some sort of financial incentive or benefit might be quite beneficial for increased implementation of green roofs. At least in the beginning, as the money is pointed out as being a highly effective mean of creating interest and promoting the green solutions, as it is then possible to create

subsidies and to help to partly cover the costs of establishing green roofs. Money, as stated by the respondent from Basel (ibid.), is a good way to kickstart development. Some might argue against this statement, or at least think that there are other solutions. The respondent from Copenhagen (Appendix 1) states that, currently, there is no financial incentives when implementing green roofs in Copenhagen. Even still, Copenhagen has been relatively successful in the implementation of the green roofs in newer parts of the city. It has been possible to kickstart the development without financial incentives, but it might be interesting to consider whether the development could have been even more widespread if facilitation and support for funding programs and subsidies has been put in place in the beginning. There is, however, a point made by the respondent from Basel (Appendix 4), that money is good at creating interest, but when this interest has been generated, then the effect might decrease over time, as the green solutions have become more “mainstream”. Copenhagen has, in some regard, been able to create interest in green roofs, to an extent that they can start to make some demands for them when making new constructions (Appendix 1).
As part of a smart city-perspective, controlling and monitoring the flow of water in the city can potentially make the city more resilient to future stormwater events. If implemented on a regional or city level, utility companies becomes able to control the flow of water in a more predictable and practical manner, instead of relying on older and more analogue solutions. This approach is, however, more expensive to implement, but ultimately it can save the utility company from investing too much time and resources in developing more conventional climate adaptation solutions (Appendix 4).

# 7.2. The “Green Roof Implementation Framework”

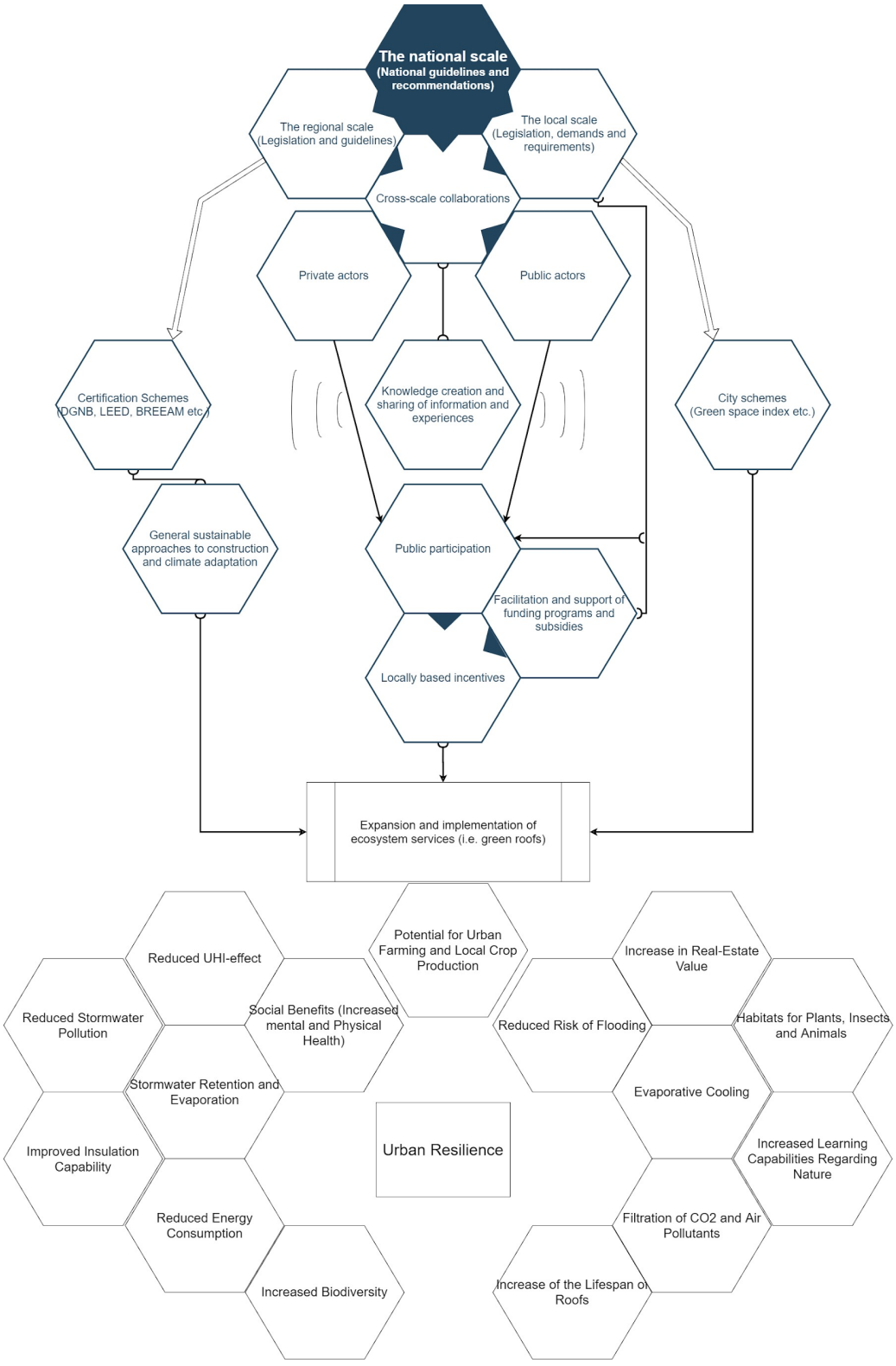


*Figure 10: A framework for successful implementation of green roofs (Authors own creation)*

### 7.2.1 The Green Roof Implementation Framework and the practical utilization:

Above is the illustrated framework that the authors would like to propose utilized when working with the implementation of green roofs in particular. There are multiple levels in this framework, they are, however, interconnected in almost every aspect, excluding some of the levels. The following is a description of the framework, and how it can be utilized in practice, what the benefits are, and which disadvantages the framework might contribute in overcoming.

As illustrated in the framework, the different authorities working on different scales are in the top of the framework, which is deliberate, as the authorities make the guidelines and legislations for other actors to follow. In the proposed framework, the national authorities are the overall decision-maker, which serves to make guidelines and recommendations for the remaining actors within the framework to follow. As illustrated through the use of arrows, the nationally decreed guidelines and recommendations influence both the regional and local authorities, and determines the framework in which they should make legislations. The difference between the regional scale and the local scale, is that, more often than not, the regional level can also influence the local scale through more specific guidelines or legislations. This is illustrated by the use of building certification schemes, as a regional demand, which encourage a general approach to a more sustainable construction industry. Then, at the local scale, it is proposed that the local authorities create and utilize what has been referred to as city schemes, such as the Green Space Index, to facilitate and support the increased implementation of green roofs. Following this proposal, it should be easier for the local authorities to implement solutions that are based on the specific context of each city, which should make the implemented solutions more successful. As the cities can create their own city schemes, they can be customized to fit almost any solutions that the authorities see as being relevant. This would, in turn, help minimize the risks of implementing solutions that do not perform as intended, as the cities have the option to change their schemes as they see fit, if the scheme is found inadequate in its current form. In the proposed framework there is also two elements of actor inclusion, which has the aim of contributing with the creation of knowledge, and exchange of information, which should benefit the expansion and implementation of green roofs. These two elements are the cross-scale collaborations between the different levels of authorities, and both public and private actors, which are on yet another scale, and finally public participation where the public and private actors are included as well. First, a closer look at the cross-scale collaborations. This

element is very much inspired by the Polycentric Governance theory, but also from the respondent's answers regarding the relevance of networks for them. These cross-scale collaborations include all the actors in this proposed framework, the three levels of authority (national, regional and local) and public as well as private actors. These types of collaborations help, as is illustrated in the framework, to generate new knowledge, to share information and to draw on the experiences of others, which should have an impact on how guidelines, legislations and recommendations are formed on the different scales. An example of such a collaboration could be the creation of consortiums, which in its basic form bears a striking resemblance to a Polycentric Governance system.

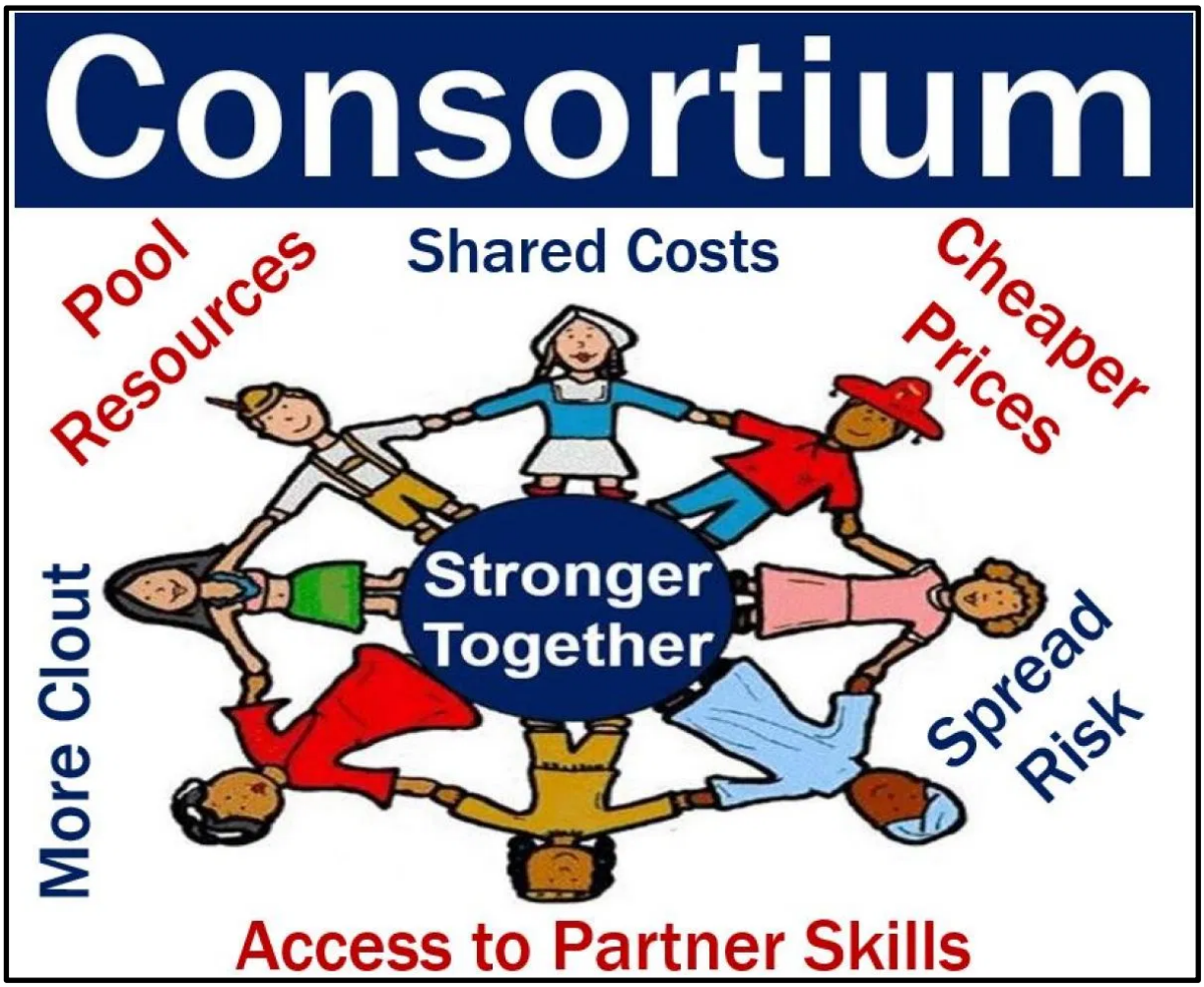


*Figure 11; Consortium - definition and meaning - (Market Business News, 2020)*

As illustrated in Figure 11, consortiums share many of the same aspects as a Polycentric Governance System, by sharing resources, knowledge, costs, and mitigating risks between the included actors. If such collaborations were created, then it should be possible to achieve the aforementioned benefits.

The knowledge generated through these collaborations are, as can be seen in the model of the framework, penetrating and affecting every other part of the framework. As a result, this element is very important in increasing the expansion and implementation of green roofs. Something that is even more local is the public participation aspect also implemented in this proposed framework. Public participation is the inclusion of private and public actors, through the facilitation and support of participatory efforts that aim at generating solutions and knowledge sharing at a local level. Public participation with the inclusion of the private and public stakeholders, opens for the opportunity to collaboratively create solutions that fit into the local context of a certain area of a city. The reasoning for this is that the inclusion of the local knowledge from the public and private actors, contribute with a local perspective and local view on the challenges that affect the specific area. In this perspective, it should become possible to create solutions specifically tailored to deal with these issues, and ensure more persistent solutions. Public participation can be facilitated by local authorities, as illustrated in the model of the framework, and closely related to this element of the framework is the facilitation and support of funding programs. These also have to include both public and private actors as they are perhaps contributing to the programs through taxes, but they are also the ones that can benefit from the funding programs. It has been pointed out by some respondents that these types of programs can help generate interest in green solutions, which is why it is included in the framework.
Both public participation and facilitation and support of funding programs can lead to local incentives which are pointed to as being some of the most important aspects of implementing climate adaptation solutions. Through these locally based incentives, the residents of an area, public or private, are encouraged to implement the solutions that are incentivized through financial benefits, clear knowledge of the values gained or other aspects. As local knowledge and the inclusion of this is deemed very important, then, the incentives that encourage action on the local level, must be equally important in the implementation of green solutions.

### 7.2.2. Contributions to Urban Resilience

All the described parts of the framework should, if implemented and utilized as intended, ultimately result in more a persistent urban development and implementation of green roofs too. It is assumed that, when a larger quantity of green roofs, or other green solutions, is implemented, then these solutions should be able to contribute to enhancing urban resilience in the cities. In the framework, it is illustrated through a large number of the known

benefits, which have a contributing factor to urban resilience, being in the bottom of the framework model surrounding urban resilience. The authors proposal for a framework should lead to increased development and implementation of green roofs, that in turn should contribute to the enhancement of urban resilience qua the many benefits that are associated with green roofs. Some of these benefits that can contribute to enhancement of urban resilience are, a reduction of UHI-effects, reduction of stormwater pollution, stormwater retention and evaporation, social benefits (improved health both physical and mental), increased biodiversity, and habitats for plant and animal life, to mention a few. These benefits are all some that contribute to the resilience of an urban area, as the specific area becomes able to withstand external “threats” to the urban environment such as flooding from stormwater, rise in temperatures and unhealthy residents. At the same time, these benefits add value to the urban environment by, as just mentioned, making residents healthier, by having cleaner air quality, and having green amenities. The values also include increased biodiversity in the area as well as serving as a habitat for plant and animal life, which have their own benefits as well, and brings more nature into the cities.

### 7.2.3. Elaboration of Critical Points in the Illustrated Framework:

In the illustrated framework legislation, recommendations and demands from the authorities have a significant role. The framework can perhaps be said to be more concerned with implementation of green roofs in new urban development, but it should be noted that this framework might also include implementation of green roofs in the existing building mass. Legislation can be formulated in many different ways, and depending on the desired outcome, both new as well as existing buildings can be included in the legislative frameworks, so that there is potential for maximum implementation of green roofs. The existing building mass are more difficult to include, but legislation and guidelines could recommend that actions directed towards implementation of green roofs are taken when doing large scale renovation of the existing building mass. As for funding programs as a tool, this could be used to directly encourage incentives and finance the construction and/or installation cost of green roofs. By having funding programs on the different scales, it is believed that it might open for better possibilities to receive financing, both as a private actor, but also as a municipal stakeholder. This would, perhaps, also make funding and the financial compensations towards installation costs, more flexible, as there exist multiple “channels” to go through on different scales, where funding for the appropriate context can be gained. As for the building certification schemes and the city schemes, they might be a contributing factor in order to develop performance standards for the implementation of

green roofs, and to enabling a comparison of benefits between green and grey roof buildings. By increasing utilization of these schemes, it would perhaps be possible to develop more green spaces in cities, as benefits would be clearly formulated, and the schemes would allow for easy to follow demands/recommendations for the implementation of green roofs.

# 8. Conclusion

In this paragraph, the conclusion on the findings of this thesis will be given. The conclusion is based on the data collection process, analysis of the empirical data that has been collected, and the different topics of discussion regarding the illustrated framework that has been proposed.

The following can be concluded based on the research conducted throughout the work with this thesis: There are well-documented and well-defined benefits that can be gained from the installation and implementation of ecosystem-based approaches such as green roofs in the urban environment. Some are, of course, more prevalent than others, but as it stands currently, there should be benefits for many different contexts that green roofs can be implemented in. The same applies for the disadvantages and barriers, where the most prevalent barrier, the cost of the green roofs, being mentioned in almost every text, and by almost all the respondents in this thesis. Considering the analysis and the research conducted in this thesis, the authors would, however, argue that the single-most inhibiting barrier, in terms of green roof implementation, is the lack of knowledge. The lack of knowledge is both affecting the information regarding the potential benefits and value that can be gained from green roofs, but it is also the cause of some of the barriers or disadvantages for green roofs. It has been discovered that green roofs can, in fact, be constructed relatively inexpensive compared to grey roofs. This is, however, apparently not a well-known fact, which causes the perception of green roofs as being an extraordinarily expensive solution to climate adaptation to persist.

Conclusions to other findings include the need for political empowerment and courage to act, regarding legislation on green roofs and other green solutions. Both in Stockholm and in Basel, legislation is pointed out as being essential tools for successfully increasing the implementation of this type of solution. As a result, the authors would recommend authorities to consider the opportunities they have, to create legislation which supports these solutions. As for which tools that have proven effective in the implementation of green roofs, the city schemes have been quite an effective tool, and one that seems to possess a huge unexploited potential in many cities, and one which the authors would recommend cities to take into account. These types of tools allow for a more customizable approach, which contribute to more persistent solutions, with a higher chance of success, being implemented in the right context.

Other tools that are worth mentioning as having a significant effect are the use of financial incentives, such as funding programmes, taxation, and reduction of fees, i.e. utility connection fees. If such measures are implemented at the start of an implementation phase, it could surely increase that chances of success. It can likewise be concluded, that networks and cross-scale collaborations are of significance, as the networks are both tools, as well as an approach for finding solutions to climate adaptation. These kinds of approaches enable the exchange of knowledge and formerly learned experiences between actors, which reduce the impact that missing knowledge has on the expansion of green roofs. This approach works across different scales and borders, which enables possibilities to learn from the cities that are considered front-runners. Best practice approaches are also able to be transferred between nations if the they find themselves in similar circumstances. There are, however, doubts whether these collaborations can be realized within a national cross-scale context, in the absence of legislation that supports and facilitates such endeavors.

This leads to the conclusions on the illustrated framework that has been proposed in the discussion. As this framework is based on the findings from the analysis, along with lessons learned from the different interviews, it is concluded that this framework is a fairly accurate depiction of an approach that may actually be of use for some stakeholders. The framework is composed on the background of knowledge regarding best practice approaches from multiple cities, along with suggestions and reflections made by the respondents and authors as well. The framework is, however, imperfect, and even though it should be implementable in many different scenarios, it cannot be so, without considering the context specific aspects of the framework. This means that, legislative actions, which is suggested, must comply with the national laws and boundaries, as well as which type of solution that would be the best fit for a specific set of issues. The framework is balancing between being fairly strict in its propositions, but also flexible enough to allow changes or additions which would increase the chances for success, to be made. By utilizing the proposed framework cities should be able to enhance their urban resilience through successful implementation of an ecosystem-based approach, while also strengthening cross-scale collaborations, which will surely be useful in other scenarios as well.

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