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The Value of Nature-based Climate Adaptation in Denmark

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Synopsis:

Climate change has resulted in new patterns of extreme precipitation that require urban development to implement climate adaptations. These weather changes challenge the existing sewer system's capacity. Thus, this report investigates: *How can nature-based climate adaptation concerning increasing precipitation create value within urban areas in Denmark?*

In this research the five Danish climate adaptations are: sØnæs, Klimaparken, Aktivitetsskoven, Selsmosen, and Tåsinge Plads. The areas have been examined through literature study, interviews, observations, and the use of GIS. To conceptualise how value is generated at these places, the conceptual framework included the concepts of ecosystem services (ESS) and Nature-based Solutions (NbS).

Common to all the projects in this report is a water-inspired recreational area, thus utilising the water as a resource. NbS depend on the local context, where the natural processes come into play. Finally, this research concludes that climate adaptation must not be static after establishment, as climate change is a dynamic process. NbS incorporates this request, integrating the solution with the local ecosystem while adding value to its ecosystem services. Thus, NbS provides the urban areas in Denmark with opportunities to adapt to an uncertain future and, at the same time, create a new value for the citizens.

Preface

The period for the report was from February 2021 to June 2021. During this time, COVID-19 resulted in a lockdown of society and the university. As a result, contact with the supervisor was limited to the virtual platforms. However, the author assesses that these challenges did not have any crucial effects on the research's outcome.

The present report is produced as the master thesis on Geography at Aalborg University. The thesis topic is one's choosing, albeit it must be an academic geographical research project. Thus, incorporating geographical concepts and practices. As a result, the report investigates selected Danish natural-based climate adaptation projects.

This study investigates nature-based climate adaptations in urban environments in Denmark and how the increasing precipitation affects these areas. These projects are an interdisciplinary collaboration between the municipalities and utility companies. Thus, the report focuses on the value creation of the projects.

Acknowledgements
Several individuals have provided and supported essential elements of the report. During the collection of empirical data, many people have contributed to our projects. Therefore, thanks must go to the interviewees for their participation and for putting us in contact with key persons. These persons include employees from Viborg Kommune, Vejle Kommune, Middelfart Kommune, Høje-Taastrup Kommune, and Københavns Kommune which enlightened us with in-depth knowledge about the public authorities' point of view. Additionally, utility companies have contributed technical knowledge on climate adaptation projects; therefore, we want to thank Energi Viborg Vand and Vejle Spildevand.

Next, the project group recognises our supervisor Martin Lehman who has contributed with constructive criticism and inspiring supervision. Thank you for the guidance and support.

Finally, a profound thank you to our dearest friends and family for their indirect support of this work by tolerating the time the authors spent away from home, our mental state, and our preoccupation with the production of this report.

Reading guide

The thesis's design follows that of a book. It is therefore beneficial for the reader when reading it electronically to turn on two-page scrolling with the front page setting. These settings will contribute to a more cohesive reading of the report and a flow of the layout. Additionally, if a printed version is preferred, we recommended choosing a colour version due to the structure and design of tables, figures, and maps, for an optimal reading experience. This research uses the Harvard Style of references, where a *List of References* is compiled in the end. The references style presents as the following (Author's last name, Year). In a situation where it was not possible to specify a year of a source *n.d.* is applied: e.g. (Boseman, n.d.). If any repeats of an identical combination of author and year, a letter is added to differentiate between them the reference: (Boseman, 2021a) and (Boseman, 2021b). Furthermore, few references indicate an attendant chapter or pages. Thus, are these indicated by (:ch. X) or (:X) respectively as the following: (Boseman, 2021:25). If a pair of preceding references are identical: (ibid.) is used.

The tables and figures in the report are introduced initially by the chapter and then succeeding after the placement in the chapter; for instance, Figure 20 in chapter 2 is named Figure 2.20. The same goes for pictures that are a referrer to as figures. The quotations in the report that are acquired from Danish sources; this includes the interviews conducted in Danish and then translated into English by the authors.

The report is made by:

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Resumé

Videnskabelige undersøgelser af klimaændringer har afklaret nye mønstre af ekstreme vejrforhold, som kræver at den nuværende og fremtidige byudvikling implementerer klimatilpasning, som kan håndtere disse vejrhændelser. Klimaændringer giver ikke kun stigende nedbør, men også flere og mere intense ekstreme vejrhændelser. Disse forandringer har over en årrække udfordrer det nuværende kloaksystem, som er anlagt ved hjælp af ingeniør løsninger til håndtering af regnvand. Derved er denne grå-infrastruktur dimensioneret efter statiske beregning af vejrhændelser. Tilsammen giver dette en grå-infrastruktur i byen, som er infleksibel, hvilket klimaforandringerne udfordrer, da grænserne for vejrhændelser flyttes med klimaforandringerne. Derfor er der brug for mere fleksible løsninger, som kan bidrage til at gøre byen mere robust i fremtiden. Der er i denne rapport undersøgt et alternativ til de grå løsninger, som er at administrere vandet på overfladen ved hjælp at naturbaseret løsninger. Derfor undersøges det, hvordan naturbaseret klimatilpasning til den forøget nedbør kan skabe værdi i danske urbane områder.

Undersøgelsen tager udgangspunkt i den pragmatiske videnskabsteori, hvis forudsætninger bygger på at viden er under konstant udvikling. Denne videnskabsteori har bidraget til undersøgelsen ved gøre det muligt at lære af de erfaringer, som kommunerne har med klimatilpasning, og dermed vurdere hvordan tilpasningerne giver værdi til byen. Det er valgt at undersøge fem urbane klimatilpasninger i Danmark, som alle har inkorporeret naturbaseret løsninger i klimatilpasningen. De fem områder er: sØnæs i Viborg, Klimaparken i Vejle, Aktivitetsskoven i Middelfart, Selsmosen i Høje-Taastrup, and Tåsinge Plads i København. Områderne er undersøgt ved hjælp af litteraturstudie, GIS og interviews. Interviewene er udført som semistrukturerede interview med projektlederne fra den tilhørende kommune. Derudover er der efter opfordring fra kommunerne udført interviews med to spildevandsselskaber i henholdsvis Viborg og Vejle, samt en boligforening i Vejle kaldet ØsterBo. Interviewene er ydermere suppleret af observation og pop-up interview i hvert område. Dette bidrog til en bedre forståelse af områder på baggrund af de oplysninger som kommunerne og de øvrige interviewpersoner gav.

Ydermere, er det valgt at tage udgangspunkt i koncepterne økosystemtjenester (ESS)

og naturbaseret løsninger (NbS). Økosystemtjenesterne bidrager med at konceptualisere den værdi, som generes på et sted, omend disse er materielle eller immaterielle. Økosystemtjenesterne sættes i relation til at skabe alternative klimatilpasningsløsninger, som dermed kan siges at have flere dimensioner. Naturbaseret løsninger er et værktøj som har et potentiale til at udløse flere økosystemtjenester i klimatilpasningen. Herved er der mulighed for at tackle konsekvenserne af klimaændringer, og derved udnytte de regulerende økosystemtjenester, samtidig med at støtter de kulturelle økosystemtjenester, såsom rekreativitet.

Fælles for alle projekterne i denne rapport er, at de inkludere et rekreativt område, som tager inspiration fra vandlandskaber og dens egenskaber. Områderne bruger vandet som ressource på forskellige måder. Især på sØnæs og Selsmosen er vandet en fast del af designet af området, hvor det centrale element er et regnvandsbassin. Det er ligeledes valgt i Klimaparken at inkludere to søer, omend udgør disse to kun en rekreativ funktion. På den anden side har kommunerne på Tåsinge Plads og Aktivitetsskoven valgt, at inkorporerer regnbede, hvor det er muligt for regnvandet at nedsive. I de tre sidstnævnte projekter er vandet som rekreativt element hovedsageligt repræsenteret, når det regner. Projekterne har fokus på brugen af området både i tørvejr og når der forekommer nedbør. Dette er udtrykt i designet af landskabet, hvor stier adskilles fra udpegede områder for vandet, men også gennem de faste inventar, som lægger op til for eksempel vandleg.

Derudover er løsninger også baseret på den lokale kontekst, hvor de naturlige processer spiller ind. Her er der blandt andet overvejet mulighederne for nedsivning ift. det terrænnære grundvand. På Tåsinge Plads og Aktivitetsskoven er de naturlige forhold for nedsivning de meste gunstige. Projekterne er som minimum designet efter at kunne håndtere en 100-års hændelse i 2100. Disse regnhændelser er forskellige afhængigt af, hvor i landet projekterne er lokaliseret. I Danmark er det fordelt således at der forekommer mere regn i den sydvestlige del af Jylland og mindst på Sjælland og øerne. Dette har sammen med det opland områderne har indflydelse på hvor meget vand projekterne skal kunne håndtere per hændelse.

Gennem denne undersøgelse kan det konkluderes at klimatilpasning ikke må være statiske efter etablering, da klimaforandringer er en dynamisk proces. Derfor er det vigtigt at etablere klimatilpasningsprojekter, som kan ændres sig med klimaet. NbS indarbejder denne krævede mulighed for at kunne tilpasse løsningen løbende. Desuden integrerer NbS lokale økosystem, hvilket giver merværdi, som er udtryk i dens økosystemtjenester. Således giver NbS byområderne i Danmark muligheder for at tilpasse sig en usikker fremtid og samtidig skabe en nutidig værdi for borgerne.

Motivation

Over the recent decades, it has been confirmed by the scientific community that climate change poses new standards for the weather we experience. This situation is significant for Danish citizens whose homes are located in low-lying areas with lack of protection against future weather events. Thus, climate change is one of the biggest challenges which force cities to adapt. But how do we as individuals, society, and the global community tackle this increasing problem? As the effect becomes a rising disruption in our life, it has been recognised by the public and political debate to carry out initiatives, which mitigates these challenges.

The difficulty which climate change poses can be located in either the natural sciences or the social sciences. However, it is the geographer's duty to build a bridge between these and utilise the tools of both academic disciplines. One of the pillars in Geography as an academic discipline is to investigate the relationship between nature and humans across time, space, and scale, thus keeping the natural and cultural aspects together.

With a Bachelor in Geography, the authors share an interest in establishing more nature in cities, so that urban development works with the natural process instead of against it. Thus, this interest influenced the theme in the present research. When investigating or developing concepts and solutions that utilities the natural process in a local environment, it is recognised that these provide or contribute to a sustainable human existence and quality of life. Natural processes offer both the resources and space for ordinary and necessary human interactions. Thus, this interest in humans' need for green spaces corresponds with the qualities within geography as an academic discipline.

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List of Acronyms

CESS Cultural Ecosystem Services

DMI Danish Meteorological Institute

EU European Union

ESS Ecosystem Services

GHG Global Greenhouse Gas

HIP Det Hydrologiske Informations- og Prognosesystem

HOFOR Hovedstadsområdets Forsyningsselskab (Greater Copenhagen Utility)

IUCN International Union for Conservation of Nature

IPCC The Intergovernmental Panel on Climate Change

KL Kommunernes Landsforening (Local Government Denmark)

NbS Nature-based Solution

RCP Representative Concentration Pathways

RESS Regulating Ecosystem Services

SRES The Special Report on Emissions Scenarios

SVK The Water Pollution Committee of The Society of Danish Engineers

UN The United Nation

WSUD Water Sensitive Urban Designs

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Interview

Observation

Research question

Sub-question 1

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Part 1
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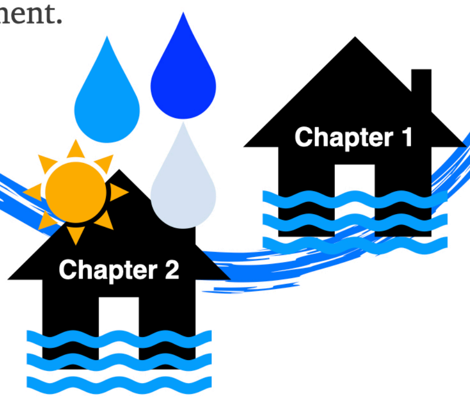
Chapter 1 introduces how climate change is increasing extreme precipitation events, hence affecting Denmark's urban environment.

Chapter 2 formulates the problem, which increased precipitation causes in an urban environment, subsequently presenting the research question and the appertaining sub-questions.



Part 2
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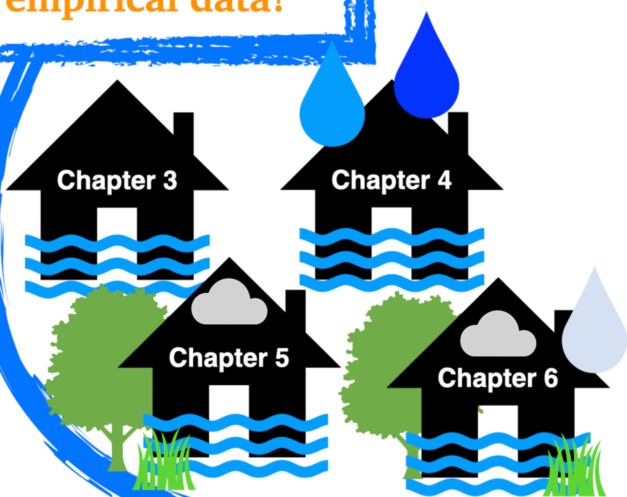

Chapter 3 present the theory of science as pragmatism, which determines the subsequently presented research design of Inductive design.

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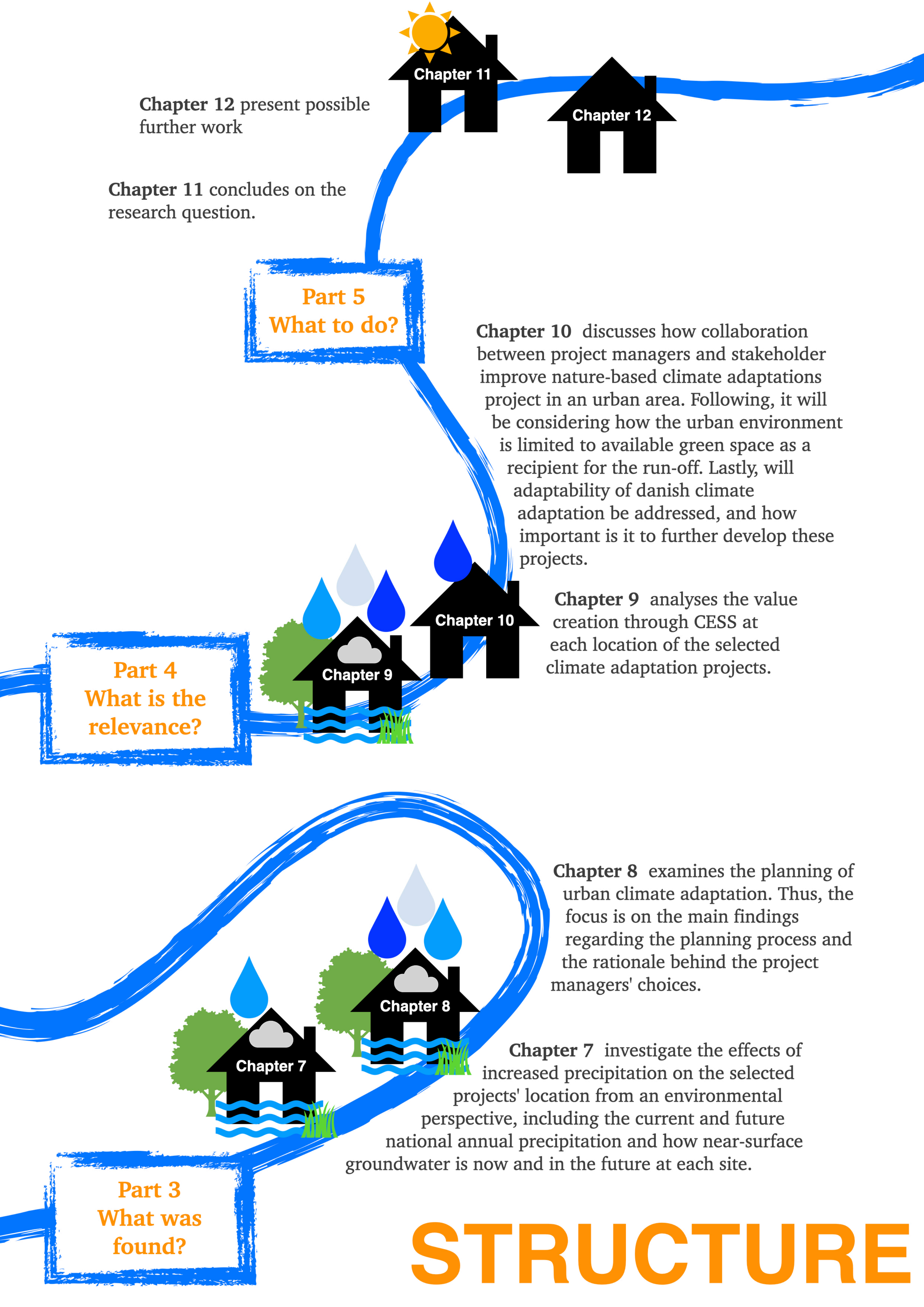
Chapter 5 present the practical methods used in the present report as literature review, GIS, interview, and observation.

Chapter 6 introduce the chosen project and the transformation of the areas. The projects are: sØnæs in Viborg, Klimaparken in Vejle, Aktivitetsskoven in Middelfart, Selsmosen in Høje-Tasstrup, and Tåsinge Plads in Copenhagen.



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Chapter 12
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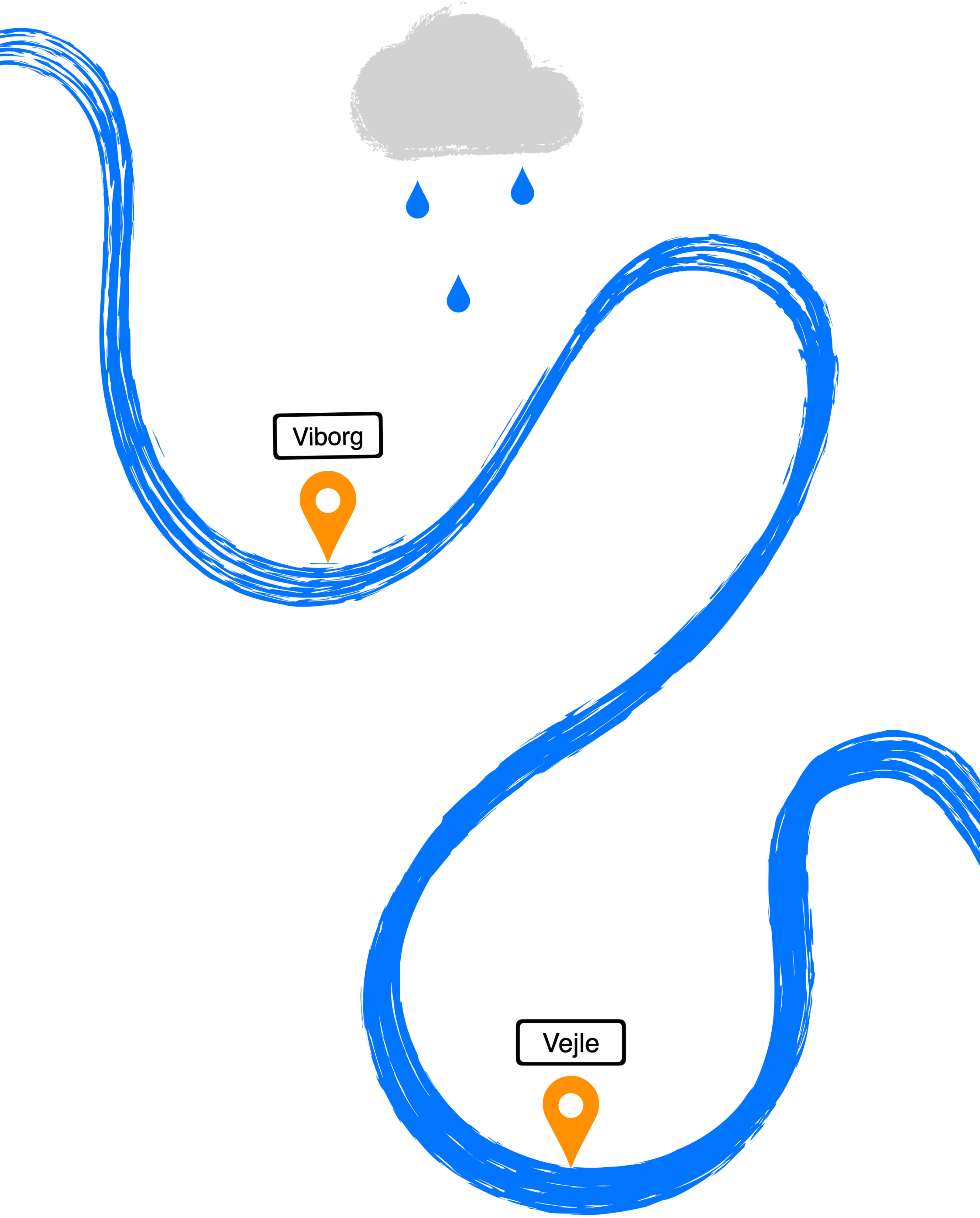
STRUCTURE


Viborg
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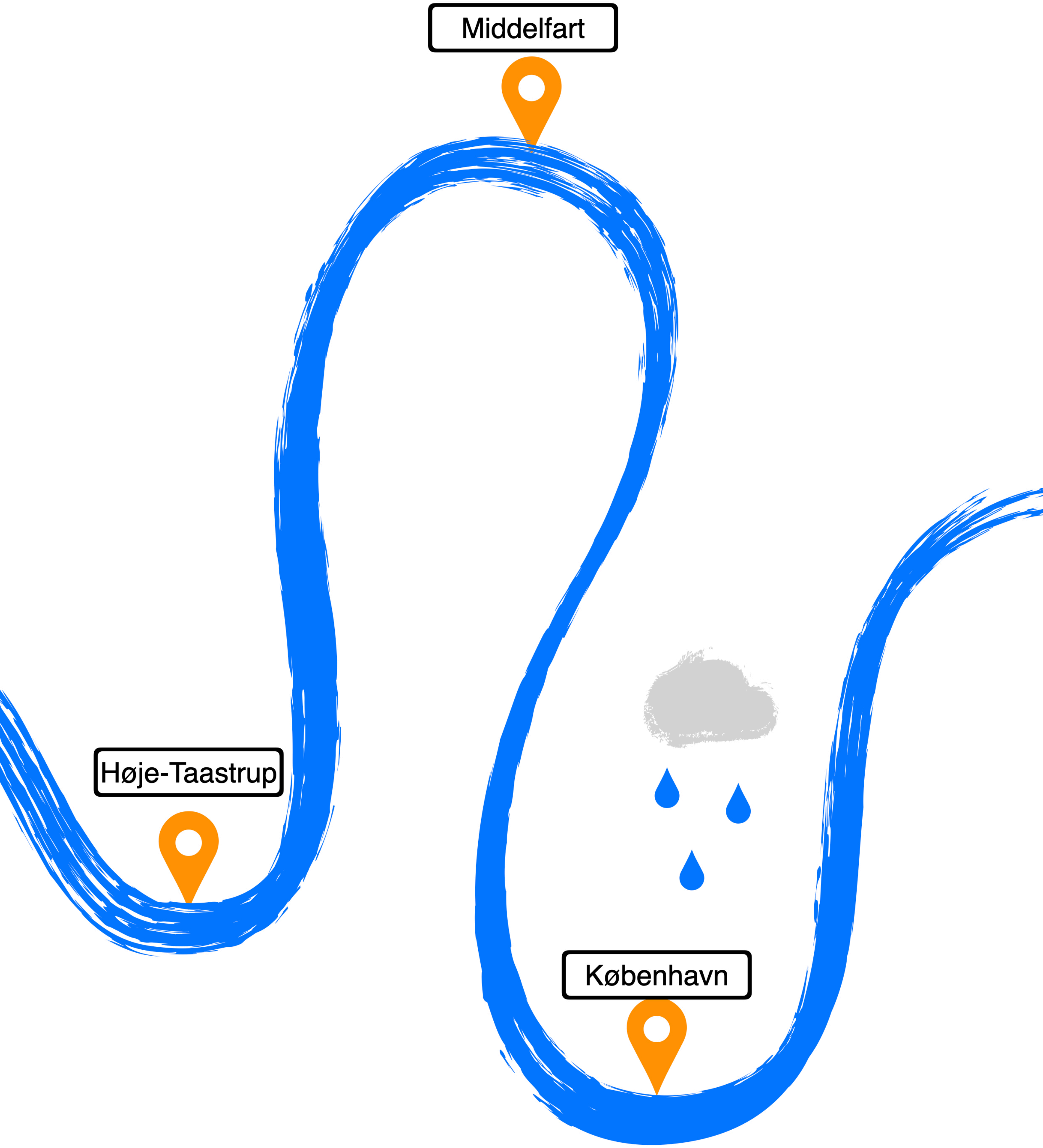

Middelfart
Høje-Taastrup
København

sØnæs

Part I | Introduction

This part serves the purpose of contextualising this research. The part will introduce how climate change affects the urban environment in Denmark. Thus, the limitations of the underground solutions' capacity to handle the increased precipitation are presented. As a result, the scope questions whether the current solutions are flexible enough for managing the challenges that come with the future climate. Finally, the project's research question is presented.

1 Challenges Caused by Climate Change in Cities

Climate change is an imminent challenge that many countries face. The global mean temperature rises, and this affects the climate as a whole. Thus, there are multiple effects of climate change. However, it is important to note that the increase in mean temperatures is not necessarily a problem in itself.

> Whether it is 8 degrees or 9 degrees it is not something we feel in everyday life. Nevertheless, the temperature rise is reflected in the extremes. We get more heatwaves, more heat records, and more precipitation records.
>
> (Peter Langen in (DMI, 2019:translated))

As the quotation suggests, the problem occurs because the increase of the mean temperature also influences the extremes. What is now viewed as extreme weather events will become more frequent, whether it is temperature or precipitation records. Therefore, failing to mitigate climate change will have consequences such as increasing extreme weather events. There is, thus, a demand for climate adaptions to mitigate the consequences of climate change (Kaźmierczak et al., 2020; Folland et al., 2001).

There have already been examples of the changing climate in Denmark, with an increase in the mean temperature and yearly precipitation. Additionally, the changes in Danish temperatures are equivalent to the global temperature rise and seem to follow that development. The extent of the temperature rise is based on global greenhouse gas (GHG) emissions, and thus not solely dependent on Danish reduction of GHG emissions (DMI, 2020b; IPCC, 2004). Figure 1.1 on the facing page illustrates the deviation in mean temperatures compares to the climate mean from 1981 to 2010.

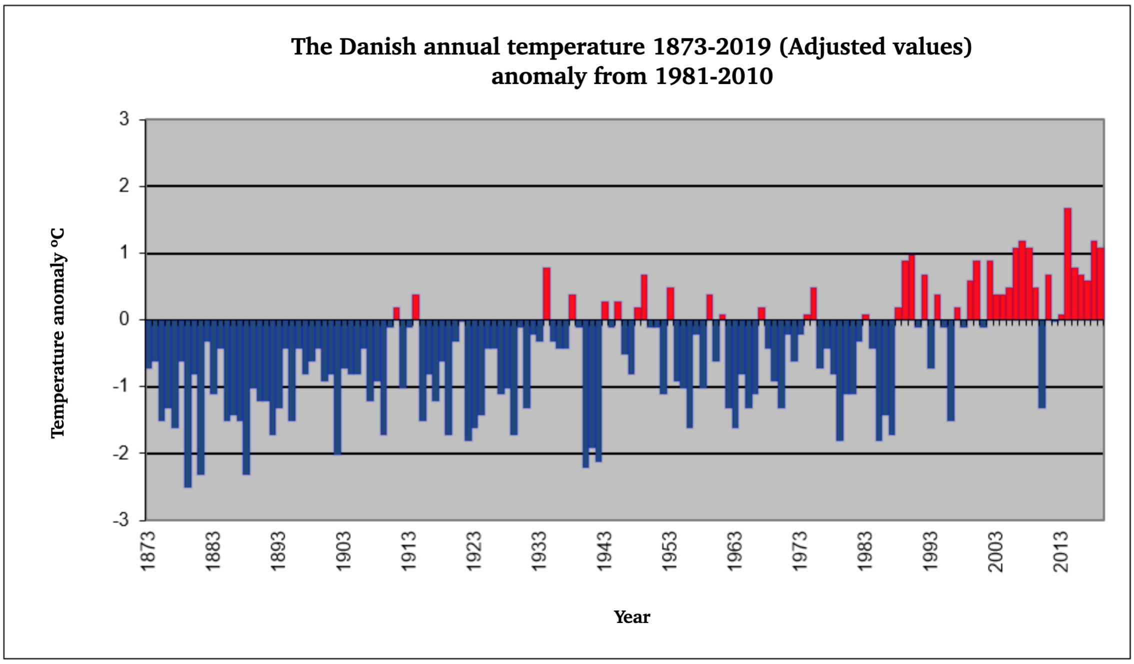


Figure 1.1 The yearly variation in Danish temperatures from 1874 – 2019. The line at 0 represents the mean temperature in the period 1981 – 2010. (DMI, 2020b:translated).

In Figure 1.1 it is evident that there has been an increase in the temperatures compared to the mean. The higher temperatures compared to the mean are becoming more frequent, with most occurrences after the mid-eighties. Thus, this temperature development induce a higher concentration of water vapour in the atmosphere (M. Olesen et al., 2014). As a result, there are some similarities, when comparing the temperature development to the precipitation, cf. Figure 1.2.

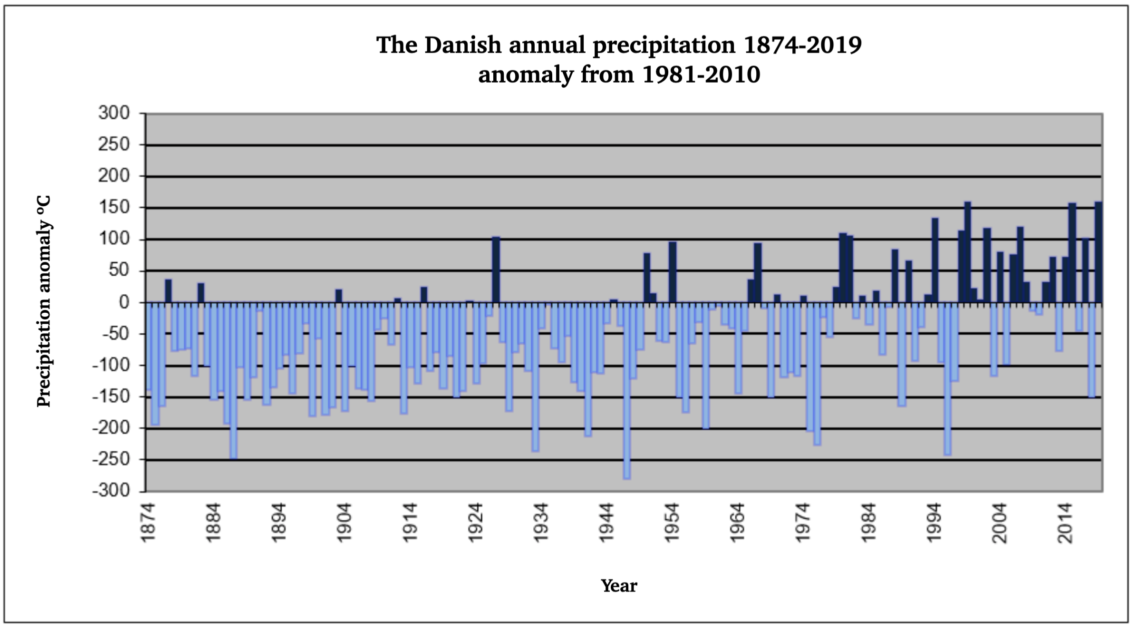


Figure 1.2 Yearly variation in Danish precipitation from 1874 – 2019. The line at 0 represents the mean precipitation in the period 1981 – 2010 (DMI, 2020a:translated).

Figure 1.2 on the preceding page illustrates an increase in deviations that exceeds the mean precipitation since the 1980s, which also applies to the temperature. The variation in precipitation indicates an approximate increase of a total of 100 mm since 1870s (DMI, 2020a). This development is predicted to continue. Langen et al. have made a prognosis as part of the *Klimaatlas* for cloudburst and a 10 year event based on the Representative Concentration Pathway (RCP) scenarios 4.5 and 8.5. Figure 1.3 illustrates the prognosis.

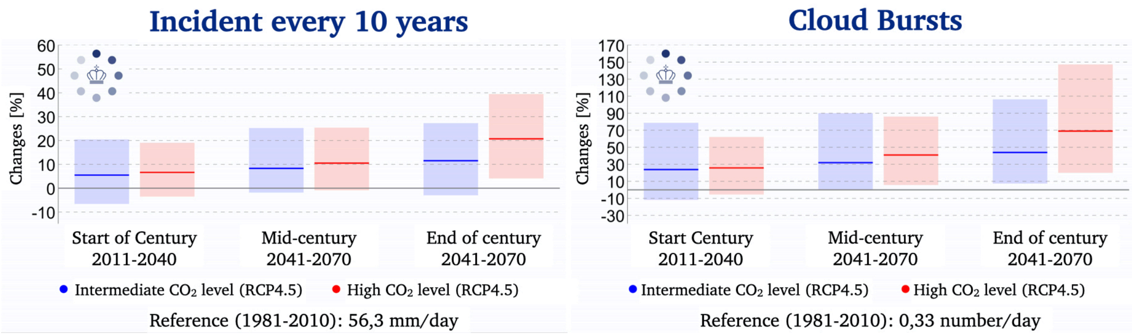


Figure 1.3 The change of Denmark's extreme precipitation in percentage between 1981 – 2010 and future periods: 2011 – 2040, 2041 – 2070 and, 2071 – 2100 in the scenarios RCP 4.5 and RCP 8.5. To the left, the 10-year event for daily precipitation, and to the right, the frequency of cloudbursts are illustrated (Langen et al., 2020:translated).

The RCP scenarios indicate to which extent the GHG influence the global climate. There is a higher concentration of GHG in the 8.5 than the 4.5 scenario (Langen et al., 2020; DMI & MST, 2018). In Figure 1.3 it is evident that there is a higher probability of cloudburst, with 70 %, in the 8.5 scenario at the end of the century. The frequency of the 10 year event also increase by 21 %. The prognosis emphasises that other effects than temperature rises, as extremes weather events, will become more frequent.

The year 2019 is an example of what to expect of the future climate. This year started out having a hotter winter than the mean period would suggest. This trend continued throughout the year with warmer weather. The total precipitation was the highest measured since 1874, next to 1999. Furthermore, the extreme weather events also intensified as there were an increase in cloudburst throughout the summer months (Rubek, 2020). Additionally, there was an increase in the total precipitation for the spring and fall, which is consistent with the projected weather (DMI, 2020c). The precipitation, including the cloudbursts, caused floods all over Denmark that challenged both the country areas and the cities (Rubek, 2020; J. E. Olesen et al., 2006).

The change in extreme weather require cities to adapt, and thus preventing societal disruption. Problems caused by floods in the cities are imminent because approximately 88 % of citizens in Denmark live in the cities (DST, n.d., 2021). The cities' design has decreased natural surface, thus increasing hard surfaces such as concrete and asphalt. The cities' impermeable surfaces limit the drainage opportunities to depend on the sewers, which are often not built to withstand extreme weather events like cloudbursts (Støvring, 2021; Lerer et al., 2015). The current Danish sewer system is bound by law to prevent backwater in terrain; Thus, reducing the extent of the floods by reducing the damage through the management of these. However, it is necessary to point out that water on the terrain is unavoidable. *The Water Pollution Committee of The Society of Danish Engineers* (SVK) standardises the danish sewer system's service level. Thus, the common sewer systems may flood every ten years, and separated sewers may flood every fice years (Olsen et al., 2017; SVK, 2005; Mark & Linde, 2006). As the frequency and intensity of extreme events increases there is a need to expand the drainage system's capacity in the cities because the events planned for will become more frequent (DMI, 2020c; Lerer et al., 2015) The consequences of cloudburst in an urban area is large if the water management cannot keep up. It is estimated that a cloudburst costs between 20 and 35 million DKK, which is about the double of a climate adaptation project. Thus, there is only two cloudburst have to occur for the recreational adaptations to pay off (DAMVAD Analytics, 2018).

The sewers are primarily located under roads, so changing them are inconvenient and costly. Additionally, a situation might occur where there is a difference between who owns the pipe and the catchment area. It is not only the utility companies that are in charge of separating the sewer and rainwater pipes in the roads but also the citizen that have to change their plot systems. Thus, this solution is not necessarily well suited for heavily populated areas (Paludan et al., 2011).

2 | Scope of the Problem

Disturbance caused by extreme precipitation such as flooded built-up areas and roads pressure the municipalities to find lasting solutions to these events. The traditional approach to managing run-off of precipitation is predominately with *Grey Infrastructure*. This term refers to engineered infrastructure and wastewater management solutions, such as sewers (CCAP, 2011:ii). The precipitation run-off depend on this grey infrastructure as the surfaces in urban areas often is characterised as impermeable. Thus, the water's ability to percolate is limited in densely built-up areas, such as inner cities, industrial areas, and roads (Pauleit & Duhme, 2000).

Grey infrastructure typically serves specifics demands: transporting the wastewater beneath the surface; and optimising the precipitation run-off from the urban areas (Mark & Linde, 2006). However, in cases of extreme precipitation the water exceeds the capacity of the sewer system. As a result, the waste water reaches the terrain if it is a combined sewer system. Consequently, the backwater is unhygienic and harmful to the environment. A solution is to separate precipitation and waste water, which can give better management of both. As a result, the system will provide better drinking water, rainwater, and flora, thus creating a more sustainable hydrological circle within the city (Miljøstyrelsen, 2014b, n.d.; Davidsen et al., 2018).

At the moment, the major part of the danish sewer system is designed after the A2 scenario of precipitation conditions. The Special Report on Emissions Scenarios (SRES), which includes the A2, is the precursor to the RCP scenarios both made by the IPCC. A2 is the most extreme in SRES but less than the RCP 8.5. The yearly mean precipitation in A2 will increase by 9 %, whereas the RCP 8.5 predicts 14 %. Thus, the scenario used now predicts a higher increase in precipitation. Therefore, the sewer system is required to handle more precipitation than the established system is dimensioned after. However, designing the sewer system after the climate scenarios reduces the possibility of damaging societal values. Thus, the sewer system planning would continuously strive to control floods. (J. Nielsen, 2008; Mark & Linde, 2006; DMI & MST, 2018; DMI, n.d.[a]).

Nevertheless, predicting future weather is uncertain. This situation challenges the inflexibility of the grey infrastructure because it has to manage the variety of weather conditions, including the future increased precipitation in number and intensity (Mark & Linde, 2006).

Consequently, using climate adaptations based solely on grey solutions to maintain and handle the consequences of increased precipitation are less efficient in managing the continuously new normal for climate change. The capacity of the sewer system diminishes when cities are expanded as the catchment area increases. Furthermore, the service life of the pipeline is made to last, for which reason the cost of changing and establishing these are high. However, to outface the grey infrastructure is not an option due to wastewater management (European Commission, 2013; Lerer et al., 2015; NSCEP, 2008; CCAP, 2011; Dige, 2019).

Yet, it is a possibility to separate the management of rainwater from the wastewater. Consequently, the rainwater will not overload the sewer systems. This separation entails a redesign of the sewer system or an alternative solution in addition to the sewers (Sanders, 1986; Pauleit & Duhme, 2000).

The subterranean water management has a single function, that triggers when cloudbursts occur; thus, this solution is expensive and misses the opportunity to form new qualities in the urban space. As result, Lokale og Anlægsfonden, Realdania og Naturstyrelsen for instance advocates for investing in nature-based climate adaptation (Realdania, n.d.[b]). The work with climate adaptation in general is well underway in Denmark. All municipalities have made a climate adaptation plan that includes a risk assessment and prioritisation of the most vulnerable areas. In multiple instances, the adaptations included nature-based solutions that consist of cohesive green spaces or several green elements. Solutions like these contribute with spaces in the cities that have value outside of extreme instances. The solutions can vary in scale concerning the project: ranging from local solution such as soakaways in backyards to large coherent system like storm water reservoirs made by the waste water companies. More extensive facilities, like reservoirs, can function as a way to create green spaces in an otherwise dense urban area (Naturstyrelsen, 2013; Miljøstyrelsen, 2017).

The VANDPLUS projects are examples of nature-based climate adaptation in urban areas, demonstrating the strength of these solutions as an alternative to create values within the cities. Additionally, these projects show how close collaboration between utility companies and municipalities could implement new and innovative climate adaptation projects (Realdania, n.d.[b]).

Instead of investing funds in subterranean grey solutions, the VANDPLUS projects prioritised developing new urban spaces by increasing the city's adaptation to manage the effects of cloudbursts. VANDPLUS believes that "*climate adaptation can be much more than underground sewers and dull gutters, that collect waste and leave it unused when it* *is not raining*" (Realdania, n.d.[b]:translated). Thus, VANDPLUS projects advocate for perceiving challenges cause by climate change as an opportunity for society to increase urban green spaces (Miljøstyrelsen, 2017; Jacobsen, 2020; Realdania, n.d.[b]).

2.1 Research Question

The concern for the effects of climate change drives the initiatives for climate adaptation projects, which includes nature-based solutions. Therefore, is it relevant to investigate how current nature-based climate adaptations contribute with value to urban areas. It is, thus, meaningful to determine which value the public authorities sees in these areas. This value, which is obtained through the research, can be used as a focal point when new sites are being developed. Thus, the present project intends to explore:

How can nature-based climate adaptation concerning increasing precipitation create value within urban areas in Denmark?

The research question comprises of several aspects. To strengthen the investigation and thus, capture the research in its entirety, three sub-question has been established. The sub-questions aim to cover different aspect of the research question, and thus combined answer the research question. The questions are presented in the following:

1. What is nature-based climate adaptation?
2. How do Danish urban areas manage the increase in precipitation?
3. What is the value of urban climate adaptation?

Klimaparken

Part II | Research Design

The present part focuses on the research design; it will emphasise how the selected theory of science, conceptual framework, and methods contribute to the research.

First, the project's reasoning of the position within the theory of science is provided. The theory of science determines the available methods, thus arguing for the pragmatic approach used in the study. Furthermore, the research design is argued to be an inductive approach.

Secondly, the theoretical rationale for nature-based climate adaptation is defined and elaborated in the Conceptual Framework chapter. The concept of ecosystem services explains how natural environments provide value through different services.

Next, the used methods are presented. This presentation includes an elaboration on how the research is conducted. Hence, the sub-questions will be put into the context of the methods used to answer each one. The methods used for each sub-question are described with the argumentation of each choice.

Lastly, is the selected climate adaptation projects in Denmark is presented.

3 Philosophical Reflections

Because geography is a wide academic discipline that uses different methods, it is beneficial to determine the philosophical standpoint, which influences the research. Pragmatism makes it possible to put the subject at the centre of the research and establish a theoretical basis and purpose for the used methods. Thus, create an analysis that evaluates the challenges and limitations of the climate adaptations' value in the present and future.

Pragmatism's ontology attempts to understand the world as we humans evaluate it. Thus, pragmatism believes the world is not entirely predictable at any giving time (Johnson et al., 2017). The world must be understood from a position where the knowledge of the world continuously expands. In other words, our understanding is never complete because we as humans cannot attain absolute certainty. Instead, knowledge is in a constant learning process, which is revised and improved. This way of understanding knowledge is not static, thus follows premises of the ever-changing climate, where the society must adapt and constantly create new knowledge. This ontology contributes to this research by allowing critical thinking towards established climate adaptations. This philosophical understanding of being and existing in the world enables us to analyse and synthesise the current knowledge while at the same time investigating how the established climate adaptation projects keep up with the new climate normal (Kaushik & Walsh, 2019). This approach results in expanding the knowledge on the given subject:

> Human actions can never be separated from the past experiences and from the beliefs that have originated from those experiences. Human thoughts are thus intrinsically linked to action. People take actions based on the possible consequences of their action, and they use the results of their actions to predict the consequences of similar actions in the future
>
> (Kaushik & Walsh, 2019:3)

As the quotation emphasises, pragmatism focuses on creating new knowledge by setting up hypotheses, testing, and evaluating certain subjects. Thus, the Pragmatism approach allows natural and social science methods, because pragmatism uses qualitative methods to incorporate the human experience into the evaluation of society's problems and determine reality from the findings. As a result, the social perspective adds to the field of natural science and their appertaining quantitative methods. It is, thus, possible to investigate the project managers' experiences about the value creation at the sites (Kaushik & Walsh, 2019).

The scientific theoretical position is essential concerning collecting the empirical data needed, thus answer the research questions fully. Thus, in this research pragmatism develops the understanding of the relationship between humans and the environment by what is collected by practical means from the world (Johnson et al., 2017).

In context to this research, generalisation is drawn from the findings, and thereby it is possible to analyse cause-and-effect relationships among values found at the selected Danish climate adaptation projects. The theory of science supports the chosen methods, which give empirical data, that verify if the conceptual framework is consistent with project managers' intended and experienced value of the climate adaptation projects. To increase the reliability of the findings, it is reinforced by qualitative interviews and supplementary observation, hence documenting the value of climate adaptations project in the current conditions (Kaushik & Walsh, 2019). In sum, the potentials and combination of methods make it possible to evaluate if the current climate adaptation accumulates value now and in the future, and argue if the sites should be maintained as they are. On the other hand, pragmatism facilitates, with the help of the methods, a bridge between the theoretical and practical worlds. It would, therefore, be possible to determine if the value cover the needs of both the citizens and public institution; thus, if the climate adaptation project should be changed or innovated.

4 Conceptual Framework

Climate change sets a new normal for weather conditions and a new standard for extreme weather incidents. This situation requires that climate adaptations must be dynamic so they can handle the increase in precipitation. Hence, climate adaptations should follow the development of climate change. This research aims to investigate how nature-based solutions are valuable for society through its ecosystem. Thus, evaluate the value of the ecosystem services.

4.1 Types of Climate Adaptation

Throughout history, societies have adjusted to and coped with the climate variability with mixed degrees of success. *Adaptation* as a societal response to the impacts caused by climate change is included in this research to address the broad risk-reduction and development objectives that the NbS adaptation provides (IPCC, 2014). The IPCC defines the word *Adaptation* as:

> The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to the expected climate and its effects.
>
> (IPCC, 2014:5)

As the quotation shows, the definition of adaption distinguishes whether it concerns the human or natural systems. Adaptation in the human system occurs based on changing the current way of living to either avoid or exploit adverse or beneficial situations. In other words, changes in human behaviour on account of benefiting and sustaining human existence. On the other hand, the human can interfere with the adaptation of the natural system: thus, the adaptation occurs on the humans' premise. Nevertheless, in some cases, the adaptation within a natural system needs this human intervention to adjust the climate. The adaptations to climate change are in this research, actions focusing on preparing the urban environment for the consequences of climate change while drawing advantage of the opportunities (IPCC, 2014).

Nevertheless, climate adaptation appears on any level of society, from the individual up to national and global levels. The adaptation responses tend to be organised higher up, such as policies, which frames developments at the lower levels. On the other side, on the lower levels, the adaptation would be more action-based and tangible (NCCARF, 2017). Concerning this research's objectives, climate adaptation will centralise on how different Danish climate adaptation projects have been formed and their premises. The different types of the general definition of climate adaptations are illustrated in the following:

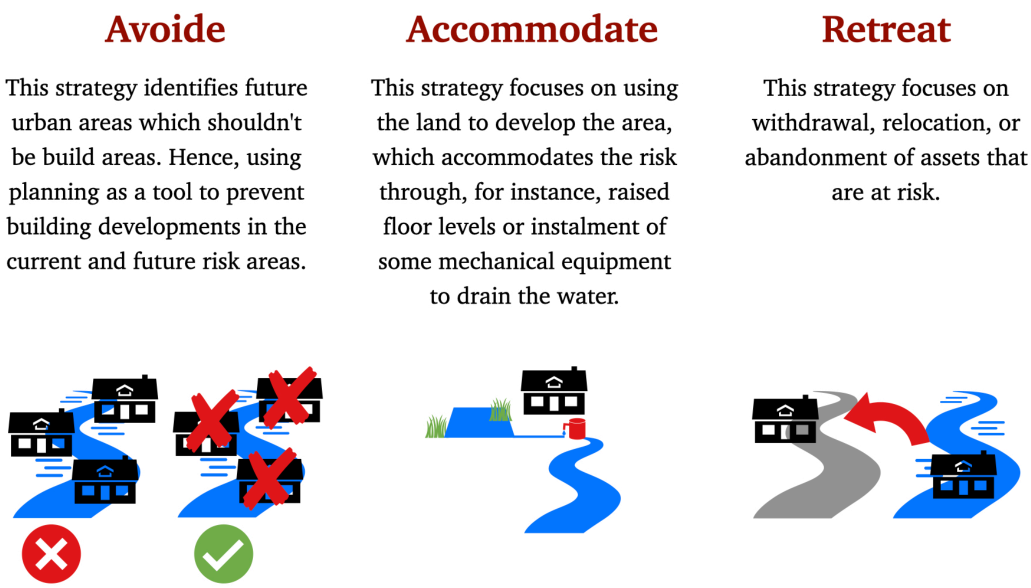


Figure 4.1 The general protecting options concerning climate adaptation. The figure is inspired by (Port Hedland, n.d.).

Given that this research includes projects in established urban areas, the *avoid* approaches to adaptation would not be comparable to the objective because this adaptation sets in before establishing the physical space. Thus, making it impossible to evaluate the value generated at the place because there is no developed area to consider. Next is the *retreat* approach, which is an option but focuses on relocating subjects permanently to safer places. However, this approach also entails that the area is abandoned after the retreat. Thus, there are not planned any replacement solutions to be evaluated. Lastly, the *accommodate* approach is an adaptive strategy designed to enable sustainable use of flood risk areas. The approach increases the flexibility of the infrastructure by allowing periodic flooding in controlled environments, thereby restricting the damage. Thus, this definition of adaptation to climate change fits with the objectives of this research because the adaptation happens by developing a vulnerable area and instead utilise the beneficial opportunities to create urban green spaces (Doberstein et al., 2018).

4.2 The Ecosystem Service

The preferences of green spaces are determined by the qualities that have significance for the user (van den Berg et al., 2003). Thus, the benefits that humans get from natural environments can be expressed by the ecosystem services (ESS). For simplicity and understanding, the goods and benefits of each ecosystem service will be referred to as the value. The services vary depending on the ecosystems, albeit there are four overall categories: supporting, provisioning, cultural, and regulating. (W V Reid et al., 2005). The supporting ecosystem services enable the other services and are not used directly by humans. However, the provisioning, cultural, and regulating creates value directly for humans. The effects of these are dependent on the scale, where some contribute to the locale environment while others also have a global effect. Thus, the different categories are valuable to each other, besides their benefits for the human. However, because the subject of this research is investigating how nature-based climate adaptation can create value for urban areas, the definition of value must, in this context, benefit humans. However, to maintain a long-lasting ecosystem, the premises for the natural process cannot be neglected for the benefit of the human.

The ESS' benefits are not always as direct and obvious as the provisioning services, like food and raw materials. The value can also be created more indirectly through the other services, regulating, supporting, or maintaining cultural aspects in the ecosystem. It can be argued that the ESS only has value because humans utilise the service, which also gives incentive for humans to maintain or expand a particular ecosystem service. Nature-based climate adaptation, which is the focus of this project, is defined as adaptations using nature and ESS to provide economic, social as well as environmental benefits (Zölcha et al., 2017)

For example, cultural service contributes to a sense of place and encourages social coherence. These services are essential for human health and well-being and, thus, a necessary value for a sustainable society. Nevertheless, the benefits of cultural service are not as measurable because the benefits are often non-material. On the other hand, the fact that ecosystem service affects the economy and results in monetary benefits cannot be disregarded. The benefits that accumulate monetary value are essential when investigating the creation of value in urban green spaces. These spaces increase the monetary value of the surrounding areas because the non-material services are upgraded (McCord et al., 2014; Trojanek et al., 2018; Realdania, 2018).

However, climate adaptation projects contain a great potential to add or increase value to a city in other ways, for instance, through an increase in the amenity value; generated by cultural ecosystem service. Nevertheless, there are numerous examples of projects, which, apart from climate adaptations, also increase the area's economic value. For instance, roads with a rainwater collection system that also increase traffic safety and add more green elements. Thereby an aesthetic expression of the road course will contribute to the area's monetary value (Realdania, 2018).

In this research, the value must, therefore, fulfil the needed conditions of a decent life for citizens in the communities, including their physical and mental well-being, which are influenced by the physical, social, and cultural aspects. Thus, it is chosen to focus on ESS, which are either *Section 4.2.2: Value Creation through Regulating Ecosystem Services* or *Section 4.2.1: Value Creation through Cultural Ecosystem Services*. The argumentation for the choice of these categorisations is presented in the respective sections.

4.2.1 Value Creation through Cultural Ecosystem Services

The *Cultural Ecosystem Services* (CESS) is included because it clarifies *what are the value of urban climate adaptation?*. Cultural services in the ecosystem are principally based on the human experience. The connection between the citizens' experience and the cultural services gives a valuable opportunity to increase the knowledge of the multi-functionality and interconnectedness of the different ecosystem components and their significance for urban life quality (Elmqvist & Schewenius, 2018). It is therefore essential to include *Recreational value* as a part of the theoretical foundation. The Recreation value help increase the knowledge and understanding of nature as an essential component of human health and well-being for individual and society (ibid.). Moreover, including this value, it is possible to investigate how cultural service in the ecosystem benefits through non-marketed and non-material use and thereby understand why climate adaptations are more beneficial for an urban area than using adaptations solely based on engineer-solutions.

The CESS contributes with various benefits, such as recreational value, enjoyment from the aesthetic, and increase physical and mental health. Common to these benefits is that they are non-material. A significant advantage of the CESS is that its benefits are inexhaustible and available for everybody (ibid.). Thereby, it is possible to understand the value in an urban area for both individuals and society through cultural ecosystem services.

Despite the CESS's positive impact on urban life, the benefits are primarily intangible, thus, challenging to document through quantifying methods. Therefore, the CESS is experienced and intuitively understood by individuals. The CESS, therefore, gives an understanding of the value of green space. Thus, qualitative methods are needed to understand the value for the citizens (European Commission, 2013).

Recreation, Relaxation, and Health

Similar to the rest of the world, urbanisation also influencing the distribution of the Danish population. In Denmark, a significant part of the population lives in dense urban areas due to the ongoing urbanisation (UN, n.d.; DST, n.d., 2021). However, this development sets new demands for cities, so urban areas are an inherent healthy place to live. As a result of urbanisation, the citizens' outdoor life and recreation occur in urban areas more than ever before. Furthermore, more people moving into the cities increase the pressure for the city planners to prioritise areas' housing, business activities, or infrastructure, among others. These activities generate monetary value in the city that causes a dense city with fewer public outdoor areas. Nevertheless, public places for physical activity are essential for a sustainable urban life (the World Bank Group, 2020; Stigsdortter et al., 2010).

Green spaces are essential for a sustainable urban life, especially in the context of public health. Green spaces provide citizens urban areas to conduct outdoor leisure activities and healthy means of movement every day, for example, walking and bicycling. Thus, providing physical activities that contribute positively to the physical health and well-being (T. S. Nielsen & Hansen, 2007). On the other hand, dense urban areas have been linked to increasing physical inactivity for the citizens. Additionally, lifestyle diseases are growing in western countries, including Denmark. Studies showed that physical inactivity results in a high risk of premature cardiovascular disease development and type 2 diabetes. Both diseases are chronic, thus negatively impacting an individual's quality of life and a cost-pressure on society (T. S. Nielsen & Hansen, 2007; Björk et al., 2008; Sommer, 2019). These health challenges underline the necessity of green space in the cities for maintaining a sustainable life. The recreational benefits, which green space contributes, result in value creation of the natural environment because it facilitates physical activity, thus positively impacting public health. In this context, the CESS benefits are present through space–health connections. In other words, healthy activities are motivated by the green spaces in urban areas. Thereby, the CESS can be used as a practical component of a preventive health strategy in urban planning (T. S. Nielsen & Hansen, 2007).

Another lifestyle-related disease that is increasing is stress. Despite that, stress is not defined as a disease (ibid.). More Danes are experiencing severe symptoms, which constitutes an increasing public health problem. The proportion of Danes with a high-stress level has increased from 21 % to 25 % in the period 2010-2017 (The Danish Health Authority, 2017). However, prolonged stress constitutes a risk for diseases, for instance, high blood pressure and depression. These lifestyle-related diseases influence the quality of life, thus, the general well-being of individuals and society negatively (The Danish Health Authority, 2017; T. S. Nielsen & Hansen, 2007). Prolonged mental illness and physical diseases are an economic challenge and cost in the national economy. In context to social-economic cost, each year, mental illness like depression costs approximately 1,220 million DKK in treatment and care and approximate 3,110 million DKK due to lost production (The Danish Health Authority, 2015; T. S. Nielsen & Hansen, 2007:11). Research studies have investigated the connection between mental restoration and types of urban environments that contain natural elements and exclusively built environments. These studies have proved that the urban environments with natural features are associated with lower perceiving stress than urban environments without such elements (Hartig et al., 2003; van den Berg et al., 2003; Stigsdortter et al., 2010).

Additionally, the presence of natural elements, such as trees and grass, is related to the use of outdoor spaces, the amount of social activity that takes place within them, and the proportion of social to nonsocial activities they support. This link between the benefits and type of environment determines value by the appreciation through the use of the area (Sullivan et al., 2004).

T. S. Nielsen & Hansen emphasises that green space in cities positively impacts health and quality of life among the population by comparing the availability and size of green spaces. The residents' health in neighbourhoods with easy access to nature tend to have better health conditions. Additionally, it primarily affects some groups positively, for instance, the elderly and citizens with low socioeconomic status. Incorporating green areas in cities will create spaces that are free from demands and stress. Even though the causes of mental disease like depression are a complex interplay of social, psychological, and biological factors, the statistical results indicate that access to a garden or short distances to green areas is associated with less stress and a lower likelihood of obesity that cannot be ignored (T. S. Nielsen & Hansen, 2007). Establishing green spaces for recreation and leisure activities allows citizens to relax, for which reason relaxation is a value within the CESS.

Culture, Safety, and Social Cohesion

Another non-material service the CESS contains is aesthetic appreciation. In context to cultural aspects such as language and knowledge, the natural environment has been a part of human history, especially when nature becomes domestic. Enjoying the beauty of natural landscapes and being captured by their elements and services have formed the environmental preference culturally for both the individual and the society (Wiehl & Manns, 2014; Hartig et al., 2003).

Nature has also been a source of inspiration for tradition and cultural foundations and identity, but also fostering social cohesion by providing space for social interaction. Green space increases neighbourhood stability and safety because research has demonstrated that increased access to green space reduces crimes and violence within the area. In communities that do not share common values, residents lose both social control and social capital, resulting in a higher occurrence of crime and violence (Donovan & Prestemon, 2012; Bogar & Beyer, 2015).

Outdoor spaces facilitate community gatherings, which creates an expansion of natural surveillance of the areas by increasing the community coherence. A common fear associated with green spaces is dense vegetation that restricts visibility and can appear to limit one's ability to escape. The perception of green spaces as a risk area with violence and crime is damaging to communities, thus limiting the physical activity in the area (Bogar & Beyer, 2015; Donovan & Prestemon, 2012).

The positive impact of green space contributes emphasises that urban green areas are a part of the cultural landscapes and susceptible to social and economic changes. These depend on being maintained to preserve a certain level or concept of attractiveness and safety in green spaces. However, such areas compromise the natural environmental conditions, which are crucial for the ecosystem, to retain a cultural concept (Wiehl & Manns, 2014).

Green spaces contribute positively to health, sustainability, and social inclusion as non-material benefits through the CESS, making these types of area values for the individual citizen and the city as a whole.

4.2.2 Value Creation through Regulating Ecosystem Services

Due to the increasing number of people in the city and the increased precipitation, some areas in the cities are vulnerable in handling the excess water. The solution could be to use the green spaces to handle this excess water and therefore benefit from the Regulating Ecosystem Services (RESS). The Regulating Services that ecosystems provide are, for instance, maintaining the quality of air and soil, providing flood and disease control. These services are easily taken for granted. However, when the service is damaged or absent, the losses are great and difficult to restore. RESS help assist the value of the mitigate effects and thereby the adaptations. The mitigation is seen as a future perspective and not necessarily something people are aware of and have as a part of the value perspective. Therefore, the evaluation of the adaptation in terms of regulating effect can contribute to an understanding of the value in a long time perspective. The RESS includes water regulation and treatment. These services are relevant in this research because when heavy precipitation occurs, nature-based climate adaption contains many benefits in terms of collecting and managing the runoff. Furthermore, is disturbance regulation as a service included. This service emphasises the importance of natural areas' ability to mitigate climate change (Costanza et al., 1997; Zusammenarbeit GIZ & Umweltforschung UFZ, n.d.).

Water Regulation and Treatment

In a situation where extreme precipitation will occur more frequently, and thus more water is introduced to the city's water cycle, it is essential to regulate and treat this water to secure a sustainable water cycle.

In context to the urban development, the surface has dramatically changed. The increase in the dense surface has caused a disruption to the hydrological cycle within the cities. The surfaces' ability to intercept, store and infiltrate rainwater is decreased by reducing the vegetation and increasing impermeable surfaces. As a result, the amount of precipitation runoff and the risk of local flooding has increased. Additionally, this situation has amplified the undesirable effects of climate change (Zölcha et al., 2017). Therefore, establishing green spaces supports the green and blue infrastructure. The water is, thus, led away from infrastructure and buildings and be stored in water basins. The water then either infiltrates or is being pumped out into another water body. If the water comes from polluted sources, there is a need to clean it before introducing it into the natural water cycle. This happens by natural settlement in a water basin or by a mechanical water purifier. The green areas thereby create value for the cities by preventing the polluted water from reaching unwanted places such as the natural systems (Miljøstyrelsen, 2014a; Jensen & Fryd, 2009). Using the regulated ecosystem service as a planning approach can contribute to the development of green space supports nature-based adaptations.

Disturbance Regulation

Local communities across the country experience the effects of climate change. Depending on the community's location, climate change constitutes various threats to infrastructure, water quality, and human health (Seddon et al., 2020). It is, therefore, essential to create projects that mimic the local ecosystems and create ecosystems that absorb the disturbances on a local scale.

With climate changes, the future weather conditions are expected in Denmark to be more extreme, such as more intensive precipitation, thus potentially increasing the material damages to public and private assets, as mentioned in Chapter 1 on page 4. Fortunately, nature-based climate adaptation improves green infrastructure that is dynamic and should withstand the disturbance from the effects of climate change. Thus, it helps communities become more adaptable because the water is led to these designated areas instead of ruining properties (Pamukcu-Albers et al., 2021; Oral et al., 2020). The green areas receive and adapt to the water due to its dynamic nature. The vegetation structure is the incentive for this dynamic as it controls the water and creates spaces for infiltration. Nature-based solutions prove to deliver a broader range of ecosystem services, specifically to vulnerable sectors of society, thus protecting against multiple impacts (Seddon et al., 2020; Costanza et al., 1997; Oral et al., 2020).

The disturbance regulation strengthens the adaptation by introducing more services to the urban environment. Thus, it secures the flow of the whole ecosystem. The ESS of the nature-based solutions offers the potential to address both causes and consequences of climate change while supporting the other categories of the ESS.

4.3 Nature-based Solutions

Nature-based Solutions (NbS) is a comprehensive concept that includes other established nature-based approaches. These approaches aim to enhance nature that helps address societal challenges such as a solution, reducing disaster risk, or increasing water security. Thus, the NbS cover a wide selection of ecosystem-related approaches. Using NbS tackle various societal challenges and thereby secure human well-being and biodiversity benefits. As a result, it is possible to address societal challenges through utilising ecosystem services (Seddon et al., 2020; Nature, 2017; Cohen-Shacham et al., 2016).

Although NbS is a relatively new concept in the environmental sciences and nature conservation, this solution has found its place to guide policy-making and aim for development. Thus, the purpose of NbS can unlock the value of ESS by promoting conservation, restoration, and management of ecosystems (Cohen-Shacham et al., 2016; Walter V. Reid et al., 2005). Several supranational institutions have already defined NbS as a concept. These include the International Union for Conservation of Nature (IUCN), the United Nation (UN), and the European Commission(EU), of which concepts of NbS are defined and how these differs are presented in the following:

	UN	IUCN	EU
Definition	*“They (NbS) are vital complement to decarbonisation, reducing climate change risks and establish climate resilient societies. They value harmony between people and nature, as well as ecological development and represent a holistic, people centred response to climate change. They are effective, long-term, cost-efficient and globally scalable”* (UN, 2019:1)	*“Actions to protect, sustainably manage and restore natural or modified ecosystems that address societal challenges effectively and adaptively, simultaneously providing human well-being and biodiversity benefits”* (Cohen-Shacham et al., 2016:2)	*“Living solutions inspired by, continuously supported by and using Nature designed to address various societal challenges in are source efficient and adaptable manner and to provide simultaneously economic, social and environmental benefits”* (European Commission, n.d.)
Differences	The UN definition emphasises the necessity of NbS as an important means to tackle climate change through the management of an ecosystem. Additionally, it included the need of the human as an essential part; thus, NbS must prioritised the demands from the human perspective in the solution.	IUCN’s definition stresses the need for management and restoration of an ecosystem to be the centre of any NbS, thus address societal challenges and adaptation.	The EU definition is comprehensive and places more emphasis on applying NbS. The solutions do not require to be nature-based solely, but inspiration and support by the natural process are also sufficient.

Table 4.1 Show the definitions and differences of NbS, develop by the UN (UN, 2019:1), the IUCN (Cohen-Shacham et al., 2016:2), and the EU (European Commission, n.d.).

These typologies of the NbS focus on either the use, management, restoration, or creating a new ecosystem. Nevertheless, these definition underlines that ecosystem is the fundamental for livelihood as they help achieve beneficial conditions for human life. Thus, the management of nature needs to support and secure ecosystems in a way that reflects the local values. Consequently, the NbS acknowledge that societal and cultural conditions must be included in the adaptations, so the structure of the ecosystems accommodates human needs.

For an operational framework, the presented definitions of NbS do not alone meet the aim of the research question. However, elements of the definitions overlap and fit with ecosystem service thinking.

The value of climate adaptation as a whole is central in this research; therefore, aspects of the UN’s definition of NbS, about increasing the response to climate change, thus reducing climate risk in a long-term perspective, supports the intention of this research. On the other hand, the IUCN's definition recognises modified and adaptable ecosystems that address societal challenges and secure human well-being. These aspects contribute to this research as the ecosystem aspect included in IUCN links to the ecosystem services values. The EU also evolves around the adaptiveness of nature as a way to address societal challenges. Hence, NbS increases the flexibility of the city and thus the robustness. Furthermore, the EU also includes sustainability in the broad definition where the long-term planning again is brought into focus.

Consequently, a combination of the definitions is, in this report, seen as the definition of NbS, expressed in the following:

> NbS use nature design to address societal challenges by reducing climate risk and increase responses to climate change long-term. Furthermore, implement modified and adaptable ecosystems in urban environments that contribute to human well-being. Thus, provide economic, social, and environmental benefits.

As a result, this definition gives an operational framework that makes it possible to investigate benefits from implementing a nature-based solution.

Planning with a Hybrid Solution

The NbS varies depending on landscape features in terms of, for instance, rural or urban areas. As a result, the solutions are context depended. When increasing natural elements or vegetated surfaces in urban areas, the risk of flooding during heavy precipitation decreases (Smets et al., 2019). Thus, NbS is composed of green or blue elements. In contrast to the grey infrastructure, cf. *Chapter 2: Scope of the Problem*, the green and blue solutions support natural processes on land and water, respectively, which supports native species and the connectivity between ecosystems. Thus, the grey solution is more disconnected from the embedded processes in the environment than the green and blue (Pauleit, Liu et al., 2011; Walter V. Reid et al., 2005). The difference between the typology of grey, hybrid, and green and blue infrastructural adaptation options are shown in the following:

	Grey	Hybrid	Green and blue
Structure	Engineered structures	Combination of biological-physical and engineering structures	Biophysical, which utilised ecosystem services
Utilisation of the ecosystem services	Very limited	Allows some assisted by technological solutions	Many, primarily existing or restored local and water bodies
Examples of solution	Canals, pipes, water basin, water filtration, and mechanical pumps system	Bioswales, Green roofs and rain gardens	Maintain or restore: fjord, lakes, rivers, seas. Introducing or restore: riparian areas and flora

Table 4.2 Show the typology of Grey, Hybrid, and Green and Blue infrastructural adaptation options (adapted from Depietri & McPhearson, 2017:95).

As illustrated in Table 4.2, the grey infrastructures utilise a limited ecosystem service compare to the hybrid and green and blue infrastructure. Although, the grey infrastructure still serves an essential purpose concerning managing the local challenges of the urban area (Depietri & McPhearson, 2017). For instance, conventional engineered systems have immense benefits, such as providing and maintain clean water and sanitation conditions (Dawson, n.d.). However, this infrastructure tends to have low flexibility, especially when the system is confronted with extreme events caused by the climate. Climate change results in uncertain weather prediction; hence, the system must become flexible. Thus, relying solely on grey infrastructures might not respond and accommodate future challenges (Depietri & McPhearson, 2017).

On the other hand, implementing solely green and blue infrastructures in an urban context for climate change adaptation are insufficient. As the Table 4.2 indicates, the green and blue infrastructures rely primarily on already and well-established ecosystems. Healthy ecosystems have an essential function in buffering cities from climate and meteorological hazards on different scales. Additionally, this infrastructure allows close to no technological intervention or supplement. Consequently, placing this infrastructure entirely within the ecological domain of an area. Thus, the feasibility of establishing a site that creates favourable conditions for enough ecosystem service to form a healthy ecosystem is considered low. Establishing an NbS solely with green and blue solutions in an urban area must compromise due to prioritised elements that constitute a city. Despite these limitations, the Green and blue infrastructures are still necessary in some cases. Green and blue infrastructures function as biophysical ecosystems, which may need management or restoration. This infrastructure is characterised by, for instance, mangroves, coral reefs, wetlands, and marsh (ibid.). Commonly for the examples are landscapes, hence underlines the required size of the biophysical environment. Thus, the solution is challenging to scale down to fit within an urban environment.

Nevertheless, establishing NbS in cities is a typical hybrid solution that combines grey infrastructure with green and blue. Hybrid infrastructure utilises green and blue infrastructures with the help of the grey solution.

The framework of NbS can catalyse the hybrid infrastructure. Because the hybrid approaches combine conventional engineering with ecosystems, it fits within the NbS approach (EPA, n.d.; Depietri & McPhearson, 2017; Dawson, n.d.). The objective of the hybrid solution is to reduce the reliance on an urban system build on grey infrastructures and derived disadvantages by combining the grey, green and blue solutions. On the other hand, the grey infrastructure will cover the limitations of green and blue infrastructure concerning the urban water cycle of wastewater management. Thus, hybrid solutions maintain the adaptability of cities through direct and co-benefits (Depietri & McPhearson, 2017).

Furthermore, the implementation of hybrid infrastructure is of primary importance in urban areas where solely green and blue approaches are insufficient to meet the rising impacts of climate change due to the space limitations. Additionally, hybrid solutions are preferred in situations when cost-effectiveness is critical in the context of climate and economic uncertainty (ibid.).

Consequently, the hybrid solutions will create an infrastructure that forms or strengthens the cohesion between the various local NbS and thus enhances the collective benefits of the ecosystem services (Dige, 2019; Pauleit, Liu et al., 2011; Cohen-Shacham et al., 2016). Including the hybrid infrastructure as an alternative solution to meet climate adaptation requirements is favourable in this research. This solution type will form the basis to clarify the mitigation effect of increased precipitation within urban areas in Denmark. Using NbS as an operational framework, the hybrid solutions support the argument that nature-based climate adaptation must include both a natural element and an engineered component as a part of the solution. This combination covers the weaknesses of the grey or green and blue infrastructure. Additionally, the hybrid solution opens up for establishing a proactive development, where the management or restoration of the local ecosystems can happen through natural or modified means. In other words, when establishing a climate adaptation with the hybrid solution, the aim of the definition of NbS is met.

4.4 Closing Statements

The ecosystems create value from their pertaining ESS. The ESS is independent of the value that humans ascribe to nature. However, the project managers can add value when they develop areas to withstand climate change. Using ESS to handle the effects is done by utilising the multi-function and connectivity in an ecosystem, thereby generating value that is beneficial for humans and the natural environment.

Climate changes, and thus nature, are the determining factor for the development and therefore provide the framework. As the climate continues to change, there is a need for society to adapt. Thus, it is advantageous to establish areas that work with natural processes instead of viewing them as limitations. A tool is NbS as the adaptation method, making it possible to use engineered solutions that operate within the natural processes. In this way, the engineered solutions are not replacing the natural processes but strengthen the ESS. As a result, the NbS provides a framework for adaptation in an urban area where the ESS value is unlocked.

5 Practical Methods

As previously stated, this research's pragmatism approach combines and emphasises the necessity of quantitative and qualitative empirical data. The reason for including both types of data is because the research's subject reaches into both social and environmental studies, and thus demand a interdisciplinary approach . The present research prioritises investigating a problem that represents the contemporary society. Thus, the selection of the theme for this study took place from challenges in the public debate and scientific field. One of the vital pillars in geography as an academic discipline is the relationship between humans and nature; the selected theme fell upon how society establishes solutions that consider the need of both humans and nature as a response to the future climate. In the initial part of the introduction, the intention was to define the problem that increasing precipitation caused. Thus, did the investigation take off from unsorted facts to later grouping facts representing the challenge that climate change entails. Hence, it contributes to specifying the object of the present research. Additionally, the sub-question was made to narrow and guided the investigation, thus, is the present research constructed around these questions.

The research design is, therefore, conducted as *inductive design* because the research searches for a pattern that departures from observation; the collections and analysis of the sorted quantitative and qualitative data contribute to the hypotheses about nature-based climate adaptation providing value in an urban environment. As a result, the investigation tries to develop explanations and theories for those patterns. Consequently, the research explains what must be present in nature-based climate adaptation in urban areas to unlock the value for the benefit of humans and nature. Thus, the data are used to discuss the results and give a scientific evidence-based explanation for the observed pattern (Boolsen, 2015). To answer the research questions, the following methods is used: literature review, GIS-modelling, and different types of interview methods. The methods attributes with data that have different purpose concerning research question, and thereby also to the sub-questions. The research question induces three sub-questions that encompass different aspects of the main question. For simplicity and conceptual understanding, Figure 5.1 illustrates how the methods contribute to empirical data.

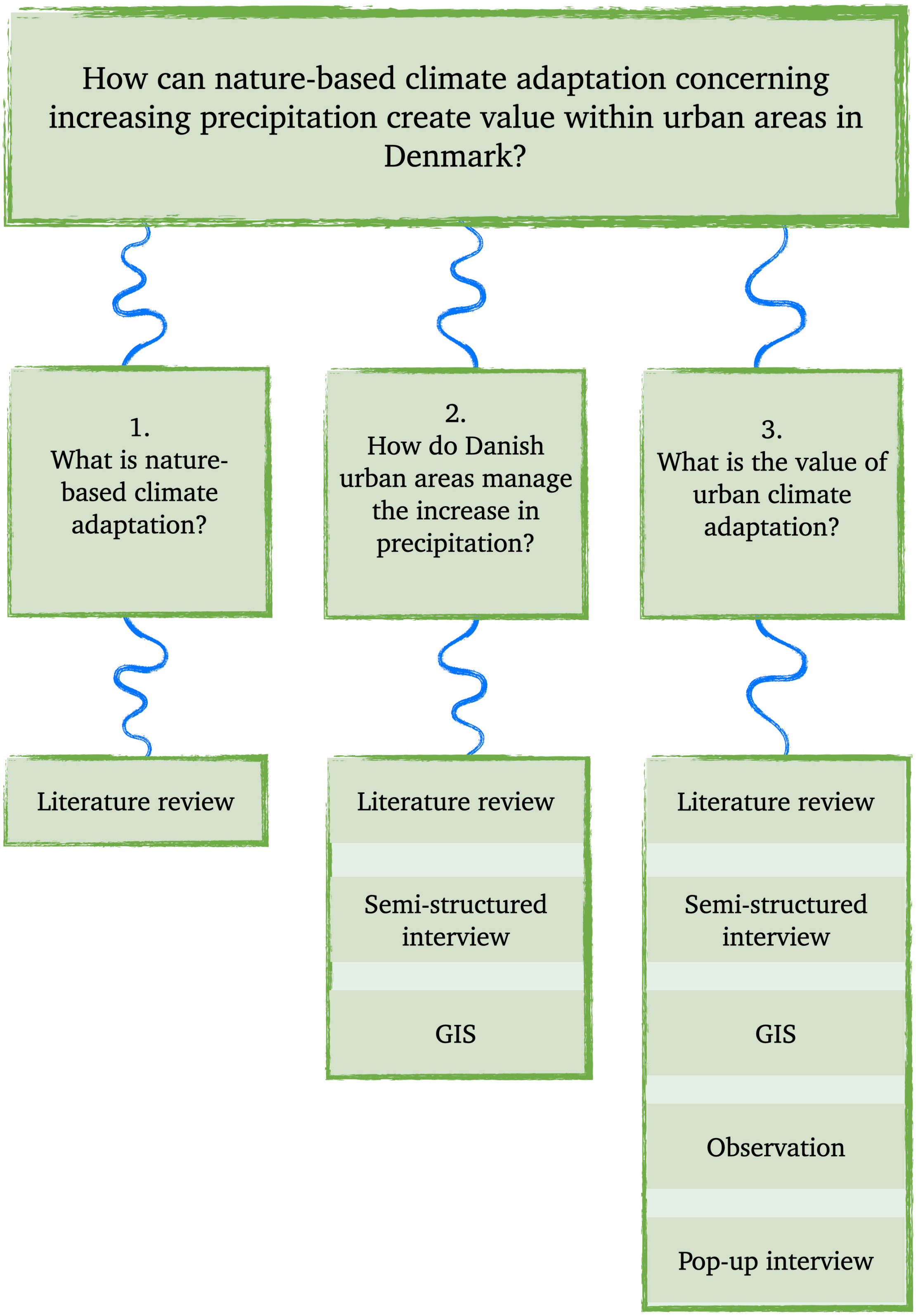


Figure 5.1 The methods used to investigate the different sub-questions and thereby be able to answer the research questions.

5.0.1 Sub-question 1

The purpose of the first sub-question is to get an understanding of nature-based climate adaptations and what that entails. Thus, there is preformed a literature review. This review contribute with an understanding of how the current scientific field has defined adaptations which incorporate nature. First, the keywords *climate adaptation* and *nature-based* are entered into Google Scholar. Afterwards, the articles that have a definition or an understanding of the term were skimmed for the key references and key terms. These key references are then used to get a further understanding of the key terms. This process is repeated both on Google Scholar, but also in AUB and on Google, until the key references and terms are defined. Additional, the website *klimatilpasning.dk* were used to understand what nature-based climate adaptation is in a Danish context. This website provided literature thorough their collection of publication and their knowledge-page. The central concept of nature-based climate adaptation is defined by combining the knowledge from the articles found in the search engines and the on the website *klimatilpasning.dk*. Thus, the unsorted fact becomes grouped data that is the basis of the knowledge of nature-based climate adaptation.

The projects chosen to investigate, in the present report, falls with the definition of nature-based climate adaptations defined in *Section 4.3: Nature-based Solutions*. The following explains the selection of the five nature-based climate adaptation projects included. These projects is all listed on *klimatilpasning.dk*. Four of the projects were found using the examples of different climate adaptations under the *inspiration*-tab. The *Eksempler på løsninger* contains a selection of different search categories. The criterion, that was chosen, within each categories presented in Table 5.1.

Category	Chosen criteria
Udfordring (Challenge)	Mere regn (Increase in rain)
Temaer (Themes)	Alle (All)
Arealtype (Type of area)	Grønne områder (Green areas)
Løsning (Solution)	Bortledning af vand (Draining off water)
Finansiering (Funding)	Finansieret af forsyning (Funded by the sewer company)
	Finansieret af kommune (Funded by the municipalities)

Table 5.1 The categories presented on *Eksempler på løsninger* on the tab *inspiration* on the website *klimatilpasning.dk*. The right column includes the chosen search criteria. The table presents the categories and criteria in Danish, as it is presented on the website, with the English translation in the subsequent parenthesis.

The criteria, mentioned in the table, resulted in 12 areas. Of these 12 area, nine was a cohesive public area with green or blue elements with city limits. The project manager of the appertaining projects were contacted. Of the nine, four responded that they had time for an interview within the project period. The four project was: *Klimabyen* in Middelfart; *Tåsinge Plads* in Copenhagen; *Klimaparken* in Vejle; and *sØmæs* in Viborg.

The four found via the search is established after the Climate Adaptation Plans were a requirement. To clarify what the initiative for establishing climate adaptation, there are included an older project, which was established beforehand. As a result, it can contribute with knowledge on how the value change over time. The older projects was not included on the example page as the page only include newer projects. Therefore, an additional project in Høje-Taastrup was included. The projects was similar to the project in Viborg and met the set criteria. The project in Høje-Taastrup was, however, listed on the website *laridanmark.dk* as an example of *LAR-anlæg i Danmark*. It was later discovered that is was also listed in the archive on *Klimatilpasning.dk*. Thus, the five chosen projects is:

Projects	Locations
sØnæs	Viborg
Klimaparken	Vejle
Aktivitetsskoven	Middelfart
Selsmosen	Høje-Taastrup
Tåsinge Plads	Copenhagen

Table 5.2 The projects investigated in the present report.

5.0.2 Sub-question 2

The second sub-question, *How do changes in precipitation affect Danish urban areas?*, enables an investigation of the water flows within the cities to understand how an increase in precipitation affects cities. Thus, data from the *Klimaatlas*-database and the software Geographic Information System *QGIS* is used. The aim is to examine the design of areas concerning their climate adaptation abilities. The examination consist of a mix of knowledge sustained through the interview, cf. *Section 5.0.3: Interview Design of the Semi-structured interviews*, maps analysis, and document analysis of the project specs, leaflets and other documents with information about the projects. These documents where found on *Klimatilpasning.dk*, *laridanmark.dk* and through the municipality and utility companies websites.

Geographic Information System

To counteract climate change, knowledge about how much reductions and adaptation initiatives is fundamental for decision-makers. IPCC, therefore, developed the Representative Concentration Pathways (RCP). The purpose of the RCP is to form a basis for assessing the consequences of the expected climate change during varying degrees of global warming for decision-makers (DMI, 2014). The RCP consists of four scenarios call RCP 2.6, RCP 4.5, RCP 6.0, and RCP 8.5. The first three scenarios represent an endeavour to tackle climate change at their individual ambition levels. In contrast, the highest scenarios RCP 8.5 present the future without taking any means of reducing the emissions of GHG (ibid.). Additionally, in this scenario, the temperature rises by approximately 3.4 °C up to the year 2100 compared to the average for the period 1981 – 2010. On the other hand, in the lower scenario RCP 4.5, where greenhouse gas emissions are minor, the temperature rises by around 2 °C (DMI, 2020c). In a Danish context higher temperatures will result in more and longer heatwaves, more hot summer nights with temperatures above 20 °C, and reducing the number of days with temperatures below freezing (ibid.).

The Klimaatlas develop by the *Danish Meteorological Institute* (DMI) contains data on expected future changes in the Danish climate at a municipal level. The map shows the development of the temperature for both the RCP 4.5 and the RCP 8.5 scenario. The Klimaatlas contains data about the anticipated future weather in Denmark, such as temperature, precipitation, and storm surge. For instance, the data comprises an estimate of how much the temperature and water level will rise and precipitation increase (DMI, n.d.[a]). Klimaatlas is available as an Excel-file and NetCDF-file, among others, which the present research uses for the maps. The nature-based adaptation is characterised by being able to evolve and adapt to a changing climate. Common, for the projects is that it is a newly established ecosystems. These are more sensitive to disturbance than established ecosystems. However, they become more robust over time. As a result, RCP 4.5 is used as a measure for the future climate.

The data *DMI_Klimaatlas_Grid_Gennemsnitsnedboer_absolut_v2020b.nc":pr_50_45* from the NetCDF-file was imported to QGIS to illustrate the mean precipitation. The dataset includes the median of the absolute precipitation values for the RCP 4.5. The data in Klimaatlas is divided by different time periods: the present consisting of a mean of the reference period from 1981 – 2010; the start of the century from 2011 – 2040; a near-future period from 2040 – 2070; and a end of the century from 2071 – 2100. Each period contains grouped data for the annual mean and mean for each of the seasons. Figure 7.1 on page 48 illustrates the yearly precipitation for the reference period. The data shows the base line for the climate models. The future models are all calculated from these. This map is included to understand the current precipitation pattern, to better understand the future changes. These changes for RCP 4.5 in the last period is illustrated on Figure 7.2 on page 49 with the data in *DMI_Klimaatlas_Grid_Gennemsnitsnedboer_aendring_v2020b.nc":pr_50_45*. The change is showed in percentage from the reference period. The changes are included as they indicate the changes that the planners have to take into account when establishing or transforming, for instance, green area into climate adaptation. As a result, they can increase the RESS in the new area, for instance through strengthening the disturbance service. The changes of precipitation is based on the median value of the scenario thus it is the best estimate.

The Figure 7.3 on page 51 is based on data from the *Det Hydrologiske Informations- og Prognosesystem (HIP)*. HIP is a public database with hydrological data about groundwater and streams now and in the future. The data give insight into the hydrological process including the near-surface groundwater (SDFE, n.d.). The near-surface groundwater contribute with an understanding of the possibility for climate adaptation and what factors to take into account on a local scale. The HIP data is provided as a WMS-service. For Figure 7.3a, the data *Terrænnært grundvand i dag (Minimumdybde Vintersituation)* is the minimum depth of the near-surface groundwater in a winter scenario based on a modelling of historical data. The winter period is where the municipalities most likely will experience problems with the groundwater as the ground is most saturated in this time of year. Thus the groundwater will be closer to the surface, and influencing how to locally managing the seeping of precipitation. The change are based on the median value of the scenario illustrated in absolute change from the reference period 1990 – 2019. For Figure 7.3b, the data is *Ændring i terrænnært grundvand i fremtiden (2071-2100 - Middel)* (ibid.). The changes are included as they indicate the changes that the planners have to take into account when developing areas. As a result, the planner can increase the RESS, including consideration about if the area is obligated to have a purification service before the water percolate so that the groundwater is not polluted.

5.0.3 Sub-question 3

The third sub-question, cf. Figure 5.1 on page 31, is to be answered with a literature review, GIS, observation, and two types of interviews. The literature review builds on the knowledge found in the first sub-questions literature review to obtain the knowledge needed to construct the interview design and be critical of the respondents' answers.

The interview method is chosen to understand what citizens and project managers experience as valuable in climate adaptation projects. The interviews are separated into semi-structured and pop-up interviews. The two types of interviews allow respondents to express their opinions and define the valuable elements of the different projects. The semi-structured interviews aim to understand the process of the projects and what value project managers have considered in the planning process. Furthermore, the project managers are asked to evaluate the project process and if they got the desired outcome. The assumption is that the project managers often move quickly to the following projects after the project is realised, for which reason they will not know the present value. Observation at the sites is an additional method to the interview because it was possible to clarify if the project managers' intention of the climate adaptation was established. Furthermore, GIS is used to present the findings of the different projects. By combing the pictures from observation with maps of the area. Additionally, it is chosen to perform a pop-up interview simultaneous with the observation. This type of interview aims to emphasise the user perspective and how climate adaptation projects generate present value. The combination of these methods, provides data about how nature-based climate adaptation can unlock both CESS and RESS for the purpose of contributing to human well-being in an urban area.

Interview Design of the Semi-structured interviews

From each of the projects listed in Table 5.2 on page 33, it is chosen to talk to the primary project manager. The primary project manager for the chosen project were all from the municipalities. The project managers have an understanding of the value creation of the individual project because they where responsible for the project process. Furthermore, some project managers suggested additional respondents that could elaborate on some of the questions the municipality's project manager could not answer. Through these interviews, it is possible to elaborate on the considerations that went into the projects, such as health values, which are often not well-described or substantiated in their project descriptions where the focus is primarily on the mitigating values. Therefore, the project managers contributes with knowledge about the added values. The respondents are listed in Table 5.3 on the facing page.

Projects	Project Manager	Company
sØnæs	Lotte Kunstmann	Viborg Kommune
	Henrik Juel Poulsen	Energi Viborg Vand A/S
Klimaparken	Ulla Pia Geertsen	Vejle Kommune
	Gitte Bisgaard	Vejle Spildevand
	Pia Lyngdrup Nedergaar	ØsterBo, Vejle
Aktivitetsskoven	Bjarne Simon Rasmussen	Middelfart Kommune
Selsmosen	Claus Dahl	Høje-Taastrup Kommune
Tåsinge Plads	Sebastian Thor Bovbjerg	Københavns Kommune

Table 5.3 The respondents chosen for the present project.

As mentioned, the aim of the interviews was to get an understanding of the value of climate adaptations. For which reason, the conceptual framework formed the interview guide. The interview guide was not organised to be used in chronological order, but organised by themes. This is concurrent with the semi-structured interview, as the respondent steer the interviews within the given frame. The interview's execution was as follows: The interviewer asked respondents what value they see in the projects, and hereafter the interviewer will jump to the themed questions connected to the value. Subsequently, when that subject has been exhausted, the interviewer will return to the question about value, and thus keeping the interview within the given frame. This cycle would continue until the respondents had covered the values defined in *Chapter 4: Conceptual Framework*. If the respondents do not bring up a value, the interview will ask them directly if they have had that value as part of the thought process in the planning. This method allowed flexibility. Hence, the values that the respondents saw as most memorable could be explored. Additionally, the interviewer will gain an understanding of the process, which went into the projects. The interview guide is enclosed as Appendix A. The interviews were performed in Danish since this was the primary language of the respondents. The assessment was that this would minimise the chances of misunderstandings as a result of a language barrier.

The semi-structured interviews, thus, provided knowledge on the process and thoughts behind the different projects. The interviews are, thereafter, transcribed in *NVivo 13* which is a data analysis software. This software help create an overview of the different interviews. Furthermore, it creates a space to compare and analyse the points of the interviews through thematising. The themes reflect the values defined in *Chapter 4: Conceptual Framework*. However, the answers differentiates, which illustrates the different views on the same value. The themes, therefore, help compare and analyse different points of the nature-based climate adaptation.

Observation and Pop-up Interviews on Site

The literature study and interviews both provide a secondhand interpretation of the climate adaptation projects. However, observation is included to examine if the finished design of the climate adaptation projects matched the project managers' goals. Therefore it was necessary to experience each project first hand, with the secondhand interpretations in mind. Thus, the observation allows investigating activities in the areas and their visitors in progress. Hence, the dynamics between the design of area and the activities is recognised. However, it is important to note that the observation was not fixed on a certain object, and thus the intention of the observation was broadly defined.

Furthermore, through the observation it was possible to speak and interact with the users at each places, thus get access to evaluate the activity that occur at the sites. As mentioned, the aim of these pop-up interviews is to understand the users perspective in these areas. Thus, what value the citizens see in the areas, and how this coincide with the project managers. The pop-up interviews are a quick interview form, where the respondents are found and asked in the given areas. The questions should, therefore, be few, short, and directly to answer, as this will increase the possibility for people to attend. The questions is listed in *Appendix B: Pop-up Interview Guide*. Each location were visited for 1,5 hour. In this period the interviewer approached citizens using the area with the listed questions. The answers where noted and compiled and sorted by the questions to compare similarities and differences between the respondents answers.

6 | Presentation of the Projects

As mentioned in *Section 4.3: Nature-based Solutions*, NbS needs to be hybrid to perform effective climate adaptations in an urban context. Therefore, to investigate how changes in precipitation affect Danish urban areas, selected Danish examples are included. These projects will exemplify how the NbS are utilised and perform in these adaptation projects. The location of these selected examples are all illustrated in Figure 6.1.

Figure 6.1 The location of all the selected climate adaptation projects in Denmark (SDFE, 2021a).

Common for the projects is that they are a partnership by the municipality and the utility companies. The partnership arises because the project area requires a change in the grey infrastructure, for which the utility company is responsible. The municipality and utility company contributes with different knowledge, which results in climate adaptation projects that are an integrated part of the urban area and the water management. The municipality is responsible for the climate adaptation plans and thereby the areas that are at flood risks, whereas the utility company contributes with knowledge about climate and management of water which can lead them to meet their service level. The value of establishing such adaptation underlines the motivation for the partnership between the utility company and municipality when entering such climate adaptation project (Middelfart Kommune, 2013).

When the municipalities currently want to establish climate adaptation projects, these projects are a part of climate adaptations plans. Thus, the agenda is about strengthening the cities ability to manage the run-off, among others. The climate adaptation plan includes multiple project of various size. The lager project often includes sub-projects. Hence, each of these sub-projects is a climate adaptations, which is part of an umbrella project. This is the case for three out of five selected projects: Klimaparken is part of Klimaprojekt Østbyen; Aktivitetsskoven is a part of Klimabyen Middelfart; and Tåsinge Plads is a part of Klimakvateret Østerbro (Københavns Kommune, n.d.; Middelfart Kommune, n.d.; Vejle Kommune et al., 2021). The remaining two projects are water basins which are made independently of other climate adaptations.

6.1 sØnæs in Viborg

sØnæs, is a climate adaptations project located in southern Viborg, illustrated in Figure 6.2 on the facing page. This project finalised in 2015 and was a collaboration between Viborg Kommune and the local utility company's water division *Energi Viborg Vand*. The area is approximately 10 hectares and owned by Viborg Kommune (Miljøstyrelsen, 2016; VANDPLUS-sekretariatet, 2015).

Figure 6.2 The location of sØnæs in Viborg. The orange colour indicates the demarcated area of the climate adaptation project (SDFE, 2021e).

The project has transformed a green area, which was previously football fields, into a water landscape with a technical facility to handling and purifying rainwater. The solution is a combination of green and grey solutions; by combining treatment ponds with an open recreational area for the public, thus, creating room for the local catchment area's run-off (Realdania, n.d.[a]; VANDPLUS-sekretariatet, 2015).

6.2 Klimaparken in Vejle

The climate adaptation project in Vejle is named *Klimaparken* and is located in the eastern part of Vejle. The extent is illustrated in Figure 6.3 on the next page, and is approximately 2,6 hectares. Apart from the other projects, the housing association *ØsterBo* is a project manager, on equal terms with Vejle Kommune, and the local sewer company *Vejle Spildevand*. ØsterBo is included because they owns the green area, which constitutes Klimaparken. The elements which constitutes the climate adaptation was completed in 2020, however the natural elements, such as bushes and trees are first expected to be completed in 2021 (Nedergaard, 2021; Geertsen, 2021; Bisgaard, 2021; Miljøstyrelsen, 2021).

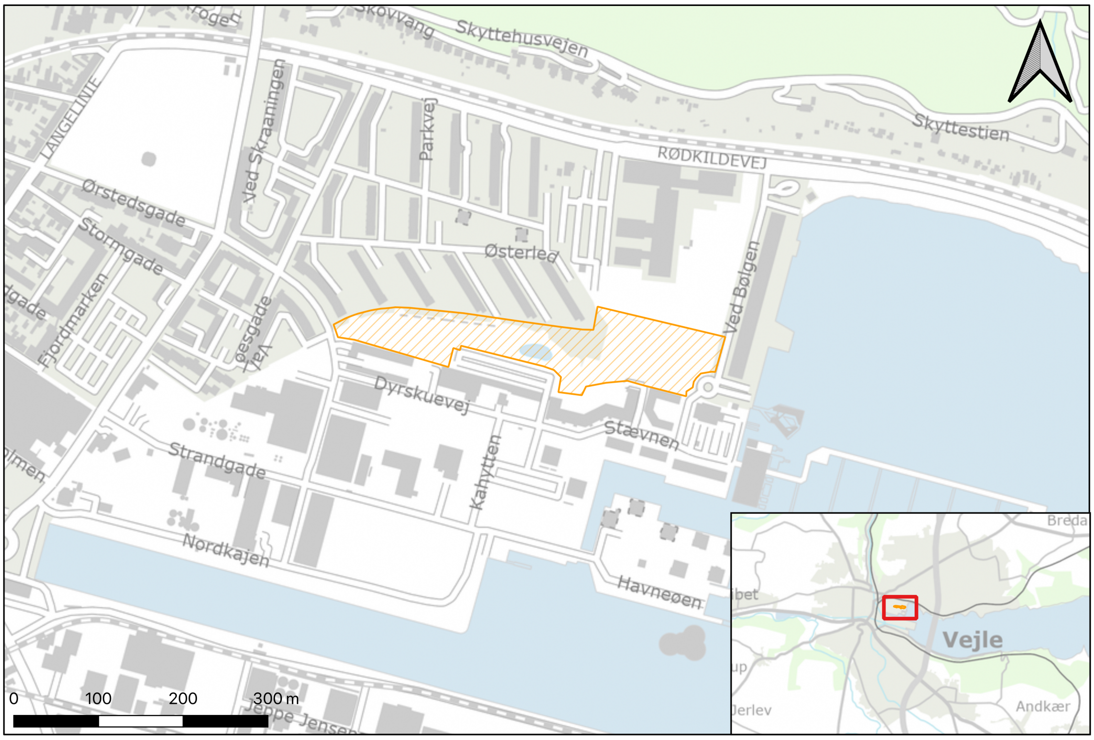


Figure 6.3 The location of Klimaparken in Vejle. The orange colour indicates the demarcated area of the climate adaptation project (SDFE, 2021e).

Although the construction of this area is not completed, the establishment of this project has not only met the housing association's requirement of handling the increasing precipitation but also requirements of the sewer company and the municipality, about easing the relying on the grey infrastructure while making room for other value to raise (Geertsen, 2021; Nedergaard, 2021; Bisgaard, 2021).

6.3 Aktivitetsskoven in Middelfart

Aktivitetsskoven is local climate adaptations placed in Middelfart. The project was finished in 2019 by a collaboration between Middelfart Kommune and Middelfart's sewer company, *Middelfart Spildevand* (Miljøstyrelsen, 2020). Aktivitetsskoven is located at the edge of the forest near Middelfart Stadium and is approximately 1 hectare (Spildevand, 2016). The following illustrated the extent and the location in Middelfart:

Figure 6.4 The location of Aktivitetsskoven in Middelfart. The orange colour indicates the demarcated area of the climate adaptation project (SDFE, 2021e).

Before the area was a lawn, which mostly used for parking, when attending the games at the local stadium. The climate adaptation has transform the site into a area, which combine adaptation with a space for physical activities. Thus, the precipitation has a designated area and where it does not cause disturbance for the neighbourhood (Kommune, 2014).

6.4 Selsmosen in Høje-Taastrup

The project of Selsmosen is located in Høje-Taastrup. The project inaugurate in 2012 due to a corporation between Høje-Taastrup Kommune and the local utility company, *HTK Forsyning*. The project entailed an expansion of an existing water basin with 20.000 m^3 (FORCE4 ARCHITECTS, 2009; Marcussen, 2013). The extent is illustrated in Figure 6.5 on the following page, and is approximately 4 hectares.

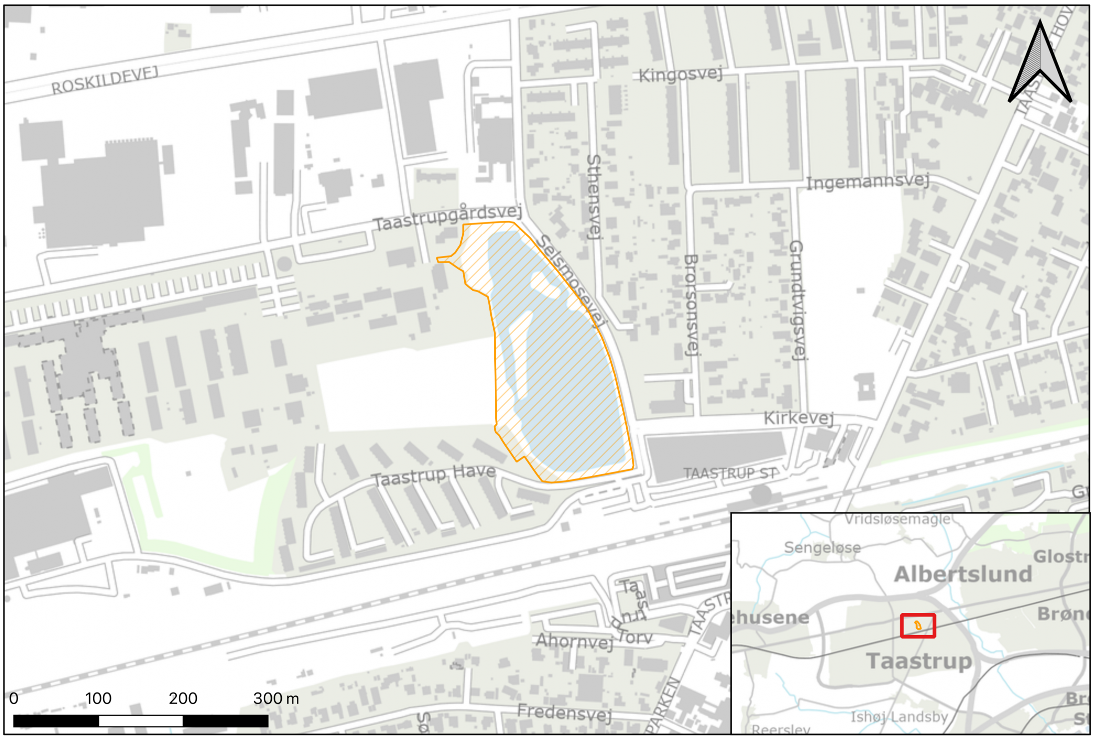


Figure 6.5 The location of Selsmosen in Høje-Taastrup. The orange colour indicates the demarcated area of the climate adaptation project (SDFE, 2021e).

Through out the process of establishing the climate adaptation, it was necessary to convert some existing green area, for the purpose of expand the capacity of the water basin. Although a green space was suspended the new focus on activities on the water resulted in an area with a recreational purpose. The area is transformed into a water activity park that combines water activities with managing and purification of the run-off (FORCE4 ARCHITECTS, 2009).

6.5 Tåsinge Plads in Copenhagen

The last of the selected climate adaptations project in this research is *Tåsinge Plads*, which is located at Østerbro in Copenhagen. The extent is illustrated in Figure 6.6 on the next page. The project was finished in 2014 and is established through a partnership between Københavns Kommune and the local utility company's water and wastewater division *HOFOR*. In addition, the landowners in the project area contribute with funds for the renovation of their own properties and sidewalks, which contributed to a lift of the area as a whole (Miljøstyrelsen, 2015).

Figure 6.6 The location of Tåsinge Plads in Copenhagen. The orange colour indicates the demarcated area of the climate adaptation project (SDFE, 2021e).

The project transformed 0.2 hectares of asphalt and a small lawn into a green space that delays and collects the precipitation from the surrounding urban areas. At the same time, create an open space for relaxation and meet-up (ibid.).

Aktivitetsskoven

Part III | Results

The objective of this part is to present the result on the variations in precipitation influence Danish urban areas. Therefore, determine *adaptation* concerning climate changes. Additionally, the part emphasises the finding of these climate adaptations. Next, it presents examples of nature-based climate adaptation in practice. The project varies in location, size, and physical design; however, they are all Danish projects. Thus, create an understanding of the context of these climate adaptations and their reasoning for being established as NbS.

7 Effects of Increased Precipitation

The precipitation changes depending on the season but also across the country. The annual mean precipitation per day is illustrated in Figure 7.1. It is evident that the southern part of Jutland experience the largest amount of precipitation while it decrease eastwards. As a result, Vejle have the highest mean precipitation per day and Copenhagen and Høje-Taastrup have the lowest.

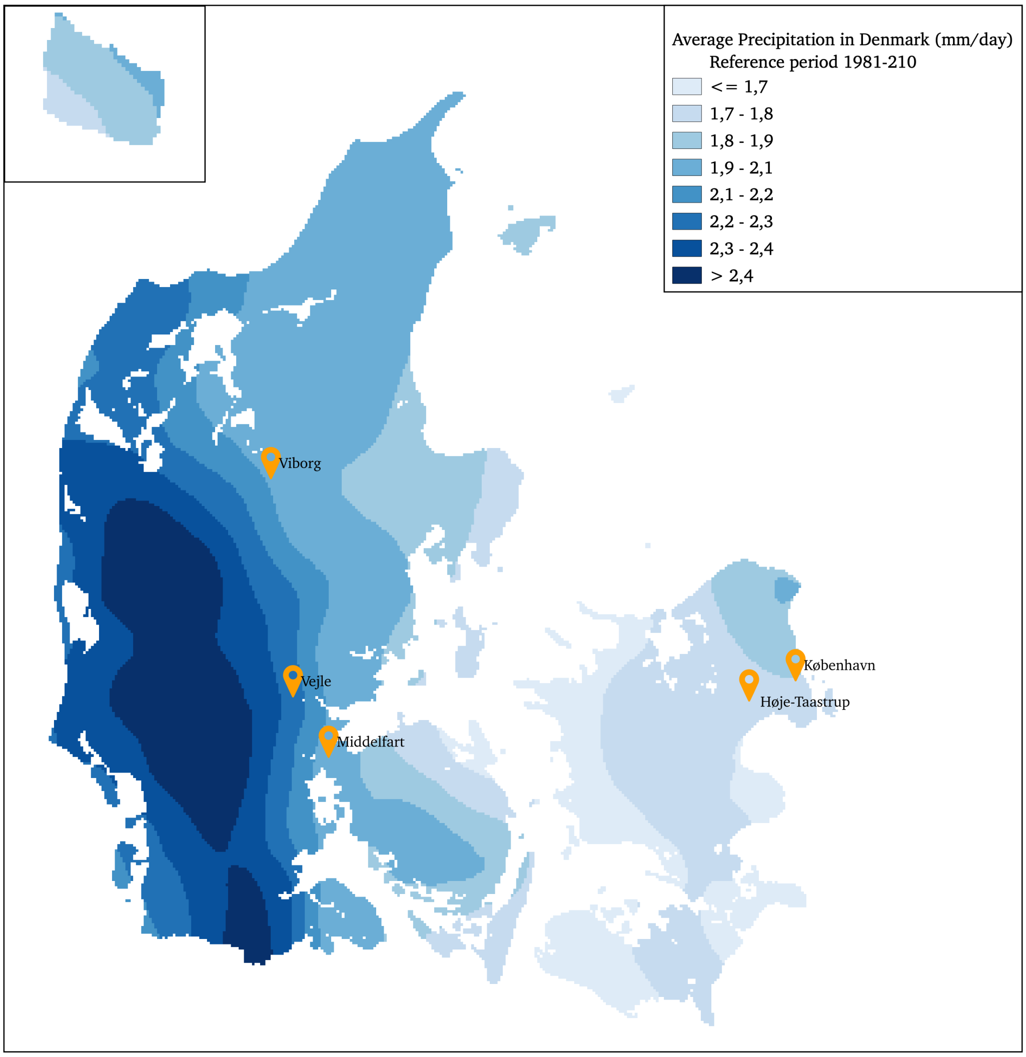


Figure 7.1 The annual mean precipitation per day in mm for the period 1981-2010 and the placement of the projects (DMI, n.d.[a]).

The precipitation in Figure 7.1 indicate normal rain. This type is the minimum capacity the area should be able to handle. Additionally, there is the extreme events including cloudburst. This normal changes as the climate changes. According to the Klimaatlas the precipitation increases in average with 6.97 % annually (DMI, n.d.[a]). The increase is not evenly distributed across Denmark, as illustrated in Figure 7.2. However, it indicates that the areas which have the lowest amount of precipitation will have the highest increase toward 2100.

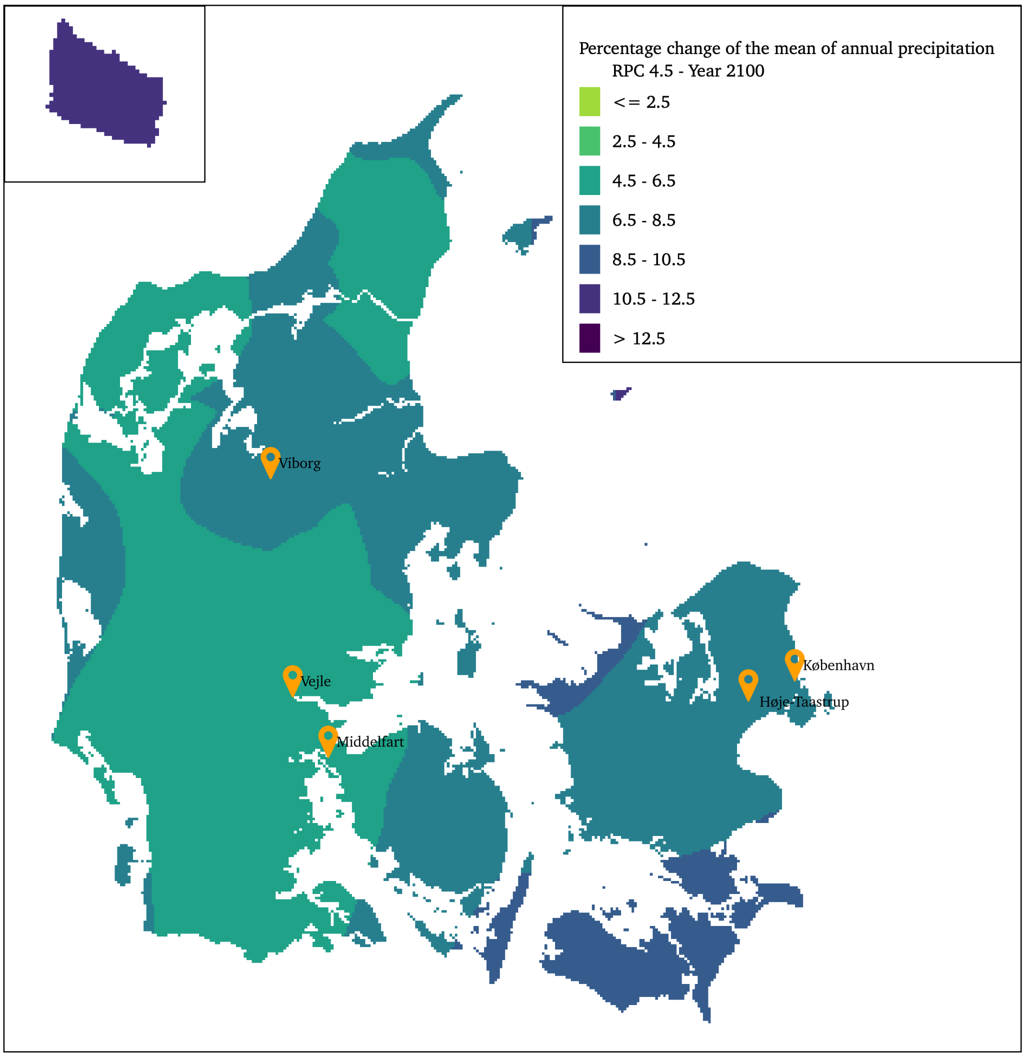
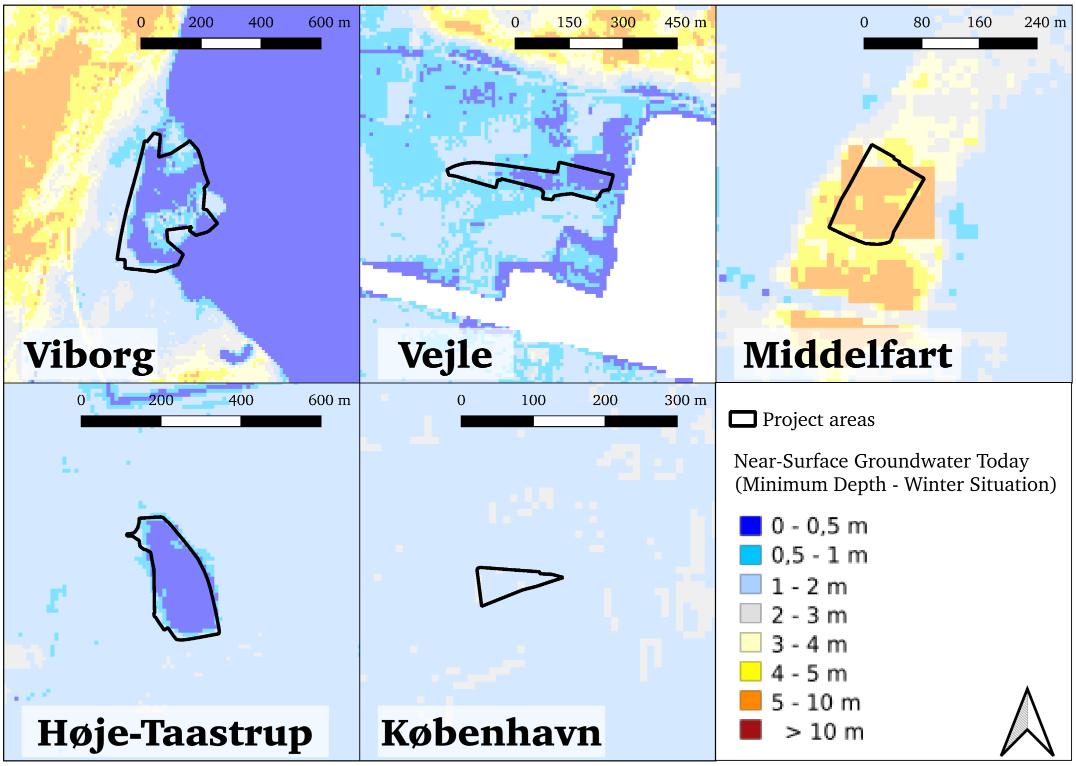


Figure 7.2 The changes in 2100 according to the RCP 4.5 scenario of the annual mean precipitation per day in percentage and the placement of the projects (DMI, n.d.[a]).

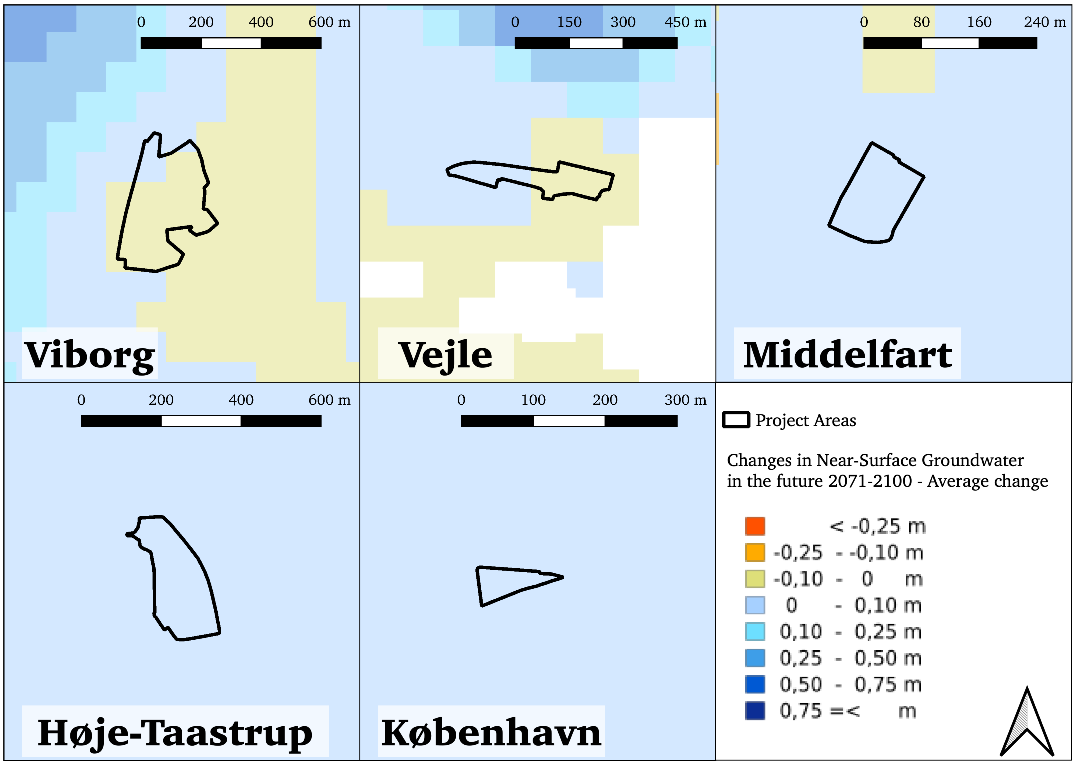
This increase in precipitation also affects other aspects of the hydrological cycle. In Denmark, the groundwater is close to the surface, in multiple places. However, it varies between the regions. Besides Middelfart, the groundwater is under 2 meters below the surface as illustrated on Figure 7.3a on page 51. Nevertheless, the reasons for this differentiate. Vejle and Viborg is located near a larger body of water in a valley which cause that the saturate zone is nearer the surface despite the top soil being sandy. For

Høje-Taastrup and Copenhagen the top layer is clayey which prompts that the saturated layer is closer to the surface. Aktivitetsskoven is, as mentioned, placed on a hill which combined with the sandy soil moves the groundwater further down to approximately 5 – 10 meters below the surface. The distance to the groundwater affects the possibility for percolation and thereby what measures that are applicable (Kusnitzoff, 2019; Henriksen et al., 2020; Jørgensen & Stockmarr, 2009).

Furthermore, the future scenarios have to be taken into account. When the precipitation increases, the groundwater level increases as well if the recipients water flow cannot increase proportionally. If the groundwater already is near-surface, floods will especially occurs in the winter as the evaporation is at its lowest (Kusnitzoff, 2019; Henriksen et al., 2020; Jørgensen & Stockmarr, 2009). The changes in groundwater levels for each of the project areas are illustrated in Figure 7.3b on the next page.



(a) The minimum depth of near-surface groundwater today. The data is an average from the period 1990 – 2019 (SDFE, n.d.).



(b) The changes in near-surface groundwater for the project areas in 2071 – 2100 for RCP 8.5 (SDFE, n.d.).

Figure 7.3 The near-surface groundwater now and expected changes for the period 2071 – 2100. The changes are based on the RCP 8.5. There are insignificant differences between the two scenarios within the projects area (SDFE, n.d.).

The changes within the project areas are from -0.1 – 0.1 m. The change does not have a significant influence when planning for the area as the groundwater will not reach a level that give a significant change. Tåsinge Plads use percolation however the the change in depth is under 10 cm and thus the areas still have over 1.5 m from the surface. Furthermore, it includes another drainage solution if percolation is impossible. In Middelfart, the change in groundwater elevation will not influence the area as the current level is over five meters below the surface.

8 Planning of Urban Climate Adaptation

The increase in precipitation in Denmark require that urban areas adapt, as mentioned previously. The climate adaptation plans result from mitigating the forthcoming decades' expected precipitation increase in the winter and more cloudbursts in the summer. These conditions forces local authorities to establish climate adaptations to protect values, whether these values are material as non-materials on a local scale (Naturstyrelsen, 2013).

The Danish Government issued the municipalities and utility companies to make municipality-level climate adaptation plans. The incentive to make climate adaptation plans came from an agreement between Local Government Denmark (KL) and the Danish Government in the financial agreement in 2013. The climate adaptation plans were to be a part of or an amendment to the municipalities' local development plan. It should comprise of a risk assessment, including a risk map and prioritisation of the efforts. The value map is ultimately based on how the individual municipality's politicians value different assets and their prioritisation (ibid.).

In context to the value, it is the political agendas that determine what to protect in the urban area. The ecosystem services are vital for establishing a sustainable foundation for livelihood. These services play a crucial role in mitigating the consequences of climate change. An area with a healthy ecosystem is more resilient to environmental disturbances than degraded land or highly built urban areas. Thus, the ecosystem service is considerably reduced and significant in regulating natural hazards like floods and erosion. Such services become even more critical in times of global climate change (Orradóttir & Aegisdóttir, 2015; Naturstyrelsen, 2013).

The origin of the climate adaptation project has not formerly been a part of the urban development; however, as emphasised in the earlier chapters, the increasing precipitation challenges the current systems which managing the run-off. The combination of climate adaptation becomes mandatory, and the local environment results in that the municipalities have different approaches to planning climate adaptation projects.

8.1 Water Landscape in sØnæs

sØnæs is located between the lake and residential area in Viborg, and thus, functions as a bridge that connects urban and natural areas. Apart from sØnæs, there are several other urban green spaces in Viborg city. These are primarily centralised around the historical part of the city, located in the central part and along the earthen part of the lake. The area before and after the establishment is illustrated in Figure 8.1

(a) sØnæs before the transformation (VANDPLUS-sekretariatet, 2015)

(b) sØnæs after the transformation (Ammitzbøll, 2015).

Figure 8.1 sØnæs before and after the climate adaptations project. As a result of the transformation, the cohesive green areas are divide by the water basin but still connected through pathways and bridges.

Before establishing the project, there were no other green spaces of relevance in the southern part of Viborg. Visitors at the old site were primarily brought by because of the route that took them around the lake. Nevertheless, the placement of sØnæs is an advantageous location concerning the use of the area. Apart form the proximity to the lake, the site is around 2 kilometres from the city centre (VANDPLUS-sekretariatet, 2015; Kunstmann, 2021).

However, the area had some challenges. Naturally, the area consisted of marsh and meadow, but was drained to be used as a livestock show venue. In 1967, the football club B67 was founded and established multiple football fields in the area (Spanggård, 2015; Kunstmann, 2021; Viborg Kommune, 2015). As early as 1986, the area was evaluated by the municipality and utility company as a potential location for a needed rainwater basin for Viborg's southern neighbourhood. The fields often flooded as they were low-lying compared to the lake. Because the municipality could not find a replacement for the local B67, the idea of establishing a water basin was never carried out. As a result, the site and the repeating floods continued (Viborg Kommune, 2015; Kunstmann, 2021; Poulsen, 2021). In situations with normal precipitation, the location could not manage the run-off effectively, and thus the area becomes flooded. For instance, the precipitation for August 2011 was 39.3 mm hence categorised as wetter than the average (DMI, n.d.[b], 2001). At that time, the area had an inability for water to percolate in combination with the infrastructure to handle run-off within the areas which resulted in the site flooded for an extended period. Since the fields were so frequently flooded, it became characteristic for the area (Miljøstyrelsen, 2016; Overgaard, 2011; Kunstmann, 2021). Figure 8.2a on the next page illustrates such a situation, where a large part of the football fields was flooded due to the monthly precipitation. Consequently, it limited the use of the area (Poulsen, 2021).

On the other hand, the road Gl. Århusvej, located next to the green area, was also at risk of flooding when extreme precipitation occurs due to the natural landscape and inadequate drains. The sewer did not work because there was not enough high difference to lead the run-off from the road to the green area (ibid.). The repeated flood of the road was problematic as it is one of the main roads for ambulance services, which means it created a societal disturbance (Realdania, n.d.[a]; Kunstmann, 2021). Such situations are shown in the Figure 8.2b. Gl. Århusvej and several other places in Viborg are challenged when there are extreme rain events, for instance in August 2012 where more than 26.7 mm of precipitation fell in a 24 hours period (DMI, n.d.[c]). Such situations result in the road was heavily flooded, and made the infrastructure insufficient.

(a) The flooded football fields which B67 used before the establishment of sØnæs (Overgaard, 2011).

(b) The extreme precipitation in 2012, with around 15 mm in 30 minutes that caused floods at Gl. Århusvej (Helmer et al., 2012).

Figure 8.2 Flooded area at sØnæs and the adjacent road before the establishment of sØnæs where the water was not led away from the terrain in both normal and extreme weather situations.

The recurring flooding of both the green area and the road emphasise the need to establish initiatives, thus, securing the roads and the low-lying buildings around sØnæs against flooding. However, the largest challenge was to find new facilities for B67. Nevertheless, in 2012 the municipality and B67 came to an agreement, thus the development of a new area with a water basin began (Viborg Kommune, 2015; Kunstmann, 2021; VANDPLUS-sekretariatet, 2015).

sØnæs, is the largest project area among the selected climate adaptation projects, extending approximately 92,330 m^2. sØnæs have a catchment area of approximately 50 hectare (Viborg Kommune, 2015). The water comes from the catchment area through a pipe system that are designed to handle rain incidents that occurs every 10 years. However, the design of sØnæs render it possible to handle rain events occurring every 100 years. When incidents happen where the rain system cannot keep up, the run-off will travel on the surface to the area. The water is led into the water basin from three pipes. Two of the pipes displayed as Picture B and Picture E in Figure 8.3 on the facing page.

In Viborg, the rainwater previously drained directly to the lake. However, this was problematic as the lake, Søndersø, has an environmental target to have good environmental conditions. The water basin was, as mention, a long time in the making, but the solution was to establish the water basin, which finally cleared the water before it is pump out to the recipient. The basin is a settlement basin and thus form sludge at the bottom, for which reason bathing is prohibited. Furthermore, the water basin have a lower elevation than the lake to prevent overflow in extreme events where the mechanical pump might malfunction. Pictures C and D illustrates the area with the mechanical pumps (Poulsen, 2021; Viborg Kommune, 2015; Kunstmann, 2021).

Figure 8.3 The additional basin at sØnæs where the numbers indicate the of which they fill up. Furthermore, pictures of the different parts of sØnæs: overflow pipes (A), inlet (B, E), and pump and outlet (C, D) (Own pictures; SDFE, 2021e; Viborg Kommune, 2015).

The area permanently have 12,500 m^3 of water but hold up to 36,000 m^3 (Viborg Kommune, 2015). The permanent water basin dams part of the area towards the lake consequently giving the illusion of an island. This island is constructed as a natural landscape. The design includes four other basins despite the one with a permanent water level. Three of the basins are located in the island. The basins are depression in the surrounding area with a watercourse running through it, which contribute to illusion of a natural landscape. The basins on the island is illustrated in Figure 8.3 with the numbers 1, 2 and 4. The water is transported to the additional basins by overflow pipes from the main water basin, the watercourse, or by overflowing the dikes where the path system is located. There are two overflow pipe systems located at the basins indicated with 1; Picture A illustrates one of these pipe systems. The basin gradually fills up in the order indicated by the numbers in Figure 8.3 (Kunstmann, 2021; Poulsen, 2021; Viborg Kommune, 2015).

The municipality wanted to underline the contrast of urban and natural environments as one of the intention behind the design of the landscape:

> We wanted to create an area that mediates the transition between nature and urban, and that is why the whole design of sØnæs is that there are things that is very urban, it is concrete and it is the red roofs, or at least the illusion of the city's red roofs that run through the entire mainland; and then at the "island", there is the more nature, it is the stamped, hilly paths, which are not built with a proper foundation, so that they move a little, depending on how they settle, and there is furniture of wood, and such things.
>
> (Kunstmann, 2021:translated)

The mentioned focus in the quotation was implemented because the municipality wanted to lose the previous image of the area as B67's football field (Kunstmann, 2021). The users all mention that they did not use the area before because it was B67 unless they were there for a match (sØnæs, 2021). Thus, a rebranding was done. The name of the area was spelled with Ø capitalised in the name to reflect the new island which became the focal point of the area. Furthermore, they wanted the space that set the framework for different events, which the users could initiate. Since the establishment, the area has been the location for isolated and recurring events of various size (Kunstmann, 2021). The area, which is characterised by the urban elements, includes concrete paths which run through the whole area. The municipality found it important to have these path as it made the area accessible despite the weather and physical challenges of the user (ibid.). The users sØnæs also mentions the concrete paths as important for accessibility. However, they express that the more natural elements is a draw. The area would not give the same experience if it did not include the natural elements (sØnæs, 2021). The municipality also have that in mind when they planned the area by being creative with the design of the water basin that mimics a more natural water body than a traditional square water basin (Kunstmann, 2021).

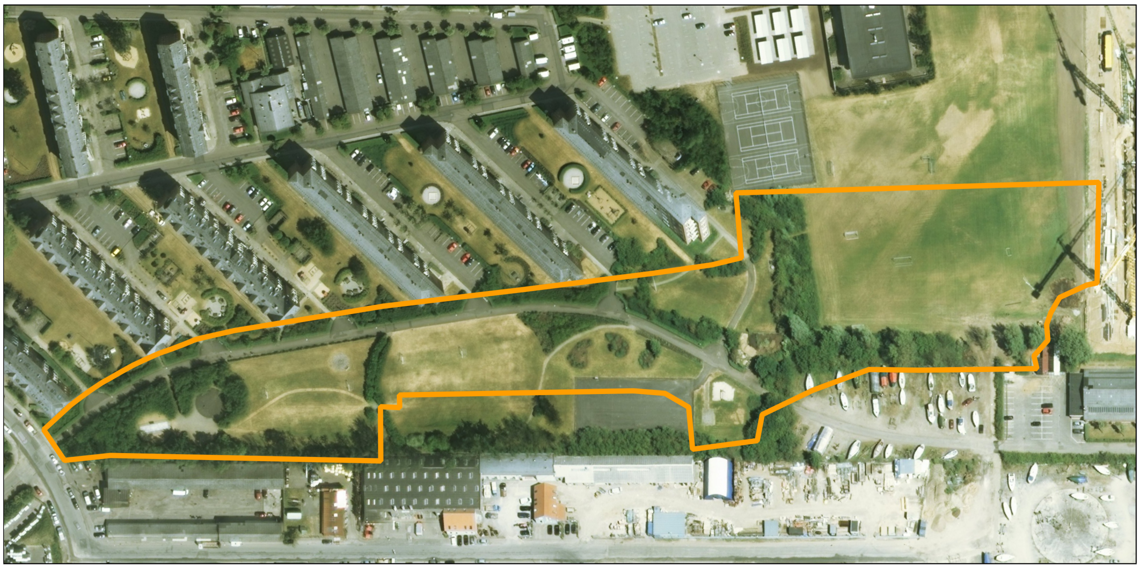
The area is, as mentioned, built to withstand events occurring every 100 years. There has been recorded cloudbursts in Viborg since it was established. In July of 2019, the city experienced a double cloudburst after a longer period with rain. The incident was recorded to be somewhere between a event that happens every 50 or 100 year, which challenged the functionality of sØnæs. There were no reports about the Gl. Århusvej being flooded and the reports was that sØnæs functioned as intended (Jönsson, 2019).

There were not any records of the area reaching full capacity or flood caused by a malfunction in the area. Thus, it can be assumed that the area serves its purpose in terms of climate adaptation.

8.2 Green and Blue Wedge in Klimaparken

Almost opposite of Viborg, most of the established green spaces, including Klimaparken, are spread out across the city centre of Vejle. Most of the green spaces follow the natural waterways, which they also are inspired by. Additionally, Vejle is surrounded by large areas of forests (Vejle Kommune, 2015).

Klimaparken is located near the harbour, as a green and blue wedge which binds the fjord and the urban environment. Before the establishment, the park consisted of lawns with a path running through to each end of the area. The site had some bushes in the western part of the area, resulting in the area was denser and more divided here. Figure 8.4a on the following page illustrates the area as it was in 2008. However, ØsterBo's residents wished to change the area to be more open. Thus, increasing the residents' and other users' feeling of security which resulted in removing the bushes. At that time, the park was not used for anything but transition (Nedergaard, 2021).



(a) Klimaparken before the transformation (SDFE, 2021d).

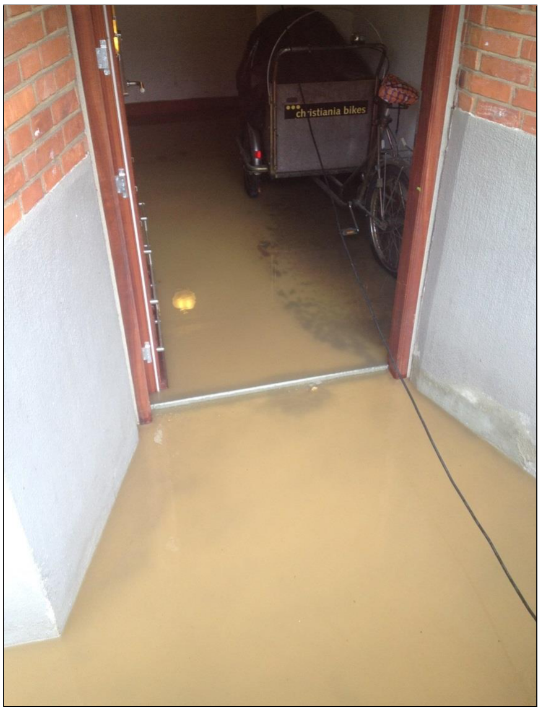
(b) Klimaparken after the transformation (SDFE, 2021c) .

Figure 8.4 Klimaparken before and after the climate adaptations project. The area became a more cohesive area, with less divided by the natural elements. However, the after picture does not show the project in terms of all the included natural elements as these are not established yet.

In Vejle, Klimaparken is placed directly beside its recipient, Vejle Fjord. When climate change caused increased precipitation and the water in the fjord to rise, the city became especially exposed to floods, now, historically, and in the future. Nevertheless, the purpose of Klimaparken is not to manage these floods. Vejle Kommune has implemented a *Storm Flood Strategy* which includes measures to decrease the area's vulnerability towards floods. Thus, Klimaparken's main function is to manage the increase in precipitation and cloudbursts (Vejle Kommune, 2020; Bisgaard, 2021). Naturally, the city is located at the end of the valley. The area north of Klimaparken is placed higher, and thus capture and send the run-off towards Klimaparken, and the rest of the Eastern part of Vejle, which lies below sea-level. As a result, the pressure on the local sewer system increases in this area. Thus, the east part of Vejle is at greater risk concerning floods because it becomes the endpoint of the natural run-off from the higher-lying areas. As a result, citizens in the eastern area suffer from repeated floods and experience material damage (Miljøstyrelsen, 2021; Vejle Kommune et al., 2021; Nedergaard, 2021; Geertsen, 2021; Bisgaard, 2021).

The plan was to lead the water through Klimaparken and to the Vejle Fjord on the surface. However, the elevation in the area is relatively flat, and near the end, it creates opposite gradients. These gradients were also part of the flooding problems as the water struggled to leave the area and thus ended up in surrounding basements. Especially the residents at Østbyparken, immediately next to the green area, experience floods of the basements and shared outdoor spaces. Such situations are represented and illustrated in Figure 8.5, where a heavy precipitation incident occurred in May and June in 2014. The precipitation measured to be up to 43 mm in May and 24,7 mm in June (DMI, n.d.[d]; ØsterBO, 2015).

(a) Collection of precipitation between the apartment building owned by ØsterBO, next to Klimaparken (Nedergaard, 2014).



(b) Østbypark's flooded basements as a result of precipitation (Nedergaard, 2014).

Figure 8.5 The apartments owned by ØsterBo experiencing floods caused by precipitation in 2014, before the establishment of Klimaparken and the separation of the sewer system.

In August 2014, Østbyparken had already experienced five indecent of flooded basements. The change in weather was evident, and the repetitive and intensity of floods with it.

These challenges implied that if the area cannot handle average heavy precipitation, the area was vulnerable when more extreme precipitation incidents occur. Formerly, such events with flooding in the basement and the common outside area would happen at most every second year, and the intensity of the flood was significantly lower. The backwater from the sewer in the basements increases and with it the impact of damage since the sewer system was a common pipe system. Consequently, the floods left behind unhygienic conditions that required more effort to clean and restore than if the backwater was solely rainwater. Such a situation demanded more than the antiflooding-valve, which previously was the solution in Østbyparken (ØsterBO, 2015; Nedergaard, 2021; Vejle Kommune et al., 2021).

The climate adaptation projects, which Klimaparken is one part of, is expected to handle approximately 267 hectare of run-off from the northern and eastern parts of Vejle. The northern catchment area leads surface water to pipes at Rødkildevej and, from there, leads through the open water corridor toward Klimaparken. Klimaparken uses the natural elevation in the landscape as part of the solution. The area consists of a 750 meters long green and blue corridor with a channel that has a low slope ending in a concrete area, which is illustrated in Picture B in fig. 8.6 on the facing page. The slope keeps the area dry when it is not raining. However, it functions as one big channel when extreme incidents occur, with a capacity of 2600 m^3 which is equivalent to an incident that occurs every 80 – 100 years. The channel in Klimaparken ends with grates connected to a pump that pumps the water the remaining way to the recipient (Geertsen, 2021). The grates and pump are illustrated in the Picture A in Figure 8.6 on the next page. There are two lakes within the area; however, the lakes have no value in terms of climate adaptation (Miljøstyrelsen, 2021; Vejle Kommune et al., 2021; Nedergaard, 2021).

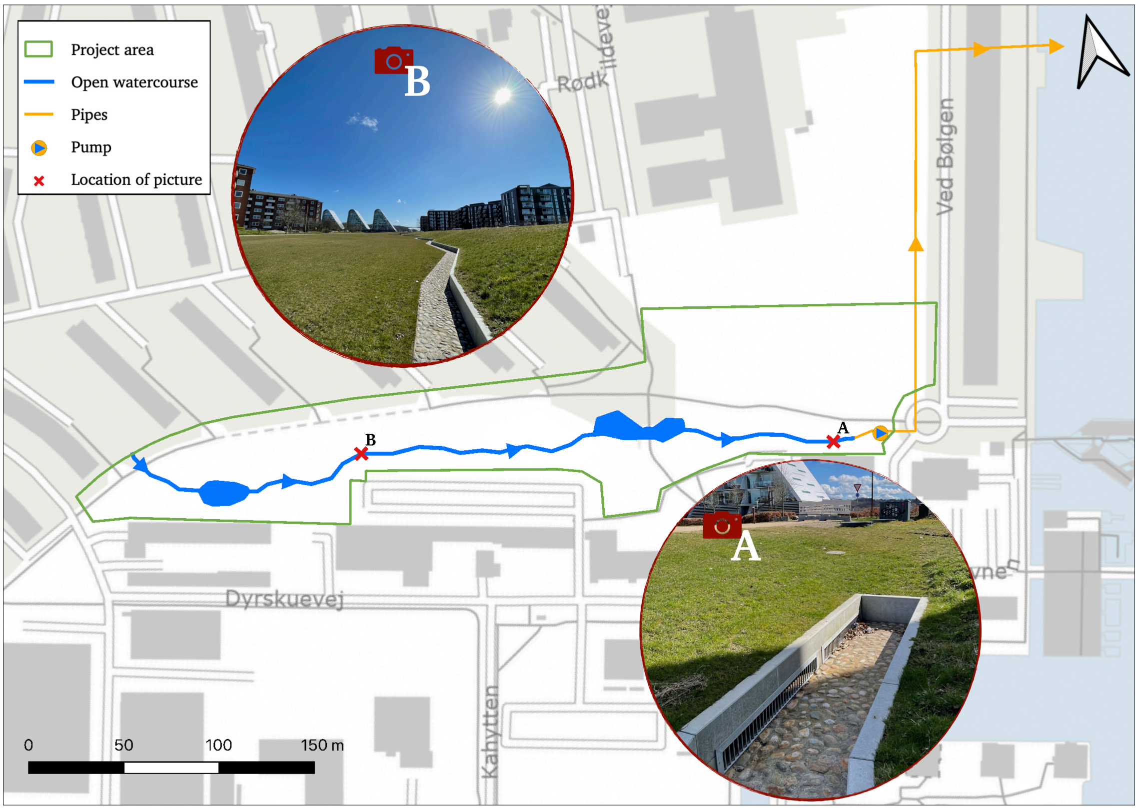


Figure 8.6 The water's course through Klimaparken (marked with arrows) and the pumps and pipes' placement indicate the run-off leading the water out into Vejle Fjord. Furthermore, two pictures: the grates and pumps (A) and the channel (B) (Own pictures; SDFE, 2021e).

Vejle Kommune also investigated the possibility for water activities in Klimaparken but deemed it too expensive and wasteful in terms of resources. However, they have included considerations concerning the quality of the water in their planning and thus have a sand trap and oil separator before the water enters the area. This purification was set as a requirement for the discharge license given. Thus, the water is purified before it enters the area and becomes accessible to interact with. Nevertheless, it is not recommended as they do not control if it is pathogenic (Geertsen, 2021; Bisgaard, 2021).

Klimaparken is connects the waterfront and Rødkilde Gymnasium with the city centre. Thus, the area is often used for transport between these (Nedergaard, 2021). The users of the area agreed that they either past through on the way to somewhere or went for a walk in the park. However, some mentioned that they stayed in the park during the summer (Klimaparken, 2021). Klimaparken is still missing some of additional features besides the climate adaptation. For instance, there are no benches and there is still landscaping which have not been planted yet (Geertsen, 2021; Nedergaard, 2021). Especially, the users from the apartment buildings was missing the extra facilities as they used them for meeting other residents (Klimaparken, 2021).

The climate adaption part of Klimaparken was inaugurated in June of 2020. Since then, there has not been any reports of the area not working or the basement in

Østbyparken being flooded. It might be due to the fact that there has not been any incidents of extreme events or that the area functions as intended.

8.3 Multifunctional Playground in Aktivitetsskoven

The project is located in the western part of Middelfart in a residential area, and was completed in 2019. The area was previously a training field for the stadium and was used by spectators to park when there was a game at the stadium. The area before and after is illustrated in Figure 8.7 on the facing page. The location of the adaptation project is beneficial, as the gravitational force is used as part of the site's mechanisms to transport the run-off to basins where it can percolate. Furthermore, Aktivitetsskoven utilise the terrain's natural slope to transport the water from the area directly to the Lillebælt (Miljøstyrelsen, 2020; Rasmussen, 2021).

(a) Aktivitetsskoven before the transformation (Rasmussen, 2021).

(b) Aktivitetsskoven after the transformation (Rasmussen, 2021).

Figure 8.7 Aktivitetsskoven before and after the climate adaptations project. The before picture is taken from the northeastern corner of the finished areas, where the after picture is taken from the opposite corner looking from the southwestern corner. After the transformation, the area became more divided, due to installed facilities and channels with plants.

Challenges with floods are a well-known problem in Middelfart due to the natural landscape. This condition applies to many low-lying coastal areas in the city. Situations with storms cause floods from the Lillebælt and adjoining bays. Additionally, the cloudbursts cause problems by rising groundwater levels and wastewater backing up. Increasing precipitation challenges the sewer system's capacity, especially in areas with difficulties managing large amounts of precipitation (Kommune, 2014). Middelfart Kommune has determined 36 areas, which are of significant value. These prioritised areas expect to be threatened by storm surges and flooding due to precipitation in the municipality's climate adaptations plan (Kommune, 2014). The area includes residential, industrial, and business areas, which means that large parts of the city are disrupted when floods occur.

For instance, the problems that have been recorded during cloudbursts result from overloaded sewers system, thus flooded basement. Middelfart is hilly in the western part of the city, contributing to the run-off ends in the eastern city. In situations with heavy precipitation, the water collects in the lower areas, which pressures the sewers; thus, backwater ends on terrain level (ibid.). Middelfart has a overflow system, which sets in when the sewer system is challenges due to precipitation. The overflow system catches the most concentrated sludge from the wastewater before it hits the strait, hence avoiding unpleasant and unintentional disposal of sewage in the natural environment. However, this systems have proven not to be a sufficient solution as Middelfart still experiences backwater. The municipality, therefore, encouraged the owners in the project area to separate their rainwater pipes and to manage the precipitation on their property as approximately 51% of precipitation ends on private buildings and areas (Middelfart Kommune, n.d.; Kommune, 2014; Rasmussen, 2021).

Aktivitetsskoven is a part of the city's umbrella project *Klimabyen*, which intends to utilise different districts to strengthen the city's capacity to handle the variation in weather on a planning level. This umbrella project covers neighbourhoods in the Western part of the city, thus also reducing the risk of floods caused by precipitation in the east part of Middelfart. The neighbourhoods contain hybrid solutions such as rain beds, detaching all the roads from the joint sewer system, or designing the roads to be trug-shaped, and thereby creating an alternative infrastructure with different WSUD that leads to the run-off toward the strait instead (Kommune, 2014; Rasmussen, 2021).

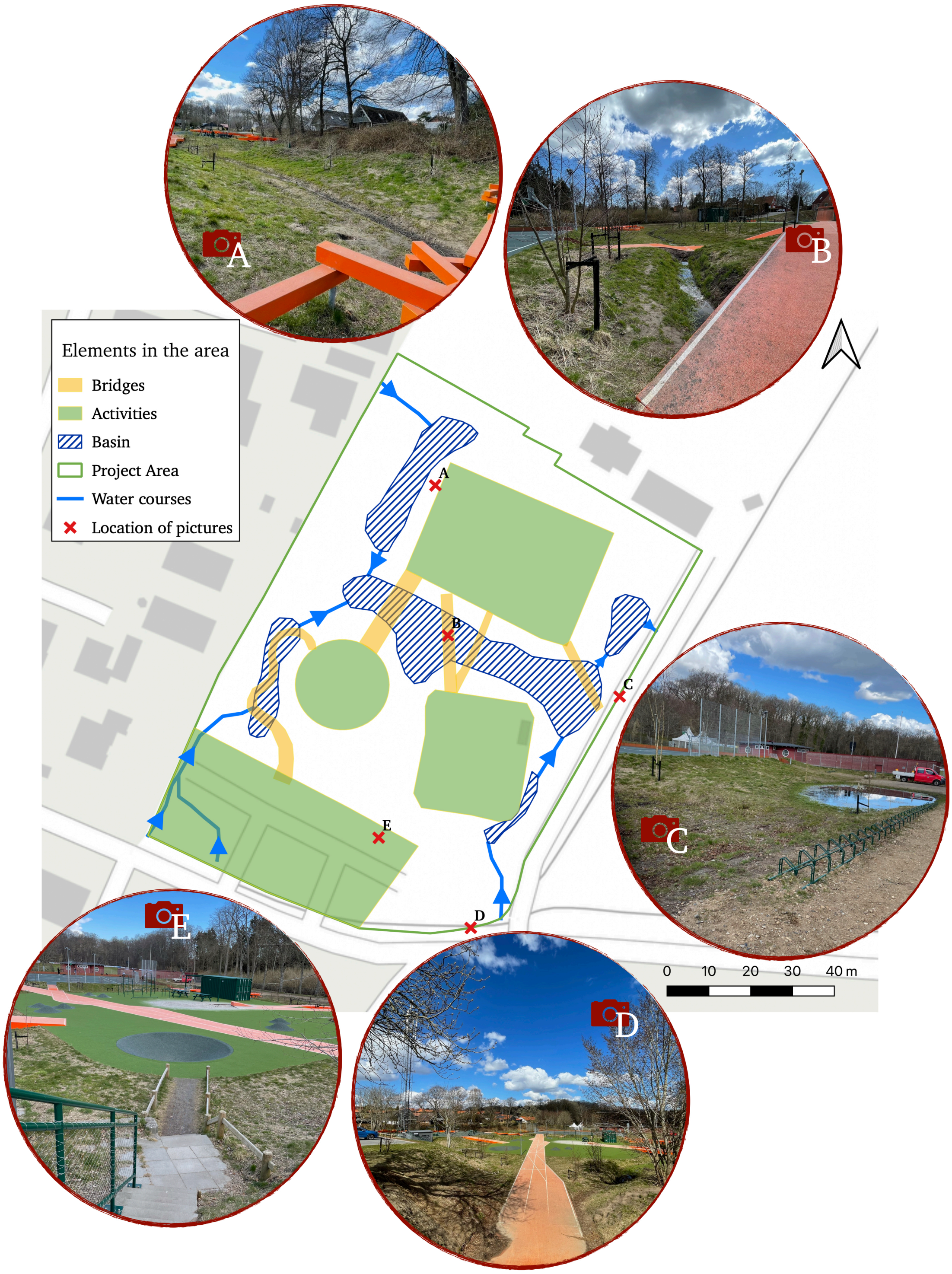


Figure 8.8 The water's course through Aktivitetsskoven (marked with arrows) and the placement of water basins. Furthermore, five pictures showing different aspects of Aktivitetsskoven: Water basin (A, B, C), running bridge (D), and stairs to the athletics area (E) (Own pictures; SDFE, 2021e; Rasmussen, 2021).

Aktivitetsskoven receives water from four points connecting to the neighbourhood, which are illustrated on Figure 8.8. At these entrances, the water reaches the first flush basins; after, it is led to basins where the water can percolate. Pictures A and B in Figure 8.8

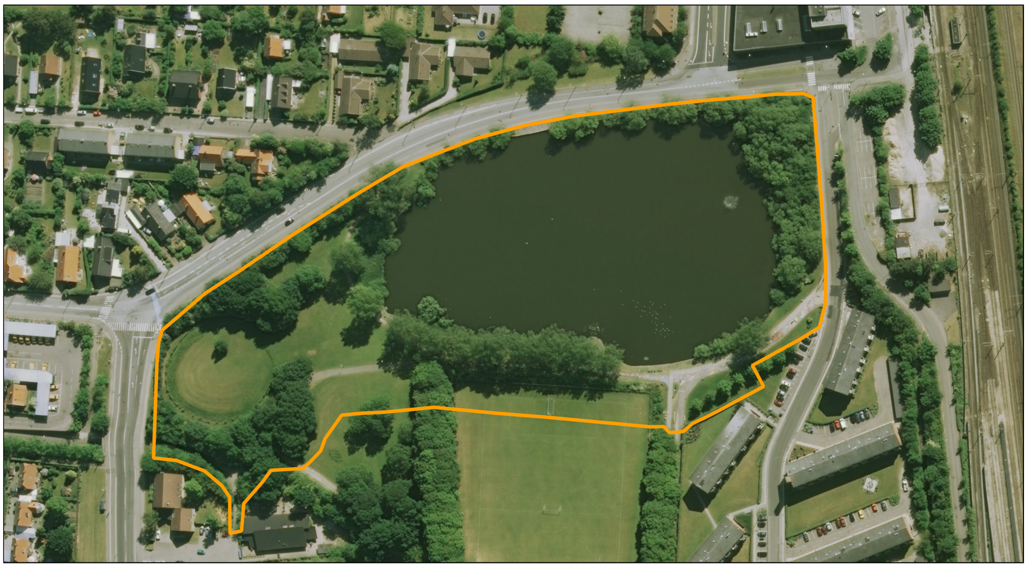
illustrates the water basins which, outside the rain events, are dry. There is one basis which have a permanent water level which Pictures C shows, it is placed in the northeast area. Nevertheless, the water will, in the case of extreme events, drain into the belt. The steep decline from the area to the recipient, and thus the natural landscape, leads the water from the area in the north-eastern part (Rasmussen, 2021).

Apart from handling rainwater, Aktivitetsskoven's purpose is also to create a public space that inspires activity and functions as a meeting place (Miljøstyrelsen, 2020). The park separates the facilities and waterways on different levels, enabling the continued use of the activities despite heavy precipitation events. Picture A and B in Figure 8.8 illustrates examples of the raised activities. Picture A is balancing bars over one of the basins and Picture B shows the pipes connecting the basins under bridges. The area, furthermore, encourages athletics activities with the elements of the park, for instance a running bridge (Picture D). Other facilities presented in the park are a parkour area (Picture E) and a multi-purpose pitch. Since the areas transform into a water landscape, the facilities are also water-inspired; thus, there is space and facilities for water play. Hence, the park will still be functional if the park is flooded because the water is separated from the playground by elevated bridges (Spildevand, 2016). The multipurpose-pitch and the play areas are used by institutions, teenager, and other families with children. The Municipality mentions that the area became more attractive for schools to use as part of their physical education. Before the area was not an attractive place. However, there were people using the space as a training field for football (Rasmussen, 2021). The users mentioned that now the area is well-attended by teenager as a meeting place and families who come for the playground (Aktivitetsskoven, 2021).

8.4 Water Activities in Selsmosen

The solution in Selsmosen is a larger water basin. The area before and after is illustrated in Figure 8.9 on the facing page. The project stems from the urban renewal project *KulturRingen* that was a collaboration between cultural institutions, housing associations, companies, and other citizens in the area. Furthermore, the KulturRingen secured external founding from *Lokale- og Anlægsfonden*. (FORCE4 ARCHITECTS, 2009; Lumby, 2009; Høje-Taastrup Kommune, n.d.).

The municipality does not face significant problems with water as they are the highest point between two watersheds. As a result, the problems are self-inflicted by the surrounding areas characterised as a residential area, which is densely built; such catchment area contributes to the collection of run-off. Selsmosen is a former marsh, making the area a natural low point. The water basin was established here to utilise the site as low-lying. The capacity of the water basin is 27,000 m^3 (Dahl, 2021; Egerup, 2010; Høje-Taastrup Kommune, 2006; FORCE4 ARCHITECTS, 2009). Selsmosen drains to Møllebækken, which ultimately ends in Køge Bugt. When extreme events occur a mechanical pump leads the water to another water basin north of the area. Thus, the solution prevent flooding of the surrounding areas if the stream cannot keep up (Rasmussen, 2021; Bisballe, 2021). To decrease the risk of flooding the nearby road, the municipality chose to raise it and establish new water passages under it. As a result the catchment area is approximately 48 hectares (Dahl, 2021; Egerup, 2010).



(a) Selsmosen before the transformation (SDFE, 2021d).

(b) Selsmosen after the transformation (SDFE, 2021b).

Figure 8.9 Orthophotos of the area before and after climate adaptation project. The project extended the basin into the green space and instead implemented water activities. Furthermore, the different sides were connected by bridges and pathways.

The increase in precipitation caused that the old water basin exceeded its capacity. For instance, a rain event in 2007 made it clear that there was a need to increase the capacity of the basin as the water flooded the surrounding areas, including the roads and neighbouring apartment buildings, which is illustrated in Figure 8.10 (FORCE4 ARCHITECTS, 2009; Lumby, 2009; Høje-Taastrup Kommune, n.d.).

The measured precipitation was 47.3 mm during 24 hours, which includes a cloudburst (DMI, n.d.[e]; Dahl, 2021). Residence near Selsmosen was challenged by damage to their property due to flooded basements and infrastructure, primarily the nearby road *Selsmosevej*. As a results, this cloudburst causes damage up to 5 million DKK in insurance coverage to the nearby homeowners association *Taastrup Have* (Taastrup Have, 2021). The reason for the floods with backwater was an overloaded sewer system. Such conditions means that the area was not prepared to manage such volumes. However, after the 2007 flood incident, the city council decided to further clarify the cause, and create a proposal to preventing new floods (Dahl, 2021; Broch, 2020).

(a) The precipitation collects between the apartment building along the edge of Selsmosen because of the 2007 cloudburst (Marcussen, 2013).

(b) The road (Selsmosevej) next to Selsmosen, which is flooded caused by heavy precipitation in 2009, (Egerup, 2010).

Figure 8.10 The area surrounding Selsmosen, which flooded because the capacity of the old water basin was exceeded.

Selesmosen was previous a combination of a water basin and green space. The additional green space opened up the possibility to expand the existing basin. This expansion, in turn, meant suspending part of the green area to make room for the extended water basin. The municipality wanted to create an innovative environment that invites activities to counteract that the park would be transformed into a technical facility. As a result, the focus was on making a park with water activities such as water rafts and ropes courses over the water. These activities made it necessary to have a water filtration system to secure play in unpolluted waters (Lumby, 2009; Høje-Taastrup Kommune, n.d.; Dahl, 2021).

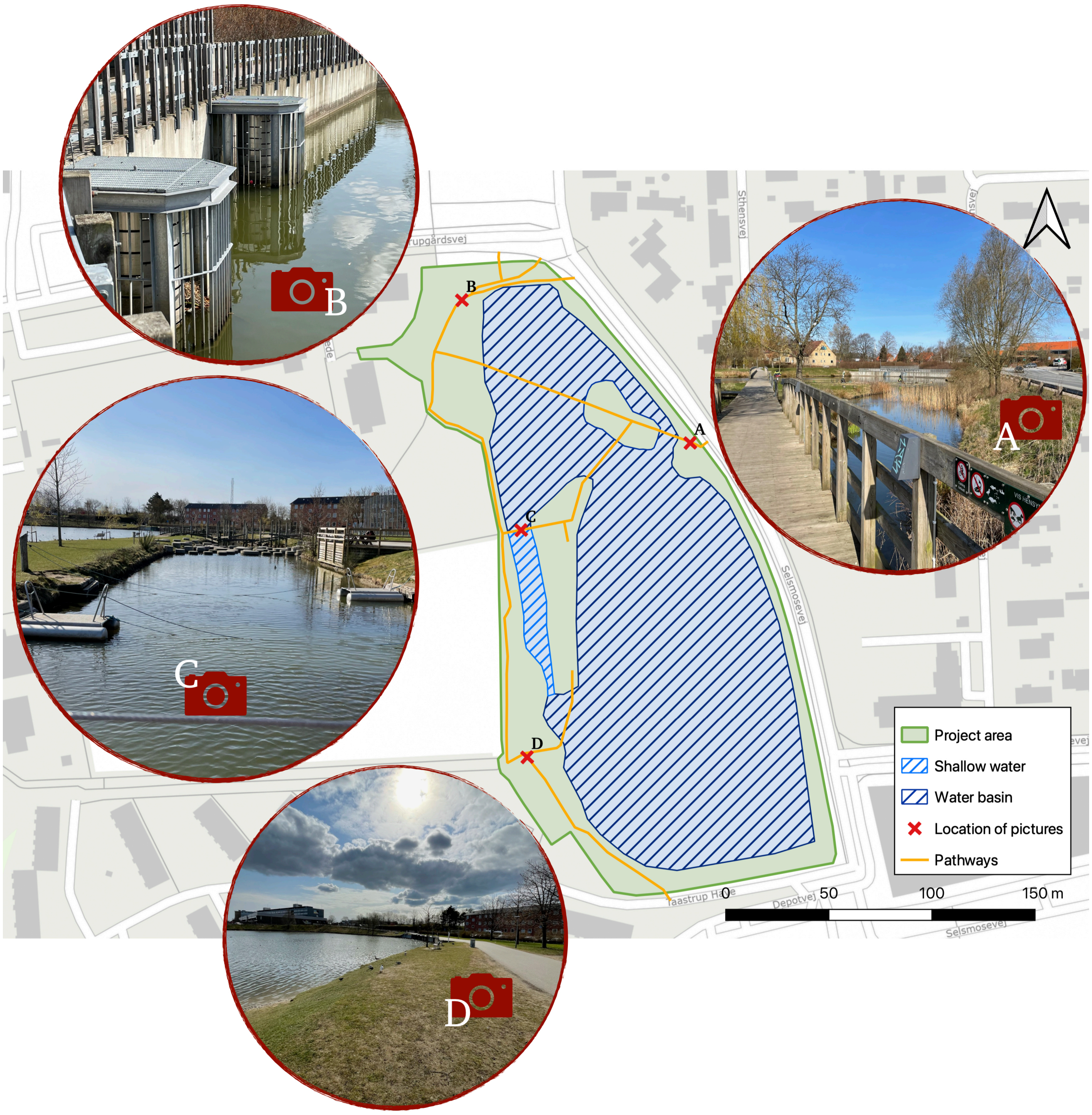


Figure 8.11 The water basin in Selsmosen including the shallow area and the islands. Furthermore, four pictures showing different aspects of Selsmosen: Bridge (A), pumps (B), water activities (C), and pathway (D) (Own pictures; SDFE, 2021e).

Another focus of the project was to create better cohesion between the theatre and the nearby train station placed on the opposite ends of the area. Before, the area was confusing to navigate and sometimes felt unsafe because of poor lighting and the dense vegetation. Thus, the new area has multiple accessible pathways that are well-lit. The pathways move across small islands connecting the sides of the new basin, cf. Picture A in Figure 8.11, and along the west part of the water basin, cf. Picture C. The new pathways give a clear route through the area from the theatre, in the northeast corner, to towards the station at the southwest corner.

Furthermore, there is a designated area for water activities which extend onto one of the islands, which is illustrated in Picture C. The water under these activities are shallow to create a safe space for children to play (FORCE4 ARCHITECTS, 2009; Dahl, 2021; Marcussen, 2013). The users mentions using the area for both stays and to walk through. The play area in the water is mentioned as a draw. Additionally, there is a school directly next to the area which is a frequent visitor (Selsmosen, 2021a). The municipality have made alteration to the water activities afterwards as they experienced vandalism. Thus, some of the activities were removed (Dahl, 2021).

Selsmosen was put to the test for the first time on July 2, 2011 where the expansion of the water basin was just completed. The precipitation was 39.5 mm within 24 hours. Within these hours, there occurred two cloudbursts with 16.5 and 14.2 mm (DMI, n.d.[e]; Høje-Taastrup Kommune, n.d.). The same extreme precipitation hit large parts of Copenhagen; thus, these were flooded. However, as a result of the climate adaptation, the locals' area of Høje-Taastrup were kept dry (Broch, 2020). Furthermore, the municipality reports that there has not been any problems since the area was established, which further underlines the vital adaptation of the area (Dahl, 2021).

8.5 Urban Rain Garden in Tåsinge Plads

Østerbro is a densely built urban area, for which reason the percolation of the precipitation is challenged. The natural terrain is replaced with stone, concrete, or asphalt for most of the city (Miljøstyrelsen, 2015).

Apart from the other areas, Tåsinge Plads did not suffer directly from repeating floods. However, Østerbro as a neighbourhood is challenged by storm surges because of the urban environment, which is a repeated problem in most central Copenhagen.

The extreme cloudbursts, which submerged large parts of the capital area on July 2 2011, caused damage worth DKK 6 billion. The weather incidence is categorised as a incidence occurring over 100 years. It was measured to be around 30 – 90 mm during the meteorological day, which causes massive disruption of the infrastructure and material damage of private property. This situation emphasised the need to increase the security of the city against the cloudbursts (DMI, 2011; IDA, 2017).

(a) Tåsinge Plads before the transformation (Lindsay, n.d.).

(b) Tåsinge Plads after the transformation (Brøndum, n.d.).

Figure 8.12 Tåsinge Plads before and after the climate adaptation project. The before picture is taken from the east corner of the finished areas, where the after picture is taken from the opposite end looking from the western area. The project has established a cohesive area that combines natural spaces and pathways with bridges.

This climate adaptation mixes of grey and green infrastructure, which can handle heavy run-off from precipitation from both the roofs and the roads. The project's catchment area and the available space for the area determine the methods for regulation. Tåsinge Plads optimise the available space by a combination of solutions underground and at the surface. The extent of the area is approximately 3,300 m^2 which makes it the smallest selected project area. The catchment area is the surrounding buildings and roads, which constitutes 1 hectare (Københavns Kommune, 2014). The area is projected to handle an incident that occurs every 500 years for that area. As a result, the water basins statistically only fills to 40 % capacity every 100 years. The area also works as a retention basin as it is connected to the sewer system. However, the dimensioning makes it so the area is effective until HOFOR (Greater Copenhagen Utility) establishes the rain sewer as it eases pressure on the local sewer system, especially when extreme precipitation occurs (Bovbjerg, 2021; Københavns Kommune, n.d.).

The water from the road is collected in bioswales between the main area and the road, c.f. Picture A in Figure 8.13 on the next page. Here, it is led through filtration mould, which clean impurities in terms of salt and oil. Thereafter, it is led to the sewers but over time it will instead become a part of the major rain water tunnel system that drains to Øresund. The water from the roofs is directed to underground water storage tanks with purification, so the water can be used for activities. Lastly, a rain garden collects the water from the surrounding area and overflow from the underground basins; thus, the flower bed functions as a water basin when extreme events occur. The rain garden is illustrated in Picture C in Figure 8.13. The vegetation is furthermore placed strategically to cope with the different water qualities and quantities. The water from the square and the roofs will seep naturally down toward subterranean basins or rain beds with salt-resistant plants. Thus, heavy precipitation like cloudburst will no longer compromise the same risk of causing backwater and flood (Bovbjerg, 2021; Københavns Kommune, n.d.).

Figure 8.13 Overview of Tåsinge Plads' elements and pictures of bioswales (A), waterdrops and parasols (B), and rain gardens (C) (Own Pictures; Københavns Kommune, n.d.; SDFE, 2021e).

The area includes a multiple areas. Towards the west the there is a hillside, where there is space for play and relaxation. Furthermore, there is multiple benches and other sitting areas throughout the area (Københavns Kommune, n.d.; Miljøstyrelsen, 2015). The users mentions that they use the area as an outdoor meeting place. The green area was in their opinion a big asset to the area because it was otherwise a quite dense area (Selsmosen, 2021b). The municipality wanted to create a diverse space where the natural elements was combined with the urban in terms of cafes, among others (Bovbjerg, 2021). The cafes, and the area in general, is mostly used in the summer to relax and enjoy the sun (Selsmosen, 2021b).

However, after establishing the project, the area's capacity proved useful when a cloudburst with 42 mm of precipitation within 30 minutes occurred in 2015. Here, the area protected the catchment area, and there were not recorded any problems with floods (Miljøstyrelsen, 2015; Københavns Kommune, n.d.).

Selsmosen

Part IV | Analysis and Discussion

Builds on findings from Results, the following chapter will investigate how the selected climate adaptation projects utilises the NbS, hence creating or adding value from ESS. The part ends with a discussion that revolves around the limitations which the danish climate adaptation projects face and how the project manager secures the adaptability of these projects, as climate change is a continual process.

9 Value Creation in Nature-based Climate Adaptation

The clarified essential RESS increases a city's flexibility to handle climate change which, as presented in *Chapter 4: Conceptual Framework*, provides direct benefits by strengthening the site's ability to manage run-off now and in the future. However, the municipalities prioritise that these areas also must have value when it does not handle the run-off from precipitation, which the CESS represents. Preciously when climate adaptation was subterranean solutions, these did not require additional value. However, when establishing nature-based climate adaptation on terrain level, the social aspect of the local environment must be considered. Thus, the design and stable facilities are altered to fit the needs of the area because the green spaces will be a part of the urban environment. Thus, the municipalities use the design of the area to create spaces for different activities within the area.

9.1 Relaxation and Social Interactions

When developing these climate adaptations, there is a focus on the stays within the areas as the municipalities want to create areas that the citizens want to use for leisure purposes.

A stable, which are found in the areas, are the benches. The placement and design of these constitute different purposes. Common is that they invite the visitors to stay, albeit the benches' functionality influences the duration of these stays. Incorporating such fixtures emphasises that the project manager prioritises incorporating co-benefits through NbS in a climate adaptation to generate CESS. For instance, the launching of sØnæs was, not only focusing on securing the areas from floods but on further establishing recreational value for the benefit of citizens, whether they want to use the area on their own or in company with others. This intention is represented in the following quotation:

> The recreational functions focus on daily use and offer new accommodation and movement options. The area creates a framework for the citizens who want to occupy the place, initiate new activities, or enjoy it alone.
>
> (Viborg Kommune, 2013:3, translated)

The intention to increase the recreational value by incorporating fixtures in climate adaptation projects is perceived in several selected locations: there were multiple types of picnic tables that invite users to enjoy food and drinks, which often prolong visitors stay in the areas. The picnic tables are constant in all of the areas. Figure 9.1 on the following page illustrates the different types of picnic tables. Since, green space is limited in cities, these stables contributes to the attractiveness of the area. Furthermore, these tables invite social interactions. Especially, the residents surrounding Klimaparken uses the area for this purpose:

> Some of what the park does is that is is a place where you can meet your neighbours from the area – Especially, when you live alone in your apartment is there a need for meeting others (...) in a public space like Klimaparken. That is why we need to establish the extra layer that the park needs namely places for stays with picnic tables and activities.
>
> (Nedergaard, 2021:translated)

There is likewise an agreement in the other areas that the users come for social interactions. Both sØnæs and Tåsinge Plads had different clubs residing in the areas (Kunstmann, 2021; Selsmosen, 2021b). Thus, nature-based climate adaptations enhance social cohesion by giving the citizens easy access to green spaces. As a result, the co-benefits contribute to the residents' health in neighbourhood. Especially the vulnerable groups, such as the elderly, are affected positively.

Aktivitetsskoven, also encourage social interaction as the multi-purpose pitch draws children from the surrounding schools (Rasmussen, 2021; Aktivitetsskoven, 2021). Thus, the areas function as a meeting place providing CESS by facilitating social gatherings.

Figure 9.1 The picnic tables at the five project areas. Starting at the top and moving clockwise, the pictures are from sØnæs, Aktivitetsskoven, Tåsinge Plads, Selsmosen, and Klimaparken (Own pictures).

Besides the picnic tables, there are also park benches in all the areas. These also serves a different function. The benches do not necessarily promote longer stays but function as a resting place when walking through the area. sØnæs have the benches along the concrete pathways where they serve as stops for breaks, especially for walking-impaired when moving around the area. Some of the benches in Selsmosen also have this function. They are placed along the paved path, hence the area seeking to be socially included for citizens. However, there are also benches in Selsmosen, that are more secluded, for instance the benches face the water, as illustrated in Picture 3 in Figure 9.2 on the next page. Thus, the benches invite users to take a break and enjoy the water. As a result, they create a space for reflection or privacy from the moving users which adds to the recreational value. Although Tåsinge Plads' location is in a more densely build area, they also have used this solution. Some of the benches, and other sitting areas, are facing the natural elements in terms of the rain gardens. Picture 2 in Figure 9.2 illustrates one of these benches. The apartment complex is visible in the background; however, the green elements still have a positive effect on the users of the area (Bovbjerg, 2021). On the other hand, the park benches can also give an overview of the area, which is the case in Aktivitetsskoven. The arrangement of the seats allows adults to keep an eye on their kids. As illustrated in Picture 1 in Figure 9.2, there are benches placed at the edge of the playground. Thus, the benches function both as a place for rest and give the children and adults a sense of security.

Figure 9.2 Pictures of park benches in Aktivitetsskoven (1), Tåsinge Plads (2), and Selsmosen (3) (Own pictures).

The benches are not the only elements within the area that invite users to stay. Other elements such as stairs also have this function. Pictures 2, 4 and 6 in Figure 9.3 on the following page illustrates different configurations of such stairs. The materials are made to fit within the overall design of the area. Picture 2 is from Tåsinge Plads, and therefore use the cobble matching the surrounding urban area. On the other hand, Selsmosen (Picture 4) have more nature-based materials in terms of wood on their stairs. The area also have multiple bridges which utilise the same materials tying the area together. sØnæs uses more urban materials for their stairs (Picture 6). That is because the stairs are located at the area which is more urban inspired. Furthermore, all of the stairs are multifunctional as the areas can experience flooding but also invites the user to relax and enjoy the nature elements in dryer periods. Thus, the materials highlight the intentions of each area and create a space for activities while providing mitigating effects. The overall experience of the area generates value in terms of the areas being stress-reducing for visitors. Furthermore, the importance of the natural elements is expressed by the user's need, which underlines the importance of incorporating nature in urban space. Thus, the areas provide the city with health value as a benefit that otherwise is a limited resource in the city.

Pictures 1, 3 and 5 in Figure 9.3 are also examples of multifunctional elements at Aktivitetsskoven, Klimaparken, and Tåsinge Plads, respectively. The bumps at Picture 1 works both as obstacles for, for instance, skaters and a place to rest. On the other hand, the edge in Picture 3 is the wall of the channel in Klimaparken but the channel is dry outside of rain incidents, and thus it is useful as a place to take a break. The bench illustrated in Picture 5 also functions as a play area.

Figure 9.3 Alternative areas for relaxation. The pictures are Aktivitetsskoven (1), Tåsinge Plads (2 and 5), Klimaparken (3), Selsmosen (4), and sØnæs (6) (Own pictures).

Klimaparken also features a large lawn. In summer, people from the surrounding apartment building and the students from Rødkilde Gymnasie use the lawn for relaxation and a place to interact (Klimaparken, 2021). Thus, this area adds to the functionality as a meeting place.

9.2 Movement Through the Area

Aside from the benches as a stable which invite to rest and interaction, pathways are also found as a stable. The reasons being practical and as a means to encourage movement. Thus, accessibility influence what type of value generated at the sites. Because all the selected climate adaptation projects are based on the hybrid approach to NbS, these areas contribute with green spaces within the cities. Additionally, this setting proposes using the sites as a place for physical movement, especially in highly dense urban areas. Utilising the adaptation projects to increase the citizens' physical activity is a value of the CESS. Thus, co-benefits can be drawn from climate adaptation, which does not directly relate to tackling the challenge of increasing precipitation in the cities.

Nevertheless, the pathways within the sites determined the primary motion. The shape of the project areas, therefore, highly influence the activity or form of motion which take place at the site. The following figure illustrates the diversity and placement of the water and the pathways.

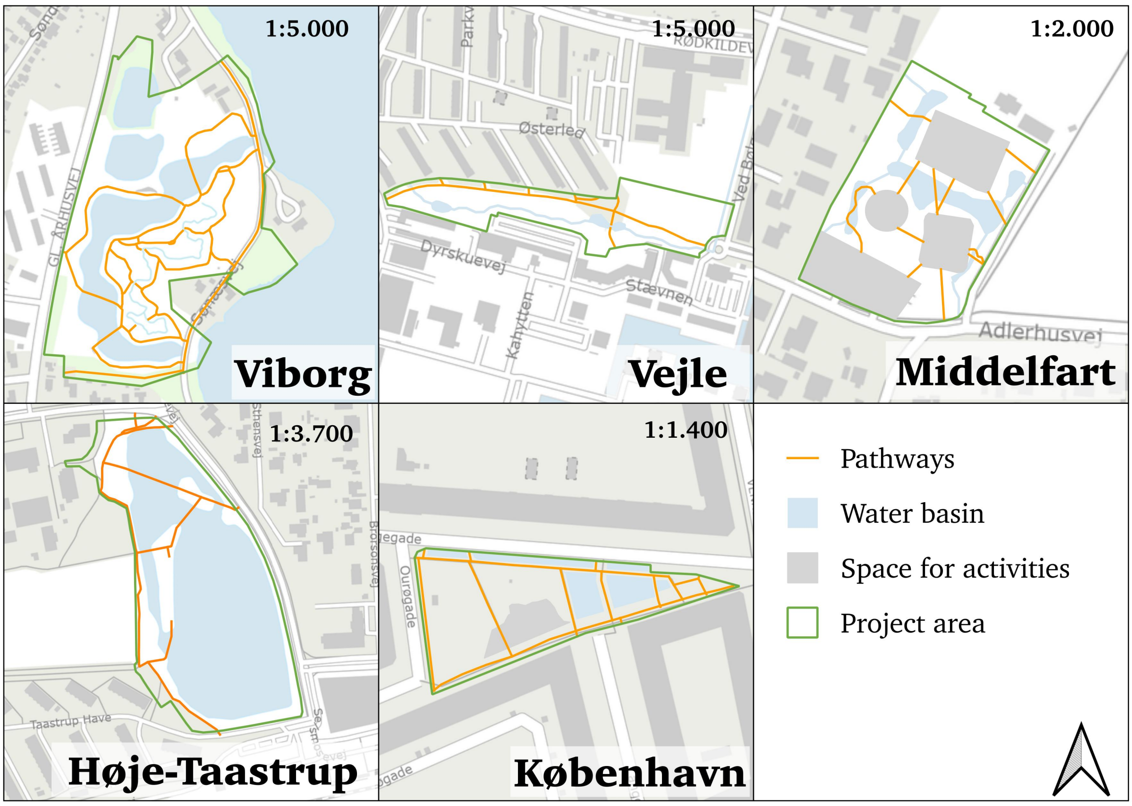


Figure 9.4 Highlights the placement of the pathways within the different selected climate adaptation projects. The maps have different scales (SDFE, 2021e).

As the figure illustrates, the shape of pathways follows the waterways or basins. Thus, is the water on the terrain is utilised as ESS and functions as a prominent element of the project's landscape. The view of the landscape is, thus, a CESS, which creates value for the benefits of humans. Comparing the pathways between sØnæs and Klimaparken shows the different designs of paths. Thus, the paths in sØnæs are more winding than Klimaparken, which are straight, cf. Figure 9.4 on the previous page. The linear design supports the effectiveness of a transition or quick visit, as mention before in *Section 8.2: Green and Blue Wedge in Klimaparken*. On the other hand, the winding paths supports and encourage motion of leisure character that supports the physical and metal health. The strait paths at Klimaparken are favourable for quick movement because the tracks do not provide any chicane, hence slowing the pace down. However, sØnæs invites the visitors to take a longer and slower walk due to the higher number of winding pathways, hence more chicanes. The number of tracks and how it bends influence the visitors' physical movement.

Another added CESS value, which the NbS projects provide, is based on the choice of material for the pathways. The paths consist of different materials, reflecting the project managers' intent with the area and surrounding environment. Thus, the pathway are the compromise made for the area to feel as part of the urban environment as well as contributing to the cohesion within the area. As a result, the paths vary between more natural materials and concrete. The following illustrates the different types of surfaces:

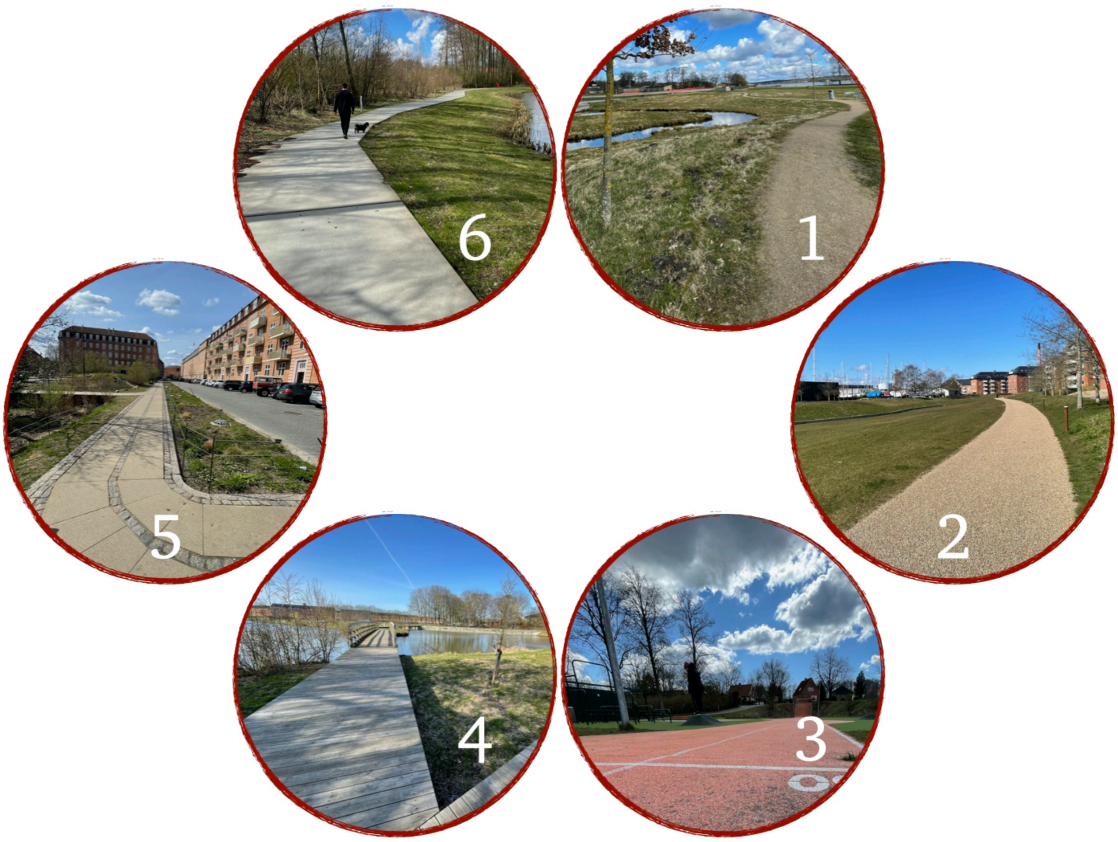


Figure 9.5 Pictures of the different pathways at the selected climate adaptation projects: sØnæs (1, 6), Klimaparken (2), Aktivitetsskoven (3), Selsmosen (4), and Tåsinge Plads (5) (Own pictures).

The different materials gives a diverse experience of each project in its given context. The pathways in sØnæs are a combination of concrete, cf. Picture 1, and gravel path, cf. Picture 6 in Figure 9.5 on the facing page. The paths connect the different green spaces while providing dry space to walk when it rains. Thus, the difference in the material of the path serves a different purpose. Additionally, the gravel paths allows floods, while the concrete paths are designated dry areas. The difference between materials supports the concept of urban and natural elements. Concerning the movements through the area, the concrete paths intend to assist the citizens who are waking-impaired. On the other hand, the purpose of the gravel paths to produce diversity in the landscape. Thus, sØnæs as a whole area embracing several types of motion, like running and walking at different paces.

Opposite sØnæs, the paths in Klimaparken are a replication of the previous straight paths, solely made of gravel, cf. Picture 2 Figure 9.5 on the preceding page. However, these paths also follow along the waterway while connecting the other neighbourhoods to the green space. As mentioned in *Section 8.2: Green and Blue Wedge in Klimaparken*, the project is not finished yet; however, the main path, which is continuous throughout the area, is meant to become a runway for cultural and educational activities in the future (Nedergaard, 2021). Thus, the paths as elements contribute to providing space for cultural and educational projects thus, strengthening the cultural identity in the city.

In Aktivitetsskoven, the focus on implementing more motion influence the design of the climate adaptation, where most of the area, including the pathways, consist of impact surface made of rubber, cf. Picture 3 in Figure 9.5 on the facing page. This surface is meant to encourage active play. The pathways serves multiple functions, where some of the paths function as bridges between the separate playgrounds but also as an play area in itself. As found in *Section 8.3: Multifunctional Playground in Aktivitetsskoven*, the water is not constant on terrain level; consequently, the paths are design for physical activities rather than enjoying the view of the water.

Picture 4 in Figure 9.5 on the preceding page illustrates some of the wooden paths in Selsmosen, that are meant to enhance the identity of the area. Selsmosen contains five designated programs that constitute the park's sub-areas identity and function: the urban space, play, sport, recreation, and culture. Thus, is the municipality aiming to establish "*a new blue park space in Høje-Taastrup; a supplement to Taastrup's many residential roads and residential areas*"(FORCE4 ARCHITECTS, 2009:6, translated). Because the paths primarily follows the lake or crossing it, the path is meant for walks while connecting the designated areas within the project area.

Lastly, at Tåsinge Plads, the pathways are made of a combination of paving slabs and paving stone shown in Picture 5 in Figure 9.5 on the facing page. This design enhances the characteristics of Copenhagen's inner city while framing the natural element within the project area. The paths are integrated with the already existing sidewalks; thus, Tåsinge Plads connects to the rest of the city (Københavns Kommune, n.d.). Hence, the path invites for walking or slower motion due to the chicane of the pavement mix.

As the different projects indicates, the pathways influencing the movement through the area, with different levels of chicanes. Because these projects are NbS, the movement thought out the areas are designed with the intention of the visitors to the explore natural elements, thus unlocking different CESS.

As mentioned in *Chapter 4: Conceptual Framework*, densely built urban areas are linked to decreasing physical activity for the citizens. Thus, it underlines the importance of a public green place for motion. For instance, in Selsmosen, where lifestyle diseases are a growing challenge, they have established the pathway, which should encourage movement (Dahl, 2021). On the other hand, moving at a slower pace encourages visitors to enjoy the sites, which is characterised as recreational value. Thus, it is also prioritised in the urban climate adaptation because urban areas naturally have a limitation of public green spaces. Thus, are the co-benefits wanted, although these values are hard to monitor and document. Viborg Kommune emphasise this prioritisation:

> It was important to us [Viborg Kommune] that the entire facility was accessible. We established therefore the concrete path that bends, which of course has been an expensive element, however likewise worth all the money because it just makes that no matter if it is raining or snowing, or sunshine that everyone has access to the area at all times of the year.
>
> (Kunstmann, 2021:translated)

As the quotation implies, climate adaptation must generate value, despite the mitigated value is temporary due to the dependence on weather. However, the municipalities require that the sites must produce some co-values in the meantime. Viborg Kommune is an example of how the municipalities prioritise more expensive solutions because the design of the paths makes the site accessible in various weather conditions. Thus, the value is social inclusion, as a results of CESS.

Apart from the shape of the project areas and the pathways, which influence activity and motions, security is essential. The secure feeling plays a vital role in determining if the visitor wants to enter public green areas. Thus, an overview of the site is required when establishing a green space that is attractive for visitors. The vegetation, such as bushes or trees, must be thoroughly selected and placed to avoid unintentional activities. This concern was expressed by ØsterBo, in the following quotation:

> The area where Klimaparken is today was also previously a green space with a system of paths, but the area was characterised by that there were shady activities in the bushes where you could hide, and for that reason the area sometimes felt unsafe for the residents to move in.
>
> (Nedergaard, 2021:translated)

Overgrown areas benefits nature; however, as the quotation indicates, too dense area results in unwanted activities, which increases insecurity. Nevertheless, removing all the vegetation gives an unattractive and dull area, hence an undesirable climate adaptation solution. After the establishment, the nature take time to reestablish, and thus the CESS might decrease when the area is first established. Thus, it is important for the project managers to notify the user of the area's development and how the recreational value increase over time (Dahl, 2021; Nedergaard, 2021).

Nevertheless, opening op, the area contributes to preventing unwanted activities from happening, and increase the attractiveness to enter. Viborg Kommune expresses the need to add a clear overview of green space as a preventive measure:

> [The area] is very open and, i.e. it is not such a place you can go and hide, and act up, and be as noisy as you want. Here you can see the whole area from the road. So it's easy to see if something is going on that you are tired of.
>
> (Kunstmann, 2021:translated)

Consequently, to create a sense of security in the area, there is a need for low-lying types of flora. Establishing climate adaptation projects, thus, contributes to change the local perception of a place by adding new value through context-specific use of NbS.

9.3 Healthy Motion for All Ages

Apart from running or walking, lots of the climate adaptation prioritise space for play and kid-friendly activities. Thus, the climate adaptation projects adds an dimensions to green spaces. While providing security for floods, these projects also make room for active play in an urban environment. "*Climate adaptation should be utilised to create a neighbourhood that is greener, more fun, and healthier*"(Kommune, 2014:22, translated), this intention emphasis that launching projects should contribute to the social coherence in the city through CESS.

The different play facilities are stable at the various climate adaptations. These facilities are either standard facilities or a design inspired by water. Figure 9.6 on the next page illustrates the classic play facilities:

Figure 9.6 Pictures of the different play facilities at the selected climate adaptations projects: Selsmosen (1,3), Tåsinge Plads (2), sØnæs (4), and Aktivitetsskoven (5, 6) (Own pictures).

At Selsmosen, some music facilities are placed as a stable part of the area cf. Picture 1. Thus highlighting the area's cultural identity with the local theatre, *Taastrup Theatre*, located in the neighbourhood. The municipality chooses to represent them as a cultural aspect in the city by the instalment of these music elements (FORCE4 ARCHITECTS, 2009). Although these facilities are not natural elements, the facilities contribute to the enjoyment of the area and benefiting physical and mental health in the area. The project manager at Tåsinge Plads wanted to incorporate elements that represent the water at the square. There is therefore five sculptures, which depict raindrops (Københavns Kommune, n.d.). Picture 2 in Figure 9.6 illustrates two of these. The raindrops reflect visitors' image due to the reflective surface; thus, the sculpture contributes to making the square an interesting urban place. On the other hand, both Selsmosen and sØnæs have areas with sand. In Selsmosen, the place is meant for volleyball activity, showed at Figure 9.6. However, the sand area at sØnæs, cf. Picture 4, intended to be a beach albeit bathing is prohibited. Lastly Aktivitetsskoven, where the facilities is focusing on encouraging sports activities. The facilities are designed with a general sports theme cf. Picture 5 and 6 in Figure 9.6.

Because the project manager choose to establish these facilities in the nature-based climate adaptation, active plays as a value are unlocked. Additionally, because the play facilities reflects some of the local social aspects, for instance the music facilities in

Selsmosen, contributes to that the elements of the landscape represent aspect found in the local society.

Water is a major part of the areas, whether it is constantly or temporary on terrain. Thus, some of the selected climate adaptation have installed water-inspired facilities, which furthermore contributes to play.

Figure 9.7 Pictures of the different water integrated play facilities at the selected climate adaptation projects: Tåsinge Plads (1, 2), sØnæs (3, 4), and Selsmosen (5, 6, 7, 8) (Own pictures).

At Tåsinge Plads, the facilities for water activity consist of tilting boards, which utilised the rainwater for play. For instance, the rainwater emerges under one of the raindrops and runs onto the paving stones. The tilting boards function as pumps, so the water reaches the surface from the underground basins, mentioned in *Section 8.5: Urban Rain Garden in Tåsinge Plads*. Thus, the precipitation create value through playful use. Pictures 1 and 2 in Figure 9.7 shows the pumps and the raindrop, which releases the rainwater, respectively. The idea of using manual pumps is a common theme among the projects. sØnæs has a manual pump installed for educational purposes to illustrate how the electrical pump system works. Picture 3 in Figure 9.7 shows the manual pump at the site. The rainwater is, thus, used to encourage and promote movement in combination with an educational purposes. Thus, the play activities within the climate climate adaptation is used to promote the green space as a cultural landscape.

Additionally, permanent water at the terrain level at the different projects create a dynamic landscape. Step plates or balance facilities give an interesting and dynamic space that encourage user to have fun or explore the area. Examples of these facilities are shown in Figure 9.7 for sØnæs and Selsmosen, cf. Picture 4 to 8. Common for all of the activities is that there is a focus on increase movement within the area, which also is reflected in the use of the area. Thus, the use of the facilities have increased for the all areas, where access to public green spaces furthermore contributes to citizens' health. In Høje-Taastrup Kommune, they have difficulties with public health, especially obesity among the local kids. This societal challenge underlines the need for green space in urban areas that offer a shared space for physical activities. Apart from mitigating the precipitation challenges, value creation concerning public well-being is a selling point to promote NbS climate adaptations. The focus on integrating rainwater as an active element in NbS for recreational, motion, health, and educational purposes contributes with CESS value.

9.4 Permanent and Temporal Water Landscape

The water in all of the climate adaptations play a central role when defining the landscape. Bridges are, therefore, present in all of the project. The bridges are integrated in various ways in the different projects. The following figure shows a selection of bridges:

Figure 9.8 Pictures of the different bridges in the selected climate adaptations projects: sØnæs (1), Klimaparken (2), Aktivitetsskoven (3), Selsmosen (4), and Tåsinge Plads (5) (Own pictures).

As found in *Chapter 8: Planning of Urban Climate Adaptation* each area has designated spaces that allow floods caused by precipitation but in a controlled environment. Thus, the establishment of the bridges contributes to the flexibility of each project when heavy precipitation occurs. Visitors can move around the area using the bridges while the water is in a designated space and thereby keeping other sites dry. In Aktivitetsskoven, the bridges service this connection purpose. Picture 3 in Figure 9.8 on the preceding page shows an example of a bridge at Aktivitetsskoven, which is elevated from the ground. As a result, the areas are separated horizontally where the activities and floods are disconnected. The designated flood space, is occupied by plants, thus the run-off is lead by the natural environment. Thus, the activities area is not disturbed by floods, instead the run-off presents in the valleys of the landscape.

Moreover, the horizontal separation is also found in Tåsinge Plads, where the lower site constitutes of denser bush areas. The bridge separates the two rain gardens illustrated in Picture 5 in Figure 9.8 on the facing page. The bridge, thus, restrains the rainwater while functioning as a recreational element. The run-off flows into an integrated and controlled environment, which gives a dynamic and attractive urban space for the citizens. The dense bushes are lowered from the pavement, which maintains the area's openness and thus will not affect the feeling of insecurity. Furthermore, the lowered area invites users to rest while facing the green space. Therefore, the area generates recreational value when heavy precipitation does not occur. The island and the water landscape that constitute sØnæs allows floods to happen at different stages, c.f. *Section 8.1: Water Landscape in sØnæs*, thus enabling a temporary basin system. At sØnæs, the basins with a permanent water level contribute to the recreational value while retaining the run-off from the city. This temporary basins system is also found in Klimaparken, as mention in *Section 8.2: Green and Blue Wedge in Klimaparken*. The bridges allows passing connection while providing flood security. Picture 1 and 2 in Figure 9.8 on the preceding page shows the bridge. These areas are not as drastically separated horizontally; on the other hand, the transition between the upper and lowing area has soft transitions with the green slopes. Consequently, the water is temporary in the sloped areas, which can be occupied by different activities outside rain incidents. The combination of soft slopes and temporary water on terrain levels creates different types of value. In a dry situation, the slope area can be used for primarily recreational purposes, and when it is flooded, the place serves as disturbance regulation.

Common for the climate adaptation projects is that they are usable when they function as flood protection. With the transformation of these area, they maintain or become a cultural landscape which accommodate both human interaction and natural processes. This double function underlines that the flexibility is fundamental in adaption projects. The examples of climate adaptation, furthermore, emphasise that hybrid solutions enhance the ESS in urban areas.

9.5 Approaches to Climate Adaptation

The grey infrastructure are on its own, not flexible enough to manage the increasing precipitation in urban areas, cf. *Chapter 1: Challenges Caused by Climate Change in Cities*. The financial costs of establishing hybrid climate adaptation projects, pay off compare to the societal costs when the facility is exposed to minimum two cloudburst (DAMVAD Analytics, 2018). These climate adaptation project is primarily driven by the government initiated climate adaptation plans with the overall aim for the climate adaptation being:

> The unusually extreme cloudbursts of recent years are a sign that there is an urgent need for climate adaptation (...) It is simply too expensive not to make an effort. There is a need to start immediately if we are to avoid significant losses in the future, but it requires good planning to ensure that we use the funds to get the most climate adaptation for the money.
>
> Ida Auken in Naturstyrelsen, 2013:3, translated

As the quotation emphasises, choosing not to establish climate adaptation project will cause significant societal disturbance in the future. The criterion about the risk assessment in the local climate adaptation plan indicates the prioritisation of the efforts.

For instance, the annual precipitation varies at the locations of the selected climate adaptation project. When comparing the locations, it proves that Vejle has the highest mean precipitation per day; on the contrary, the projects located on Sjælland have the lowest, as already stated in the *Chapter 7: Effects of Increased Precipitation*. Additionally, the diversity in precipitation will continue until the year 2100 despite the precipitation changes. Based on *Chapter 7: Effects of Increased Precipitation*, the groundwater varies, and is a determining factor for the use of percolation in the projects. On Tåsinge Plads the run-off stems from the roads and the roofs. The road water quality do not meet environmental regulation for percolation, without some purification component in the design. Thus, this natural conditions underlines that the environmental stages must be considered when establishing a climate adaptation project that is in sync with the local environment, whether it is a natural or cultural factor.

Planning climate adaptations either follows the *avoid*, *accommodate*, or *retreat* approach as explained in *Chapter 4: Conceptual Framework*. The type of approach is selected according to the municipalities' prioritises. The selected climate adaptations project use the accommodate as the primarily approach. The climate adaptation projects are changing the current way of living to use the adverse natural process for the benefits of humans liveability. As mentioned previously in this chapter, the adaptations are not designed to avoid floods entirely but to allow it to occur under controlled circumstances, whether the water is temporal or constant on terrain level. However, some of the characteristic from avoid and retreat approach to adaptation, is also discovered in the selected projects. For instance, the avoid approach is implied in the climate adaptation plans. These areas are determined as part of the risk assessment, thus discouraging new buildings at the site. On the other hand, activities was allocated to make room for new activities. This allocation was the case for local club B67 at sØnæs, cf. *Section 8.1: Water Landscape in sØnæs*. The establishment of this climate adaptation depended on including the fields for the water basin. Thus, characteristics from the retreat are present in the accommodate approach. Thus, using the accommodate approach the municipalities, allows utilising the local environment to develop the area, and accommodate the risk.

Nevertheless, concerning the selected climate adaptations project, the accommodate approach considers the natural ecosystem service and the cultural ecosystem service. Allowing occasional floods within the area, servers both as regulating and cultural ecosystem service. Furthermore, establishing elements permanently within the climate adaptation projects will enable visitors to use the site for various leisure activities across different ages. Based on the results and the findings in this chapter, a common element for the selected projects is that the project managers have expressed that the climate adaptations project also prioritise as green space for recreational activities.

10 Overcoming the Obstacles for Urban Climate Adaptation

Climate adaptation in Denmark is still underway. In the last ten years, there has been much progress. However, there are still many unknowns. The established projects give an indication of the value created in these area and what to take into account in the planning process.

10.1 Finding the Space in an Urban Environment

Establishing NbS in urban settings demands space, thus the climate adaptation must be accommodating. The establishment of green spaces is often a hard sell, as the apartment building generates monetary value (Rasmussen, 2021). Therefore, the areas used for NbS are often places that are dead spaces or already used for recreational activities. The dead space in the urban area is, for instance, Tåsinge Plads which before was an overdimensioned road and a small lawn, and thus the space was mainly unused (Bovbjerg, 2021). As a result, it was decided by the municipality to make an urban green space in this area. Acknowledging these spaces and using them for WSUD and NbS will increase the area's value as the area's functionality increases. Thus, the municipalities have an opportunity to find the available spaces in an otherwise dense area. However, the density of the cities is also what limits the possibilities for development as the available space is limited. As a result, the municipalities look towards their properties which often results in developing existing green spaces. Nevertheless, they do call for the stakeholders to take the initiative on their properties as well.

In more suburban areas, the individual households can adapt by disconnecting from the public sewer system. Consequently, the municipalities and utility companies only have to deal with the precipitation from the public areas, like roads. However, the households' management of precipitation demands that the homeowner is educated in the WSUD solutions. Thus, if the municipalities and utility companies want to increase the households opting for this solution, it would be beneficial to have more guidance on WSUD solutions. However, the individual households disconnecting from the sewer system is not possible in the same way in areas with blocks as these do not have the same flexibility in available space as the buildings occupy the cadastre. Nevertheless, common for both land uses is that their municipalities have to plan within the available space.

The available space also influences the catchment area that the projects services. Nevertheless, it is also beneficial to create smaller sub-projects that, in combination, have a significant effect on managing the increasing precipitation. The catchment area is the determining factor in terms of the amount of precipitation the area receive. However, when promoting these projects, the municipalities often plan for an event that statistically occurs every 100 years regardless of the catchment area. Thus, when comparing the area's functionality, it is important to relate it to the place in which it services. Tåsinge Plads is designed after the largest rain incident. However, it has the smallest catchment area, and thus the needed space for water decreases.

The projects are designed after incidents affecting the current catchment area. Nevertheless, the municipalities and utility companies might have plans to expand the catchment area through subterranean pipes. However, in doing so, the incidents that the site can handle decrease. Thus, if the intensity of the incidents increases, the projects do not have the wanted adaptation effect.

10.2 Collaboration between Project Managers and Stakeholder

The selected climate adaptations projects illustrates how the municipalities and utility companies collaborate on alternative solution to the grey infrastructure. The collaboration is challenged after their separation into two organisations (Kunstmann, 2021). They each have different responsibilities in terms of managing the water and thereby adapting to the effects of climate change. However, the different responsibilities also contribute with different qualifications which benefit the projects.

Nevertheless, the process is not always frictionless. The utility companies are responsible for the management of precipitation in terms of the RESS and the municipalities are responsible for the added value in terms of CESS. The planning has derived costs for the utility companies as the surrounding sewer system has to match that of the project area. For instance, the utility company has to separate the sewers in the catchment area if the water is transported through the pipes. Thus, the planning of the projects has to be long-term. The planning process is furthermore challenged by the legislation, which the municipalities have to take into account:

> What you also have to keep in mind is that it takes time and resources. You have to want it, be patient, and you have to respect each other's boundaries and area of expertise. There are some things that you have to compromise on, and there is some legislation we as a municipality have to comply with.
>
> (Geertsen, 2021:translated)

The quotation implies the friction, which can occur in the collaboration. The municipality, for instance, has the responsibility concerning the legalisation of the Environmental Protection Act, which can put a stop to the projects (Poulsen, 2021). Thus, there is a need for innovation to work with the act and not see it as a limitation. Here, the NbS is beneficial as it is possible to create modified ecosystems that positively influence protected nature, while serving the need of the municipalities and the utility companies. However, the protected areas will always have priority in the planning.

The municipalities' creative approach to area renewal challenges the utility companies because they are accustomed to stringent planning where the function was prioritised rather than design of the solutions, for instance, the water basins tend to be uniform. However, the utility companies are aware that the stakes are higher when they establish projects in the urban environment. The margin of error is limited as the projects are part of the urban landscape. The collaboration with the municipality is therefore helpful as they as use to creating these attractive urban environments:

> We have a technical system that must accommodate a specific volume, but then we thought creatively about the design. It does not have to be a square basin with steep slopes; it can just as well be a more landscape motif as the one at sØnæs.
>
> (Kunstmann, 2021:translated)

The landscape motif mentioned in the quotation contributes to the users' perception of the area. Using NbS creates spaces that increase the green urban spaces and the green infrastructure within cities. The users enjoy these areas and do not necessarily identify them as climate adaptation. Thus, value creation, more often than not, is linked to the CESS. However, if the users are aware of the area's function as climate adaptation, the area's value seems to increase.

Nevertheless, when transforming an public area in the city, the neighbours often have an opinion when the project is located in their neighbourhood. Public involvement is therefore essential for the project managers. Public meetings are a well-used method to communicate about the transformations that take place and a chance to give those affected a voice. However, it usually only draws specific types of citizens and not the broader range. As a result, some citizens are unaware of the development that takes place in their area. Thus, the municipalities have to use other methods. In

Middelfart, the project managers had road meetings where the project managers came and talked specifically to the affected citizen at the location (Rasmussen, 2021). Thus, the municipalities reached more affected citizens, albeit there are always citizens who stay unaware. Nevertheless, these alternative meetings decrease the possibility of this. Viborg Kommune used a similar approach as they were aware of the limitations of public meetings. Thus, they had an event in the pedestrian street where they handed out postcards. The postcards allowed the citizens to send wishes for what they wanted at sØnæs. Thereby, the municipality increased the participation in the project as they reached stakeholders that not necessarily had the time for public meetings.

Consequently, the development of new green spaces is mostly seen as a positive thing by the citizens. Nevertheless, public involvement is not without its challenges and demand resources. For instance, in Klimaparken, where the involvement of the housing association prolong the process as they have multiple departments with a democracy, which amounts to several meetings about the project:

> It has been a long process, partly because it has been important for us to involve our residents in the work of developing the park - it is their area and those who will use it. Therefore, we have held workshops and established a follow-up group of residents for the development work with the park.
>
> (Nedergaard, 2021:translated)

However, Nedergaard furthermore mentions that they have not encountered any real problems because there was a consensus that it was a good project, which met the conditions of all the project managers. On the other hand, at sØnæs, the neighbours were worried that establishing such a large area would create noise pollution (Kunstmann, 2021). Thus, the municipality had to make sure that it was not the purpose of the area. Nevertheless, the municipalities had in common that there were citizens who were sceptical of the projects. However, in these situations, the municipalities focus on making the citizens heard. This focus is also the case when stakeholders propose ideas that contradict the purpose of the area. Therefore, it is essential that the project managers are critical and only include concepts within the scope of the projects. Thus, increasing the ESS for the whole target group.

10.3 Adaptability of Danish Climate Adaptation

When making the climate adaptation projects in an urban environment, they must be flexible, hence covering the limitation of the inflexible sewer system when the future precipitation increases in intensity and frequency. However, based on the results and the analysis, the selected projects accept occasional floods in a controlled environment, and thus increasing or adding the flexibility that the local urban environment needs. On the contrary, building climate adaptation projects that ultimately prevent floods or only allow infrequent floods can be very costly compared to how much it benefits the city:

> You can make a sewer that can accommodate a 1000 year weather event. It just can not pay off from a social point of view. It [the project] is simply not worth it, and there is only one who pays for this, and that is the citizens.
>
> (Rasmussen, 2021:translated)

Thus, as the quotation underlines, it is possible to over-dimension the sewers, but it would not be profitable for society. Therefore, cities can implement NbS as a mean to increase flexibility for the benefit of the city, in situations where extreme precipitation occur. Nevertheless, continued development of adaptations without matching of expectations with the citizens might be problematic. The citizens, thus, become too dependent on adaptations to manage the floods. The dependency also stems from the utility companies' service level, which is the standard for flood protection from sewers. This level gives them a responsibility to handle the increased precipitation as the incidents they plan for intensifies. However, the utility companies already experience problems living up to the responsibility in older and low-lying parts of the cities. Nevertheless, the citizens expect the municipality to manage these challenges, thus renounce their responsibilities. Consequently, the citizens will become unprepared when the flood evidently occurs. This situation occur especially in densely built areas where the permeable surfaces are limited. This speaks for continual making green spaces with a climate prevention dimension. For each established climate adaptation, the city would receive another green space that can accumulate recreational and regulation value from ESS.

Climate change is an ongoing process; thus, weather predictions are changing. Such condition results in that the municipalities and utility companies must be prepared to develop existing climate adaptation projects further; thereby, meeting future knowledge about society, and climate. However, it has been found in the research that the selected projects are not being monitored after the establishment. The primarily reason for this is because revision is not part of the process. However, when establishing an nature-based adaptation it is essential to monitor if the ecosystem give the wanted effects in terms of RESS. Otherwise the combination of natural elements and grey solutions must be revised. To optimised and utilised the ESS in the future where knowledge about climate have changed, experiences from past projects are essential for developing new. However, the municipalities' trust in the advisers may overshadows the need to evaluate the finished climate adaptation project. Thus, it is unclear if the projects can withstand the projected weather event (Bovbjerg, 2021). As a result, the local neighbourhood may experience floods again because the annual precipitation and extreme weather may change too quickly. Thus, the floods cause damages because the climate adaptation is not modernise according to the contemporary context.

Nevertheless, the municipalities do learn from experiences with the planning process through public involvement: but it is primarily experiences about the recreation in the areas and thus the CESS. As a result, the municipalities have a baseline for what is needed in the development of urban green spaces:

> What we learn from and what we can see a need for are good access conditions, a path, and proximity to water. And it is always a good thing to add a bridge or some platforms or something where one can come down to the water and also school students can come down and do surveys. Good accommodation options, and it's everything from just a few benches or picnic tables to a bonfire place to a house for packed lunch, where you can take shelter (...) So these are some basic things that we know just work, and we should not compromise on these.
>
> (Kunstmann, 2021:translated)

As the quotation emphasises, when establishing green spaces in the city, the experiences are essential. Some stable elements are required to make the area attractive for the public, regardless of it is a climate adaptation project. Thus, the projects must satisfy the users' needs. The project manager, Kunstmann, stated that relying solely on catalogues when establishing such projects can result in misinvestments. However, NbS is based on local context, for which reason it is adapted to the local environment. As a result, this approach will to a greater extent, be the suitable investment that unlocks and generates value through CESS and RESS.

Tåsinge Plads

Part V | Conclusion and Inspiration for Further Work

In this last part, the first chapter will conclude on the research question, including the research objectives, and thereby the analysis and discussion of the report. Next are some reflections of the methodology and a presentation of ideas for further work, discovered throughout this research.

11 | Conclusion

To develop a responsive and flexible society to manage the future climate, there is a need for alternative and local solutions. The urban areas are particularly vulnerable to floods from increasing precipitation because they depend on the sewer system. Nature-based solution is a tool that contributes to adaptation to the effects of climate change in an urban area. NbS uses the green and blue elements as a means for adaptation, thereby working within the natural processes. Nevertheless, the NbS does not exclude engineered solutions but provides a solution that combines the strength of both grey and natural solutions. Thus, the grey solution is a tool to enhance the benefits of the ESS in nature-based solutions. As a result, NbS creates areas that include a hybrid solution, where it is possible to unlock the value through the ecosystem services that the green spaces provide.

This report have examined five climate adaptation in Denmark which uses NbS, namely: sØnæs in Viborg, Klimaparken in Vejle, Aktivitetsskoven in Middelfart, Selsmosen in Høje-Tasstrup, and Tåsinge Plads in Copenhagen. NbS varies in concept depending on the scale it is used on; on a national scale, NbS presents as a policy. The initiative for nature-based climate adaptation in urban areas mainly stems from national demands to create climate adaptation plans for city development. Thus, the municipalities are obligated to determine risk areas on which to focus the initiatives. Thus, the municipalities use NbS for tangible solutions. Common for the project is using the run-off to define the landscape, whether it is temporal or permanent on terrain level. Thus, floods create recreational value while easing the pressure on the local sewer system when extreme precipitation occurs. Therefore, the municipalities and utility companies use NbS to implement climate adaptation while creating a public green space in the cities.

Establishing NbS in urban areas increases a city's response to climate change because the city has a designated location for potential floods. Thus, the city avoids floods in unwanted places, preventing damage of monetary value and disruption of the infrastructure. As a result, the NbS unlock disturbance service within the ESS. Because this type of climate adaptation moves from subterranean to terrain level, it requires collaboration between the municipalities and utility companies. NbS is context-depended concerning the social and natural environment, and thus the collaborators can use each other's strength in the planning. As a result, it will be a beneficial investment for the collaborators when they enter such a project because of the wide range of value that the project will add to the city and local neighbourhood.

Cities have a lack of green spaces due to the optimisation of the areas for housing developments and infrastructure. Developing climate adaptation based on NbS creates public urban green spaces that have a wider range of value than the expansion of the grey infrastructure. Establishing alternative green solutions on terrain level will give a transition between the natural and urban space. Thus, the natural elements contributes with a recreational value through CESS for the citizens. Cohesive green areas provide space for motion that increases the health of both body and mind. Thus, NbS to climate adaptation has an extra dimension, which contributes to the city's livability. Throughout this research, the municipalities mentioned increasing or adding to the cultural value through CESS. This prioritisation contributes to the good life in urban areas through the establishment of the climate adaptations project.

Climate change is not a static process, and thus the adaptations cannot be inflexible. It is, therefore, important to choose solutions that change with the climate. NbS incorporate this demanded possibility of adaptability into the solution. Furthermore, NbS integrates local ecosystem into the solution, which gives co-benefits in terms of ecosystem services. Thus, NbS provides the urban areas in Denmark with opportunities to adapt to an uncertain future while creating some value for the citizens at this moment in time.

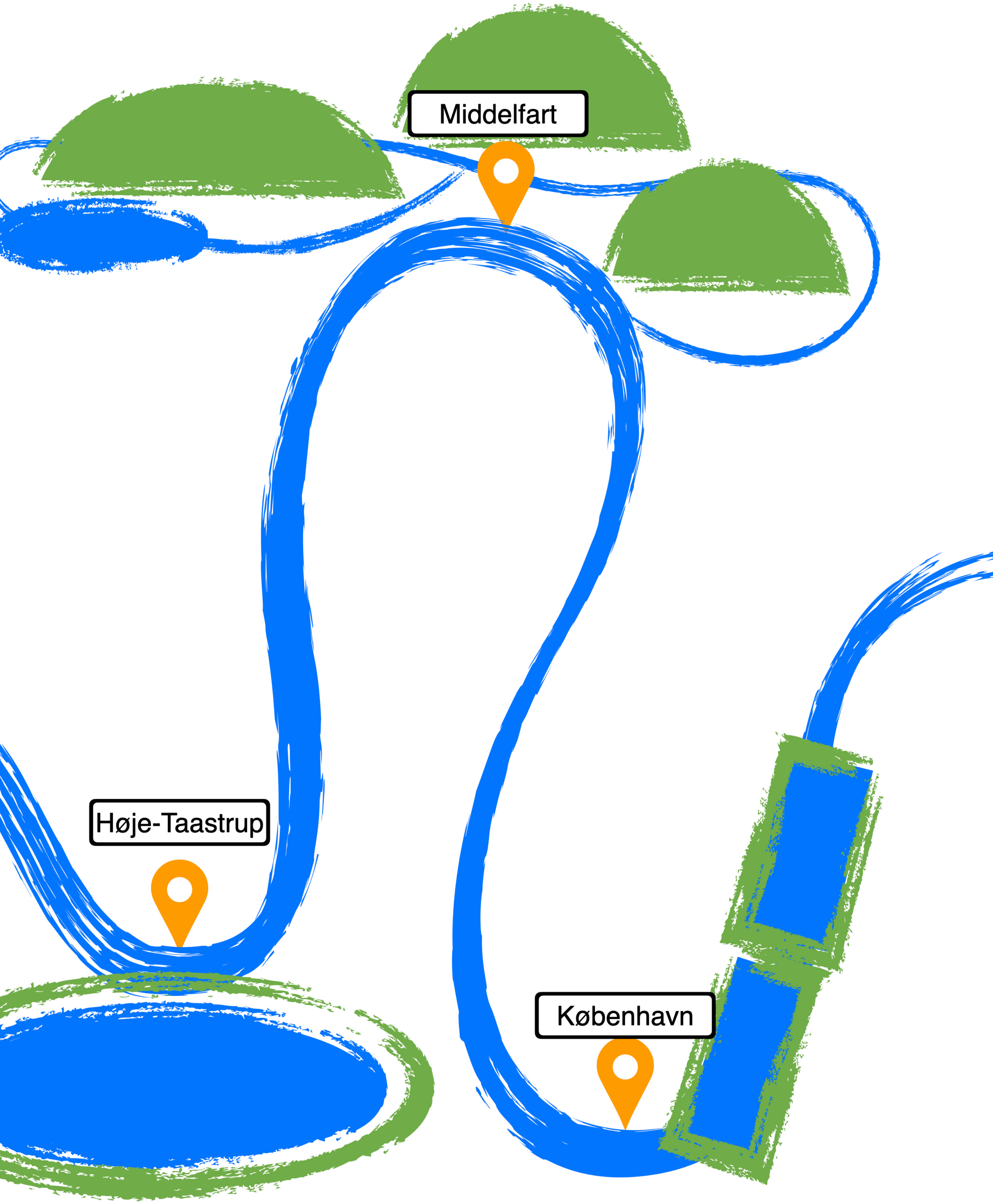
12 | Inspiration for Further Work

Throughout this research, a combination of the quantitative and qualitative methods is used. Upon reflecting on the methodology in this study, some aspects of the reliability of the conclusion may be affected by methods, which is worth mentioning for further work. First, the essential points are formed from the methods used in this project. Subsequently, it is argued that using these methods in light of their advantages and how they contribute to answering the research questions. Although the interview guide was the same for the respondents, the outcome of the interviews varied. The respondents had a different educational background that affects their roles or focus in the projects. The result was that some were keener to talk about the cultural ecosystems services, whereas others were learning towards the more regulating. However, they often had a sense for both ecosystem services as they are connected in these projects. Looking forward, it would be beneficial to talk to all of the involved project employees to investigate some of the aspects that fall outside the project managers' expertise. The semi-structured interview enables conversation through the interview guide, which leads the interview but is not restricting. However, one of the respondents asked for the questions beforehand so they could prepare. This preparation challenged the interview as it became more limited, and the respondent was not willing to deviate from the questions they were sent. Nevertheless, the answers were from the interview guide, and the values were covered.

Another influencing factor was the respondent's relation to the project. Some of the original project managers changed jobs; consequently, the respondent we came into contact with may have secondhand knowledge of the idea and planning phase, limiting the responses. However, the interview still contributed to knowledge not otherwise obtainable since the respondent had worked with the areas subsequently. The knowledge from the interviews accumulated. Thus, the interviewer could use knowledge from the previous interviews in later interviews. The interviewer could thereby challenge some of the answers the respondents gave. This accumulation of knowledge underlines that the interview generates data. It is important to note that the first interviews' outcome was as adequate as later interviews were, albeit the subsequent interviews were more critical. In retrospect, the reliability of the observation method in this research is limited because of the time spent at each location. As a result, the observation at each site was used to confirm findings in the interviews and literature study rather than discovering new findings. For further work, to increase the reliability of observation as a method, the time to carry out the observation at the site should be longer, for instance, over a week. Thus, it will be possible to observe the site in a different set of time and weather; hence, it could indicate and discover activities accumulated at the location and how these activities unfold and interact.

Several subjects were found interesting throughout this research but were left out because these did not contribute directly to the research question. However, citizens' reason and willingness to establish climate adaptation is relevant to mention for further work. As residential areas occupy large areas in cities, these cadastres form large catchment areas for the run-off, which influences public management. Thus, these areas play an essential role in the local hydrological cycle and the city's development toward adaption to the future weather. However, the municipality and utility companies are trying to encourage privates to separate their sewers and establish rain gardens to ease the collective run-off on the sewer system. Such a situation makes it relevant for further work to investigate what the citizens have at stake when floods from extreme weather occur. Additionally, what is their options and resources to recover from or prevent such floods because the damage is not necessarily limited to material damage. Investigating this subject for further work will cover the private aspect of floods from precipitation. Thus, the concept of NbS could be investigated through climate adaption on private lots. As a result, the study could give a comprehensive clarification of the initiatives behind establishing nature-based climate adaptation in cities and what value such projects will bring.


Viborg
Vejle



Middelfart
Høje-Taastrup
København

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A Semi-structured Interview Guide

The interview guide used for the semi-structured interviews. The interviews were conducted in Danish as it was the respondents first language, thus the guide also is in Danish.

Baggrund

- Hvad er jeres størst klimaudfordring?
  - Vandstand, nedbør, tørke, temperaturændringer?
    - Hvilke udfordringer oplever byen i den forbindelse?
- Hvorfor *Indsæt projektnavn* ?
  - Skala-spørgsmål: Hvorfor flere små end fx. større parkområde (eller omvendt)?
- Hvem var en del af samarbejdet i projektet?
  - Hvordan var fordeling af arbejdsområde?
  - Hvordan har den finansielle proces været?
- Hvilke udfordringer skulle *Indsæt projektnavn* løse?
  - Hvilke udfordringer (om nogen) har *Indsæt projektnavn* ikke formået at løse?
- Har området en høj omkostning, i pleje og vedligeholdelse?
  - Hvis nej, kan området selvregulerende?
- Er projektet bragt til veje af klimatilpasningsplanen?
  - Hvis, nej: kunne du se, at det ville opstå et lignende projekt på baggrund af klimatilpasningsplanen?
  - Hvis, ja: hvorfor?
- Bruger I aktivt klimatilpasningsplanen i jeres arbejde? Hvorfor?

Deres værdier? *Når de har svaret på dette spring så videre til den ESS, som passer til deres svar. Derefter prøv at lede mod de andre ESS, hvis de ikke har nævnt dem.*

- Hvad bidrager dette område til?
  - Hvis de nævner én eller to: Har I haft andre overvejelser med inden over?
- Hvordan ser I på merværdi ift. udviklingen af nye områder?
  - Er der nogle som er vigtigere end andre?

Cultural ESS

- Hvad er rekreativt i dette projekt?
  - Hvorfor skal dette projektet indeholde rekreativitet?
  - Hvem er målgruppen for de aktiviteter?
- Hvilke ting måtte man gå på kompromi, for at gøre plads til de rekreative elementer?
  - Var det et spørgsmål i planlægningen af hvad der skulle vægtes højest?
- Har I overvejet hvordan grønne områder kan bidrage til folkesundheden?
  - Hvis, LAR-løsninger: Har I overvejet flere sammenhængende grønne områder, ift. større mulighed for at drage fordelene af grønne områders påvirkning på. folkesundhed?
- Kan I se en udvikling i brugen af stedet ift. før etableringen?
  - Samlingspunkt eller gennemgang?
  - Positiv eller negativt? Har det overtaget et andet steds funktion?
- Er der sket en ændring i brugen af stedet i den tid det har været etableret?
  - Har stedet bibeholdt sin popularitet?
  - Bliver det brugt i samme grad?
  - Er det brugt mere eller mindre over tid?
  - Har Corona har en påvirkning?

Borgerinddragelse

- Hvilke type af borgerinddragelse have I i projektet?
- Hvornår er borgerne inddraget? (Før, under og efter)
  - Hvor meget?
  - Hvor mange var inddraget? Var det nok?
  - Hvem var det?
- Har I mødt nogle komplikation ift. at inddrage borgerne?
  - Hvis ja, hvilke?
  - Hvis nej,
    * Har der været nok borgerinddragelse?
    * Hvordan har I lavet en proces for at undgå dette?
- Hvordan har modtagelsen været på det færdige projekt ift. borgerne?

    - Hvad I overvejet hvad der kunne gøres bedre?

Regulating ESS

- Hvilken type hændelse er der taget udgangspunkt i og hvorfor?
    - Hvorfor er der taget udgangspunkt i XX års hændelse i projektet?
    - Hvad forventes der? Vi skal have personen til at forklare processen
- Kan I allerede nu se positive effekt af etableringen? (Naturlig parameter).
    - Hvordan monitoreres disse effekter?
- Er projektet projekteret til at kunne modstå at hændelserne bliver oftere og mere intense?
- Hvilke overvejelser har der været ift. hvor vandet skulle ledes hen?
    - Har kvaliteten påvirket af vandet påvirket, hvor man leder vandet hen?
        - Har I brugt oplandet som styring ift. projektets udformning? Vejvand eller hustage?
- Hvorfor har I valgt grå elementer frem for grønne elementer (eller omvendt)?
    - Ren grå, grøn eller hybridløsning?

Moterary

- Påvirkning af de omkringliggende områder?
    - Huspriser? herlighedsværdi?

Evaluering

- Hvis I skulle gøre det igen, hvad vil så gøre bedre eller lære af?
    - Har etablering af *Indsæt projektnavn* formået (om nogle) skabt nye udfordringer eller forstærket nogle?
- Hvilken værdi har *Indsæt projektnavn* givet til *Navn* By?

Hvis der er nogle spørgsmål, som de ikke kan svares på, så spørg om vi kan få en kontakten, for at få svar på dette spørgsmål.

- Hvem ved det så?
- Kan du stille os videre?

B | Pop-up Interview Guide

The interview guide used for the pop-up interviews. The interviews were conducted in Danish as it was the respondents first language, thus the guide also is in Danish.

Spørgsmål:

- Hvor tit bruger du bruger du området? Og hvad bruger du området til?
- Har din brug af området ændret sig efter dét er blevet lavet om, til det nuværende udseende?
- Ville du bruge det til dét samme, hvis området var meget urbant fx. hvis det var mere asfalteret?
- Har det betydning for dig, at det er et klimaprojekt ift. værdien af området?