

Nature as a facilitator for urban coastal resilience

A thesis on how to link nature-based thinking and climate resilience in the urban coastal context



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Abstract:

This thesis examines how the concept of Nature-based Thinking can contribute to building climate resilience in recent projects within the field of coastal urban climate change adaptation in Denmark. The state-of-the-art interventions for nature-based solutions for climate change adaptation have been identified to assess the potential of the urban coastal nature-based approach. Furthermore, the study examines the theoretical conceptualization of climate resilience by assessing current projects in Assens, Aabenraa, Svendborg, and Vejle and analyzes the contemporary perceptions in the case projects regarding barriers and opportunities of the use of nature-based climate change adaptation. To examine the full potential of the concept of Nature-based Thinking, a planning tool of 'reflective discussion-cards' has been developed to widen the discussion of urban nature and climate resilience. For nature to be able to facilitate the building of climate resilience, the thesis recommends future urban coastal projects of climate change adaptation to acknowledge path-dependencies within the field while integrating the core principles of climate resilience. Furthermore, the thesis recommends openly encouraging discussion and reflection between stakeholders in adaptation projects on how to enhance biodiversity by integrating nature-based solutions and further building an urban coastal environment for nature beyond solely anthropogenic values.

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Preface

This thesis has been conducted as part of the MSc program Urban, Environmental, and Energy Planning within the specialization of Cities and Sustainability at Aalborg University.

Acknowledgments

The research started in February 2022 and continued until June 3rd, 2022.

The overall interest of this thesis is the opportunity to create transformation in the field of climate change adaptation in a Danish context. Within this interest, facets of resilient nature-based adaptation, sustainable development of urban coastal areas, and mitigating contributions to climate and biodiversity crises have been areas of further interest. Moreover, the interest stems from an aspiration to challenge and open the discussion of alternatives for urban coastal climate change adaptation in the Danish context, as to question the contemporary urban projects, which this thesis argue constitutes narrow, short-term discussions merely on hard protection measures, fixed dike heights and uncertain prediction of future climate impacts.

There are several people I would like to thank in connection with my research. Firstly, to my AAU supervisor Birgitte Hoffmann, thank you for positively supporting my ideas and always bringing interesting references, constructive comments, and great discussions to the table. Second, thank you to the interviewees from all over Denmark, who contributed with vital insight. I especially would like to thank Anna Als Nielsen, project manager in Svendborg Municipality, inviting me to their internal workshop and sharing case project insights. Third, thank you to my housemate My Maarbjerg Skovgaard for supporting with beautiful drawings of urban nature. Lastly, thanks to Laurits and my family and friends for support, interest, and lots of encouragement.

Reading instructions

The reference style of APA is used in the report. On condition that a paragraph is solely cited after the final period, then the cited reference is applied throughout the full paragraph.

Disclaimer

This thesis was written within the framework of problem-oriented research at Aalborg University.



Kristina Momsen Sloth,
Aalborg, June 2022

Executive summary

The Danish coastal cities face a complex challenge of risk of storm surges and sea level rise as the climate changes. About 1/6 of the Danes live close to the sea, and already 20% of the coastal zone is protected by technical features. However, as the climate changes are uncertain, the contemporary use of the 'predict a future – prevent this future' planning method within the field of climate change adaptation is being criticized. Instead, the attention is tilting towards the concept of climate resilience. Simultaneously, the biodiversity crisis is growing and 47% of the Danish biodiversity are in decline, and the loss of nature is a key driver of climate change, while climate change again accelerates the damage to nature. However, as the crises are linked, so are the answers, and therefore this thesis calls for multifunctional and resilient urban projects to limit climate risk while enhancing biodiversity. Thus, the objective of this study is to unfold the opportunities and challenges of using the biodiversity-enhancing concept of Nature-based Thinking as a means to build climate resilience. Therefore, the thesis investigates: *How can Nature-based Thinking in the field of coastal climate change adaptation contribute to the climate resilience of Danish coastal cities?*

The thesis and answer to the research question are based on four analyzes with each associated sub-question. The first analysis pursues to answer: *Which coastal Nature-based Adaptation typologies exist, and what do they constitute?* Thus, the study presents a state-of-the-art review to identify the nature-based climate change adaptation, in this thesis termed Nature-based Adaptation, applicable in an urban coastal context, and further assess what the measures constitute by constructing a 'Nature-based Adaptation catalog.' The second and third analysis seeks to answer the sub-question, respectively: *With the theoretical starting point in the principles for building climate resilience; are projects for urban coastal CCA projects in Denmark, with the focus on four contemporary projects in the cities of Svendborg, Assens, Aabenraa, and Vejle, building resilience in connection with Nature-based Thinking?* and: *Which perceived barriers and opportunities regarding Nature-based Adaptation are reflected upon in the case projects of Vejle, Svendborg, Assens, and Aabenraa?* The research related to the answer of these analyzes are based on selected contemporary Danish case projects and pursues to examine the projects through the glasses of the theoretical and conceptual framework of building climate resilience by Tyler & Moench (2012) in connection with the concept of Nature-based Thinking by Randrup et al. (2020). The second and third analyses are based on interviews with relevant stakeholders in the case projects and are tailored to examine the project's work and perceptions regarding resilient Nature-based Adaptation. The fourth and final analysis builds on the concept of Nature-based Thinking by Randrup et al. (2020) and the creation of 'Multispecies Design' by Metcalfe (2015). The analysis seeks to answer the sub-question: *Based on results from previous analyzes, what kind of planning tool could be advantageous to lift the discussion about Nature-based Thinking and climate resilience?* Thus, the analysis seeks to gather the threads from previous analyzes to develop a reflective planning tool useful in the development phase of Nature-based Adaptation projects.

The research found that the concept of Nature-based Thinking in the field of coastal climate change adaptation can contribute to the building of climate resilience in terms of transformability of path-dependent tendencies, as well as building of nature-based long-term persistency to storm surges and sea level rise and building of adaptive capacity of stakeholders in terms of increased awareness and new knowledge. However, the research found that the contemporary potential of building resilience through Nature-based Thinking merely applies to two out of four case projects, which indicate that future Nature-based Adaptation projects in Denmark could continue to face challenges of acceptance and integration.

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List of Acronyms

EU = European Union

CCA = climate change adaptation

DAPP = Dynamic Adaptive Policy Pathways

IPCC = Intergovernmental Panel on Climate Change

NBA = Nature-based Adaptation

NBS = Nature-based Solutions

NBT = Nature-based Thinking

RCP = Representative Concentration Pathway

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1. Introduction

“What you do makes a difference, and you have to decide what kind of difference you want to make.”

- Dr. Jane Goodall, Scientist & Activist

There is no longer doubt the climate crisis is human-caused, and while the UN Climate Panel (IPCC) calls for immediate deep reductions in GHG emissions (IPCC, 2021, p. 19), projections of global warming warn of the current climate being pushed in the direction of a new and warmer climate with more extreme weather (IPCC, 2021). Climate changes increase extreme events (drought, storm, floods) while accelerating climate stresses such as rising temperature and sea level rise (IPCC, 2019; UNFCCC, 2021). A global average rise in sea level will cause extreme sea level events that historically only have happened once per century to occur annually at many locations already by 2050 (IPCC, 2019). These issues call for urgent and comprehensive planning for future climate change adaptation in Denmark (Danish Board of Technology, 2021).

In Denmark, 1800 of 8750 km of the coastal zone is already protected by permanent technical solutions (Fragò et al., 2018). However, no national plan for coastal adaptation exists and municipalities, therefore, are in charge of the plans for their coastal areas (Danish Board of Technology, 2021). However, inspirational projects such as *“The cities and the rising sea”* by Realdania and the Ministry of Environment in Denmark are initiated to facilitate innovative and exemplary urban coastal climate change adaptation projects (Realdania, n.d.-d). Especially the climate challenges for urban coastal environments are relevant, as the changes in sea level rise are uncertain. Adaptation can be seen as a ‘wicked problem’ due to the consequences only seen in the relatively long term, thereby bringing significant local challenges of conflicting short-term and long-term interests, inability or lack of adaptation action, and competing values among stakeholders. (Fryd & Jørgensen, 2019). Many people and much value are situated in the coastal zones causing concern due to especially long-term projections to sea level rise and extreme events such as impactful storm surges (Ibid.).

Multifunctional projects that constitute planning for resilience to uncertain climate change impacts and urban nature-based solutions are highly relevant. One aspect of relevance is that there are already plans for more than 130% of the existing Danish landscape, which means that especially projects with the ability to accommodate several requirements should be prioritized. (Danish Board of Technology, 2021). Another aspect of relevance is that the biodiversity and climate crises are intrinsically linked, which has led to highly encouraging nature-based solutions to be a preferred part of future development (European Commission, 2020).

This master’s thesis unfolds the opportunities and challenges of planning for nature-based climate change adaptation projects in the urban coastal environment. The study takes a point of departure in four Danish urban coastal towns in the Realdania project *“The cities and the rising sea,”* namely: Svendborg, Assens, Aabenraa, and Vejle. These urban case examples explore the use of nature-based coastal climate adaptation. Furthermore, the study investigates the potential of proactive discussion of climate resilience building in the coastal urban environment and the concept of Nature-based Thinking. The thesis aims to challenge the present planning of climate change adaptation in Denmark and propose a transformational change toward climate resilience building through Nature-based Thinking. Thus, concerning the quote from Jane Goodall, and in the face of global challenges of climate change and loss of biodiversity with potential devastating local impacts, proactive planning is *the kind of difference* I can make.

2. Problem analysis

In this chapter, the problem-oriented background for the thesis is laid out. The aim of the chapter is to provide the reader with a justification and contextualization of the research. The problem analysis is built upon the introduction in Chapter 1 and constitutes a presentation of the general expectations of the Danish climate change impacts, the need for climate change adaptation, the path-dependency of these measures, and the relevance of climate resilience. Furthermore, the need for a transformational change toward nature-based and biodiversity enhancing urban coastal landscapes is described. Finally, this will seek to scope the problem formulation in the form of the leading research question and related sub-questions in the following Chapter 3.

2.1 A new paradigm in coastal climate change adaptation

In a Danish context, the climate is changing towards warmer temperatures, increased frequency and magnitude of storms, and an increase in pressure of water from all sides: sea level rise, storm surges, rising groundwater, and increased precipitation and cloud bursts (Danish Board of Technology, 2021). These tendencies are already being felt nationally as the yearly average temperature has increased by 1.5 Celsius, the annual precipitation rate increased by 100 mm, and the sea level has risen 2 mm annually, all in the last century (Danish Board of Technology, 2021). In Denmark, the rise in the average sea level is especially a cause of concern, as the sea is expected to rise 0.61 (0.3- 0.9) m by the end century, as illustrated in Figure 1 below (DMI, 2018), and further long-term projections even estimate more than 2.3-5.4 m global sea level rise by the year 2300 (RCP8.5)¹. The concern is not the change itself; it is, however the rapidness of the changes as the speed reduces the abilities to cope and adapt for both humans and nature (IPCC, 2021). Thus, projected changes call for climate change adaptation for both population and nature, as Denmark, together with Japan and the Netherlands, are designated as the three OECD countries especially vulnerable to sea level rise (CONCITO, 2017).

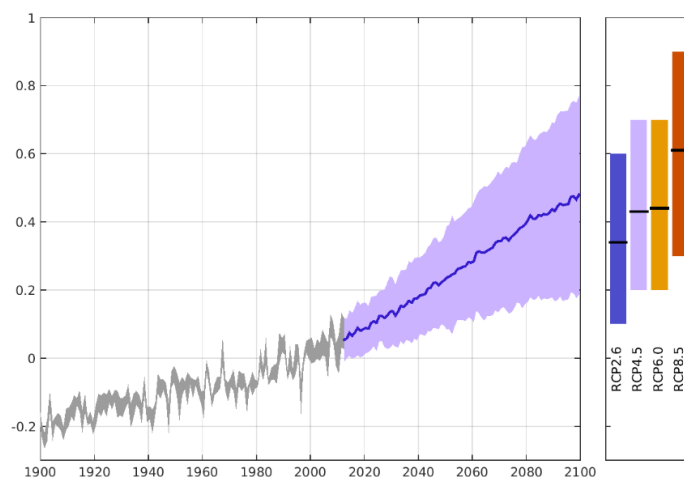


Figure 1: Projected relative sea level rise in Denmark. (Figure adapted from DMI, 2018)

2.1.1 Climate change adaptation in Denmark – problems of the past, present, and pipeline

In Denmark, about 1/6 of the population lives below the elevation of 6 m (Fryd & Jørgensen, 2019), causing concern due to the long-term projections in sea level rise, especially as Denmark already is the EU country that has experienced the second most cost related to climate damage per citizen (Danske Regioner, 2021). Awareness of the urgency for immediate and comprehensive planning for coastal climate change adaptation

¹ Representative Concentration Pathways are scenarios for selected concentrations of greenhouse gases (IPCC, 2019).

(in the further research referred to as ‘CCA’) is also increasing in Denmark (Danish Board of Technology, 2021). Nevertheless, there is no national integrated water resource management, as is otherwise the basic idea of the EU Water Framework Directive from the year 2000. The missing national and regional links have contributed to scattered and incoherent coastal solutions, far from a sustainable and suitable approach. (Danish Board of Technology, 2021). The national plan is initiated (Ministry of Environment of Denmark, 2022); however, until this plan is politically vouched for, the Municipalities are in charge, and missing links for sustainable strategic approaches continue (Danish Board of Technology, 2021). The challenges of the future climate risk and additional missing strategic links are lately being acknowledged through the example of the partnership campaign (project period year 2018-2022) between Realdania and the Ministry of Environment in Denmark called *“The cities and the rising sea”*. This campaign aims to support Danish urban CCA projects, which constitute exemplary proposals to combine urban livability, CCA, long-term planning horizons, and flexibility. (Realdania, n.d.-d). Furthermore, the campaign aims to build research knowledge, general dialog, and awareness of the issues in the Danish population (Realdania, n.d.-d), which is highly relevant as 58% of the Danes worry about flooding due to the changing weather (DNNK et al., 2021).

On one side, the awareness being built through campaigns such as Realdanias and the coming national plan are highly important; however, on the other side, CCA in Denmark is *not* an unknown challenge on the agenda. The previous procedures for CCA are relevant to consider, as they constitute factors that have paved the road for the future CCA projects in *“The cities and the rising sea”* and the national plans.

Since 1990 the UN Climate Panel (IPCC) has suggested three strategic approaches to CCA in the light of sea level rise: ‘protection, accommodation, and retreat’ (IPCC, 1990), as illustrated below in Figure 2. The framework is widely used for coastal zone management, including in Denmark (Faragò et al., 2018).

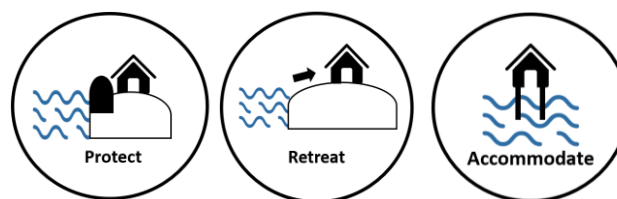


Figure 2: Strategic CCA approaches. (Own illustration)

In Denmark, 1800 of 8750 km of coastal zone already resemble the ‘protection strategy’ with permanent technical solutions protecting the shore (Faragò et al., 2018). The historical Danish preference for ‘protection’ measures builds on reactive responses to impactful storm surges such as the impactful event in the year 1872, which caused extreme sea levels in much of Denmark. These reactive responses have predominantly resulted in hard solutions such as sea walls, dikes, sluices, and groynes in the coastal and urban landscape and a few soft protection measures such as implementing terps and sand nourishment. (Ibid.).

Recent programs for coastal CCA are still primarily driven by past events (such as the year 2013 storm ‘Bodil’ in Denmark), and proactive schemes are rare and rarely funded, especially this is the case when projects cross municipal borders (Rambøll, 2015). However, some recent coastal interventions (the year 2000-2017) do involve a more proactive position to the changing climate and projected impacts, although the primary strategy is still one of ‘protection’ measures. In contrast, only a few examples of coastal ‘managed retreats’ have followed the first-ever Danish project of Gyldensteen Beach in the northwest of Funen in 2013 (Faragò et al., 2018). The difference from the historical protection interventions is that the recent ones have tendencies of elements of aesthetic, multifunctional and recreational values (Faragò et al., 2018).

Although more recent proactive planning for future climate risk, pipeline CCA projects in Denmark still use historic mono-functional ‘protection’ measures in the urban environment (Faragò et al., 2018). A pipeline example of a CCA measure spread out in numerous projects practically heterogeneously all over Denmark is the intervention of sluices/locks (Henriques, 2017). And one could ask if this is the only way of the future Danish climate change adaptation since so many projects aim for this? (Henriques, 2017).

2.1.2 Consequences of the path-dependency in Danish coastal CCA projects

The future continuation of the ‘mono-strategy’ that protection constitutes could cause challenges, as the ‘protection’ strategy is experiencing issues to create added values for cities and coasts and preserve cultural and natural values (Faragò et al., 2018). Hard structures are undisputed known to be an efficient way to mitigate the risk of coastal climate hazards. However, these constructions often negatively influence the landscape and limit the opportunities for multifunctional values (Danske Regioner, 2021). CCA interventions will affect the natural dynamic and therefore affect the landscape and biodiversity, and even the biological carbon uptake (Danish Board of Technology, 2021).

One could argue that path-dependency is present in the coastal CCA as the reactive ‘protection’ strategy dominates historical, recent, and pipeline projects (Faragò et al., 2018). The lack of prioritization of ‘accommodation’ and ‘retreat’ strategies is highly relevant. This could have long-term consequences, potentially creating an issue with the lock-in tendency to optimize hard structures instead of transforming to new holistic solutions for CCA. This could cause one to ask whether it is the right approach to continue down this path of rarely proactive planning dominantly using the mono-strategy of ‘protection’ with the use of hard structures such as sluices/locks, when this constitutes planning only for the ‘near future’ and these decisions additionally are known to fail to preserve cultural and natural values?

Another issue of path-dependency in the field of CCA could be the method of ‘predict and prevent,’ which is the standard approach to avoiding the negative impacts of climate change (Tyler & Moench, 2012). The approach stems from the fact that the main approach of CCA is to avoid the negative impacts and, in essence, relies on historical climate data combined with future climate predictions to prevent likely impacts. This is a challenge, as predictions are inherently uncertain, especially concerning the complexity of climate change. (Tyler & Moench, 2012). Therefore, the planning for future climate risk is decision-making under uncertainty, creating a great challenge for planners and policy-makers (Vermeersen et al., 2018) and encouraging the method of ‘predict and prevent’ where a certain projection of future climate is ‘chosen,’ and plans are made to prevent this specific scenario (Tyler & Moench, 2012). However, the ‘predict and prevent’ method is being criticized for its inadequate capability to deal with surprises. (Ibid.). Tyler & Moench (2012) argue that instead of focusing on adaptation for specific future predictions, the focus would be more effective if planners considered the problem as one of *building resilience*.

2.1.3 The relevance of resilience building in the field of coastal CCA

IPCC defines resilience as “*the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change.*” (IPCC, 2007 in Tyler & Moench, 2012, p. 312). In the context of Danish CCA, the concept of urban coastal climate resilience could be framed as a new paradigm within the field, as the concept has experienced increasing interest and awareness from the recent extreme events such as the storms Bodil (2013), Egon (2015), and Urd (2016) (Danish Board of Technology, 2021). The context of climate resilience, however, goes beyond the element of recovery of floods and other hazards, as resilience thinking represents a holistic

system approach that investigates the capacities of persistency to climate shocks and stresses, transformability, and adaptability, of socio-ecological systems (Elmqvist, 2014; Folke et al., 2010; Frantzeskaki, 2016). Especially the holistic focus is what differs between the concept of climate resilience and the approach of CCA, as CCA often tends to under-emphasize the role of flexibility, learning, and encouraged transformational change as essential elements (Tyler & Moench, 2012). In contrast to urban and arguably conventional, CCA, which mainly focuses on 'predict-and-prevent,' an approach based on climate resilience, has several advantages since the concept encourages change and innovation in considering unpredictable climate shocks and stresses (Ibid.).

Having introduced these perspectives of impacts from climate changes, path-dependency within the field of CCA in Denmark, and the relevance of urban climate resilience, it is relevant to clarify that this research aims not to investigate climate resilience alone. Yet, what this thesis claim is especially interesting, is how climate resilience in the field of CCA can be interlinked with the biodiversity crisis and accomplish trade-offs, thereby facilitating transformative changes in contemporary projects. I argue that a transformative change within the frame of resilience could be one of the nature-based climate change adaptations.

2.2 Transformational change towards nature-based climate change adaptation

The biodiversity and climate crises are intrinsically linked (European Commission, 2020). Loss of nature is a key driver of climate change, and climate change accelerates the destruction of nature. However, as the crises are linked, so are the solutions. Nature is critical to fighting climate changes, as nature regulates the climate, and nature-based solutions have the ability to protect against climate and weather-related hazards and are therefore essential for both CCA and climate mitigation. This creates a need to enhance and address the interdependencies and trade-offs between biodiversity and climate (European Commission, 2019).

The crisis of the loss of biodiversity and collapse of ecosystems is one of the most significant threats in this decade (the 2020s), creating a need for urgent action to invest in the protection and restoration of nature as *"we need nature in our lives"* (European Commission, 2020, Chapter 1). The current trajectories are not sufficient to accomplish action for climate change and achieve the several SDG goals related to sustainability and nature. Instead, the EU stresses that transformative change is a requirement for scaling up biodiversity conservation, ecosystem restoration, and nature-based solutions (NBS) (IPBES, 2019 in European Environment Agency, 2021). Especially the umbrella concept of NBS is a promising path to achieving transformative change in practice (European Environment Agency, 2021).

The European Commission defines NBS as: *"Solutions inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social, and economic benefits and help build resilience. Such solutions bring more, and more diverse, nature and natural features and processes into cities, landscapes, and seascapes, through locally adapted, resource-efficient and systemic interventions."* (European Commission, n.d.).

In the context of CCA measures, NBS as defined above, is widely becoming an integrated approach within the field. Nature-based CCA, or what I would argue could be defined as the term *Nature-based Adaptation* (NBA), see illustration in Figure 3 below, is the definition of NBS as an integrated part of a project for climate resilience or an adaptation strategy able to either control or absorb the impact of climate change (Noble et al., 2015).



Figure 3: The combination of nature-based solutions (NBS) and climate change adaptation (CCA) constitutes the concept of Nature-based Adaptation (NBA). (Own photos from Fanø year 2022)

NBA has several advantages over conventional measures as natural systems are flexible, safe failure interventions, and will strengthen over time compared to engineered systems (Drake, 2021), and since NBA are efficient as coastal security and can bring essential added values in the form of increased blue and green biodiversity, carbon uptake, and recreational landscape values (Danish Board of Technology, 2021).

2.2.1 Coastal NBA in Denmark – where are they hiding you?

In a Danish context, the combination of enhanced biodiversity and CCA in the form of the NBA approach is especially relevant, as the loss of national biodiversity is prevalent. A larger Danish research project in the year 2011 estimated that 47% of the national biodiversity was in decline, demanding immediate targeted actions if the loss of Danish biodiversity were to be halted (Ejrnæs et al., 2011). Furthermore, 63% of Danes are concerned about declining biodiversity and would prefer more resources to be set aside in case CCA is related to biodiversity (DNNK et al., 2021), indicating a general awareness among Danes on the issue. Moreover, the recent Realdania campaign “*The cities and the rising sea*” have conducted research on the wishes of the Danes for CCA. The integration of nature-based approaches and ‘accommodation’ are especially popular among the youth in Denmark, and the desire for accommodating NBA stems from the increasing demand for the physical integration of climate mitigating acknowledgment in the CCA projects. (Danish Board of Technology, n.d.). For these wishes to be fulfilled, I would argue that the concept of climate resilience and the concept of NBA need general awareness and acceptance in the population for it to succeed.

However, nature as an integrated part of the urban coastal CCA projects does not precisely ‘sprout’ in Denmark (Fryd & Jørgensen, 2019), although institutions such as Danish Regions (2021) in their paper on recommendations to the coming national CCA plan, recommend the approach of NBA as being the future absolute preference along with projects that ‘let the water in’ in the urban space (accommodation) instead of ‘keeping the water and nature out’ (protection), together with general recommendations of holistic, long-term, and resilient planning. A reason for the absence of urban coastal NBA in Denmark is the general lack of knowledge in terms of nature- and landscape-based solutions as to what they do and how they can be useful in terms of CCA (Fryd & Jørgensen, 2019). Furthermore, the current situation and reasons for the absence of coastal NBA are described by Danish professionals within the field as follows: “*NBS is important for the future CCA solutions. NBS, however, takes time to build, and the experiences with the approach are lacking.*” (Wiberg, 2022, p.c.) and “*NBS is not about ‘re-inventing the wheel,’ but it must be long-term thinking, and one must deal with aspects of culture and the environment and static dilemmas.*” (Sørensen, 2022, p.c.) and “*The subject is rather conflict-filled for cities with harbors as there is a conflict of interest in port/harbor cities. When there is*

an existing city, there are not so many opportunities for nature." (Andersen, 2022, p.c.). These quotations indicate a lack of experience with the NBA, difficulties concerning culture, and general perceived conflicts due to the fight for the urban space, which indicates that nature is not yet an active player within the field of planning for CCA. Furthermore, general multifunctionality in the urban environment is associated with a rarity: *"The future projects must be multifunctional. However, the reality is not like that, the projects rarely manage to be multifunctional, and in reality, multifunctional projects are not often built."* (Dehlbæk, 2022, p.c.). As Nature-based Adaptation is considered a multifunctional approach in this thesis, this highlights a challenge for integrating nature into the urban coastal CCA projects.

2.2.2 Introducing Nature-based Thinking

As previously mentioned, a transformative change within the resilience frame could be the integration of nature in the CCA projects. However, as nature is considered absent in most urban coastal CCA projects in Denmark, the discussion of integrating and accepting urban nature could use a new language or planning approach. This new approach, I argue, could be the concept of Nature-based Thinking (NBT) by (Randrup et al. (2020). NBT builds on two main steps: the first step is developing multifunctional projects with nature-based solutions in the urban environment, which according to this thesis, could constitute the approach of NBA, and the second step consists of developing a new transformative awareness of urban nature. The last step stems from a perception that urbanization, until now, has constituted a driver for what has been named "the extinction of experience" with nature and the consequent loss of civic care for sustainability actions. To turn this tide, nearby urban coastal nature should be actively integrated amongst the city dwellers. (Randrup et al., 2020). Urban coastal nature doesn't solve everything, fits into all urban environments, and is not the entire trade-off solution to the crises of biodiversity and climate. Nevertheless, it brings awareness, multifunctionality, and innovation. (Ibid.). Furthermore, as NBA projects still are 'hiding' within the urban coastal landscapes, and as planners wish for better and more tools in their toolbox to develop green cities and enhance biodiversity (Jensen, 2022), this thesis aim to investigate how Nature-based Thinking could become one of those 'tools' to contribute to climate resilience and enhancement of both blue and green biodiversity in the urban coastal environment.

3. Research Question

The previous chapter has pointed out the following significant challenges: (1) Climate change and the biodiversity crisis are the two most complex crises that require immediate interlinked action. (2) Past and present planning for CCA in Denmark is predominantly reactive as it builds on the experience of storm surge events, is often the approach of 'protection,' and often consists of hard concrete structures or planned sluices/locks to deal with the expected worsening climate impacts. (3) Nature-based Adaptation, and thus Nature-based Thinking, is not yet an active player or concept in the Danish cities' adaptation to coastal climate impacts even though the nature-based opportunity space is considered a crucial piece in the future management of climate issues. In addition, Chapter 2 has provided an insight that building climate resilience to the future uncertain climate impacts, instead of the contemporary 'predict-and-prevent' method used in the field of CCA, could be a preferable objective. In contrast, according to this thesis, the means to resilience could constitute the integration of the concept of Nature-based Thinking. This thesis therefore investigate how CCA in current coastal urban projects can undergo a shift towards the principles of climate resilience by using nature more actively in work with CCA and therefore seek to investigate the following leading research question:

How can Nature-based Thinking in the field of coastal climate change adaptation contribute to the climate resilience of Danish coastal cities?

To answer the research question, the following sub-questions are formulated.

The first sub-question presents an identification of which typologies for Nature-based Adaptation exist in the context of coastal urban areas and further an assessment of what these typologies constitute:

- 1) *Which coastal Nature-based Adaptation typologies exist, and what do they constitute?*

The following sub-questions investigate how the integration of Nature-based Adaptation, assessed in sub-question 1, can contribute to climate resilience. To investigate this, it is, according to this thesis, necessary to understand what climate resilience represents and how this could be connected to the principles of Nature-based Thinking applied in this thesis. From this theoretical starting point, I would argue it is relevant to first and foremost assess the contemporary work on nature-based CCA in Danish coastal cities and assess whether the ongoing work is building resilience and which perceptions of barriers and opportunities there exist, according to the theoretical principles adopted in this thesis. Thus, the following sub-questions are relevant:

- 2) *With the theoretical starting point in the principles for building climate resilience are projects for urban coastal CCA projects in Denmark, focusing on four contemporary projects in the cities of Svendborg, Assens, Aabenraa, and Vejle, building resilience in connection with Nature-based Thinking?*
- 3) *Which perceived barriers and opportunities regarding Nature-based Adaptation are reflected upon in the case projects of Vejle, Svendborg, Assens, and Aabenraa?*

When the contemporary coastal CCA projects are assessed, according to this thesis, it is possible to use the developed knowledge to investigate how projects can create synergies between the building of climate resilience and the enhancement of nature. Thus, a planning tool that could contribute to the discussion of nature-based climate resilience is developed, leading to the final sub-question:

- 4) *Based on results from previous analyzes, what kind of planning tool could be advantageous to lift the discussion about Nature-based Thinking and climate resilience?*

4. Research Design

This section will present the research structure and scientific approach of this study. First, an outline of the individual parts of the report's structure is shown in Figure 4, presenting a visualization of how the thesis elements relate to each other. Second, each chapter used to answer the research question will be described.

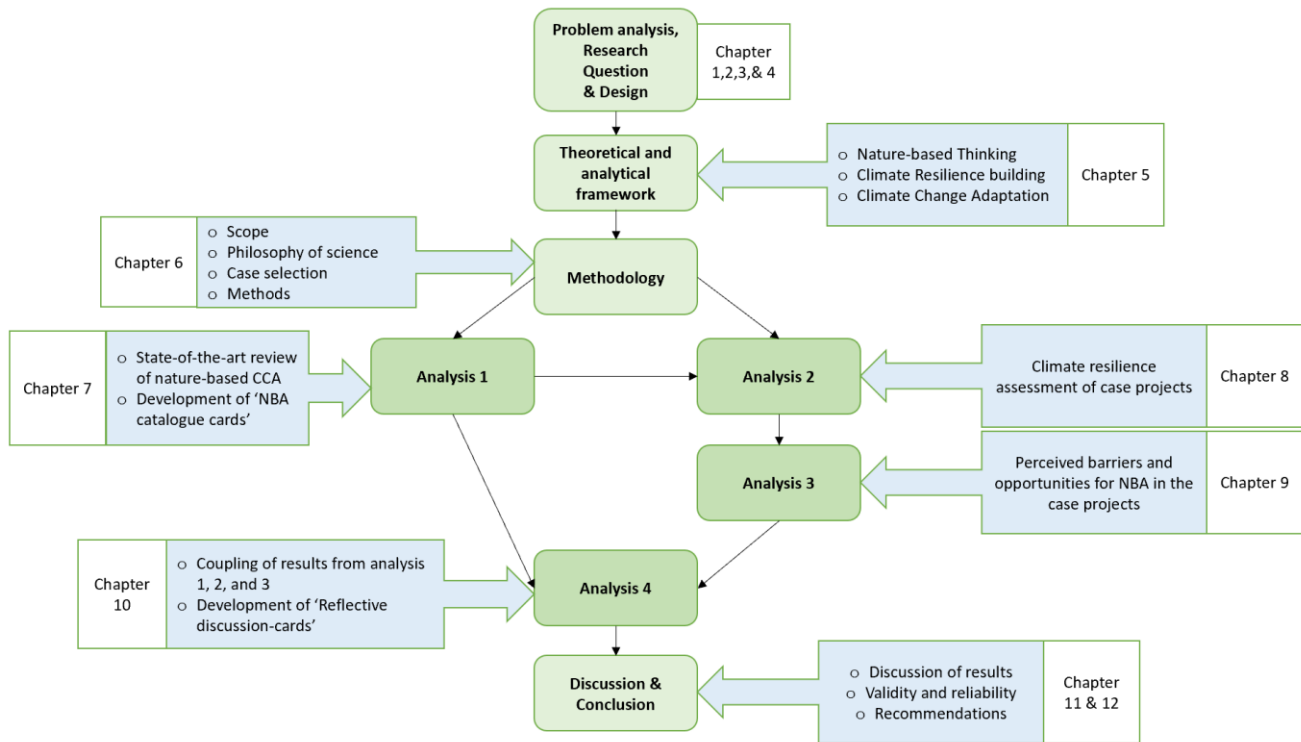


Figure 4: Research design of the report (Own illustration)

This thesis consists of 12 chapters which constitute the following aspects:

Chapter 1 introduces the problem-oriented background for the thesis.

Chapter 2 presents the problematization of historical, contemporary, and future challenges relevant to CCA and nature-based resilience, including the terminology, and the relevance, of coastal CCA, Nature-based Adaptation, Nature-based Thinking, and the relevance of building climate resilience.

Chapter 3 introduces the leading research question and the associated sub-questions.

Chapter 4 introduces the research design as a reading guide to the structure of the thesis.

Chapter 5 describes the theoretical and conceptual framework used to analyze the thesis results.

Chapter 6 describes the methodologies of the thesis, including the philosophy of science, the scope, the background of case study research, and arguments behind the selection of Danish case projects in Aabenraa, Assens, Vejle, and Svendborg. Finally, this chapter describes the methods used in each analysis chapter.

Chapter 7 seeks to answer the first sub-question: *Which coastal Nature-based Adaptation typologies exist, and what do they constitute?* The analysis describes the state-of-the-art options of NBA through analysis of a wide range of Danish and international, mainly European, literature reviews and open-source catalogs of coastal CCA and NBA measures. From this literature, the chapter presents a state-of-the-art review in the form of a catalog of 'cards' on typologies for Nature-based Adaptation applicable in the setting of coastal and urban areas in

Denmark. The 'NBA catalog cards' contribute information and inspiration and highlights how applying nature-based typologies for coastal CCA can address climate challenges such as sea level rise and storm surges, constitute strategic CCA approaches, contribute to the discussion of technical features and sustainable indicators, and present examples of already realized and pipeline NBA projects.

Chapter 8 seeks to answer the second sub-question: *With the theoretical starting point in the principles for building climate resilience; are projects for urban coastal CCA projects in Denmark, with the focus on four contemporary projects in the cities of Svendborg, Assens, Aabenraa, and Vejle, building resilience in connection with Nature-based Thinking?* The analysis explores the theoretical principles for climate resilience related to the theoretical concept of Nature-based Thinking through the Danish case projects of Aabenraa, Assens, Vejle, and Svendborg. The analysis constitutes an assessment of interviews with representatives of the case projects and participation in a public hearing and private, municipal workshop for the case project of Svendborg. The chapter provides a knowledge base of the four case projects on the resilience principles and associated theoretical components concerning Nature-based Thinking, of persistency to climate change impacts, transformability, and adaptive capacity of social actors. Furthermore, the chapter uses the results of Chapter 7 in which to investigate which NBA typologies the case projects plan to use in their contemporary projects. The purpose of the chapter is to examine how the theoretical principles of resilience can shed light on whether the nature-based elements in the case projects contribute to resilience building, which brings forward an understanding of the potential for NBA as a general tool for building climate resilience in Denmark.

Chapter 9 seeks to answer the third sub-question: *Which barriers and opportunities regarding NBA are reflected upon in the case projects of Vejle, Svendborg, Assens, and Aabenraa?* The analysis builds on the assessment of resilience building in Chapter 8. It highlights the further opportunities for, and barriers to, the integration of NBA as an approach to building climate resilience in the four case projects. The analysis is based on the interviews and workshop participation conducted as the empirical source in Chapter 8. It constitutes the reflections of the lessons learned by the interviewees regarding barriers and opportunities for the integration of nature in the four case projects. This analysis aims to gain a greater insight into the conditions that could limit or enhance NBA as an approach in the Danish planning for resilient CCA.

Chapter 10 reflects upon the fourth and last sub-question: *Based on results from previous analyses, what kind of planning tool could be advantageous to lift the discussion about Nature-based Thinking and climate resilience?* The analysis is based on the main findings from the results in the previous Chapters 7, 8, and 9, together with a point of departure in the theoretical concept of Nature-based Thinking. The analysis comprises the development of a planning tool of 'reflective discussion-cards' constructed to open the discussion on the role of nature in the urban space and nature as a transformative aspect when building resilience.

Chapter 11 provides the discussion of results from the analysis chapters and the reliability and validity of these results. Furthermore, the discussion includes recommendations and points of attention regarding the perceived contemporary challenges and prospects of building climate resilience through Nature-based Thinking.

Chapter 12 presents the conclusions. In addition, there are **five appendices**:

- 1) Appendix A provides an interview guide for the municipal actors in the selected case projects.
- 2) Appendix B provides a resume of an attended workshop with Svendborg Municipality.
- 3) Appendix C presents the resumes of the interviews conducted.
- 4) Appendix D provides the original design principles of the Multispecies Design cards.

5. Theoretical and analytical frameworks

This chapter comprises the theoretical considerations and analytical framework on which the thesis is based. First, Section 5.1 consists of the theoretical framework which constitutes the concepts for Nature-based Thinking, climate resilience, and coastal CCA. This framework represents the theoretical lenses through which the thesis results should be read. Second, Section 5.2 consists of the analytical framework relevant to answering the established research question and sub-questions in Chapter 3. This section constitutes the conceptual design of the theoretical framework and comprises a guideline for the analytical process for the report.

5.1 Theoretical framework

First, the chapter will introduce the concept of Nature-based Thinking (NBT) and its relevance in terms of planning for CCA interventions. The journal article “Moving beyond the nature-based solutions discourse: introducing Nature-based Thinking” is the primary source used by Randrup et al. (2020). Second, the concept of building climate resilience is introduced as the theoretical lens to wear throughout the thesis, as the concept is considered the ‘objective’ of the research. The primary source used is “*A framework for urban climate resilience*” by Tyler & Moench (2012). Third, this chapter introduces the key points behind the concept of coastal CCA, what it can contribute to within the urban coastal context, and what connection CCA might have with nature-based solutions. The primary sources used in the last section are IPCC (1990, 2014).

5.1.1 The concept of Nature-based Thinking

Parks and trees are the sole remnants of nature in the city for the unused human eye. (Spirn, 1984). However, nature is everywhere; it is the air and earth, the water from below and above, and all living organisms. Unfortunately, the traditional thinking has set nature against the city, contributing to how the city is perceived and built as an entity apart from nature. Urban nature has been used and perceived as an added luxury rather than an essential part of the landscape and city. To seize the inherent prospects of urban nature, a new attitude is required as the city must be recognized as part of nature. (Ibid.). The new attitude toward urban nature that Spirn (1984) argues is vital, could, according to this thesis, be the one of *Nature-based Thinking*.

The concept of Nature-based Thinking, developed by Randrup et al. (2020), stems from recent international agreements that transformative changes are needed to promote urban nature and greener cities and turn the tides for the degradation and loss of biodiversity. The concept of NBT is about making space for nature everywhere and reconnecting humans with wildlife, including in the densest urban environments. (Randrup et al., 2020). The following theoretical framework builds on the work by Randrup et al. (2020).

The concept of NBT defines nature-based solutions as a new conceptual approach to the human-ecological connection, meaning that the application of NBS could be the first step to achieving a new balanced relationship between anthropogenic and ecological values, a first step required if a transformative change towards biodiverse cities is to succeed (Randrup et al., 2020). NBT focuses on NBS over conventional infrastructures, such as Nature-based Adaptation over traditional structures of CCA. However, the evolution of NBS is only one essential step in a transition toward NBT, though alone not enough to ensure a turn away from the criticized traditional landscape planning processes towards instead gradual, long-term approaches that restore the services and benefits of urban nature which the concept of NBT stands for. (Ibid.).

The second step, and the main point for NBT, is acknowledging the value of nature beyond ‘solutions and services’ and thereby recognizing nature’s intrinsic value: ‘nature for nature’s sake’ (Randrup et al., 2020). Often, NBS (incl. Ecosystem-Services, and Nature-based Adaptation) deals with what people and technologies can derive from nature, and the concept has been criticized for its instrumental and anthropocentric values, as

the language “solutions and services” creates cities with humans as the only center of attention. NBS is defined as ‘solutions that are inspired and supported by nature,’ however, the simple inspiration of nature is no longer sufficient when aspiring for transformative urban development and breaking disciplinary boundaries. Instead, the focus should be on the holistic relationship between human nature and technologies. NBT argues for urban planning to promote values of nature beyond ‘solutions’ to balance anthropogenic and ecological importance. (Ibid.). In the context of CCA, the concept of NBT, therefore, reasons for both the use of NBS and the step beyond. This means broadening the definition of NBS by promoting natural values for the sake of nature itself “to contribute to the requested transition toward sustainable cities.” (Randrup et al., 2020, p. 920). As Randrup et al. (2020) describe, nature could be an urban stakeholder: “the concept of Nature-based Thinking embodies the perspective of nature with people, rather than just nature for people” (Randrup et al., 2020, p. 925).

Main points

I argue that a central point for this thesis, is that transformational change can take the form of Nature-based Thinking; a step away from nature being a human-oriented service towards biodiverse cityscapes, the promotion of gradual, long-term perspectives in the planning, and making room for urban nature even in the densest urban setting. An essential point is a demand for a change in the way values of nature are culturally perceived; nature is not only a service for humans, but nature should experience values for nature itself. Thus nature should be a valued stakeholder in the urban environment. The concept of NBT constitutes two steps regarding transformational change. The first step is incorporating NBS and thereby achieving a new connection and balance between anthropogenic and ecological values, which, in this thesis, will take the form of an analysis of options for CCA combined with NBS (Nature-based Adaptation). The following step is to acknowledge that nature is more than ‘solutions and services’ and instead recognize that nature brings value to itself. This step is connected to the analysis of Chapter 10 in the form of ‘reflective discussion cards acknowledging NBT.’

5.1.2 The concept of building climate resilience

The following theoretical descriptions of climate resilience are primarily built on Tyler & Moench (2012) and their ‘framework for urban climate resilience that facilitates planning for climate adaptation in cities’ (Tyler & Moench, 2012, Chapter 4). Furthermore, the section builds on input predominantly from the work of the UN Climate Panel (IPCC) by Field et al. (2014) and Danish and international iconic authors exploring resilience building: Fryd & Jørgensen (2019), Folke et al. (2010), Walker & Salt (2006) and Frantzeskaki (2016).

Just as the concept of NBT acknowledges the demand for transformative change, climate resilience advocates for a transition of the socio-ecological system away from an undesired state toward a more attractive one (Fryd & Jørgensen, 2019). Sustainability is the strategic guiding principle to limit climate change, while resilience is the concept by which one can ensure holistic adaptation to climate changes (Ibid.). In the context of CCA, this thesis argue the lack of adaptation for the impacts of climate change is an undesired state, whereas adaptation, mitigation, and resilience are the more desirable ones.

IPCC’s argumentation for the relevance of climate resilience as a framework for CCA and sustainable development is far from a new-found agenda (Field et al., 2014), as the theory of resilience has been around for decades (Walker & Salt, 2006). The relevance of resilience in urban planning for coastal CCA stems from the criticism of the contemporary CCA approach that Tyler & Moench (2012) argue is too focused on ‘predicting and preventing.’ The method of ‘predict and prevent’ of climate futures is inherently uncertain (as elaborated in Section 2.1.2) and should, instead of focusing on predicted climate, consider the problem as one of building general resilience (Tyler & Moench, 2012). Frantzeskaki (2016) argues that resilience thinking forces a shift in planning traditions away from lock-in tendencies, business-as-usual procedures, and path-dependencies in the

urban development, actions that should be abandoned. In the context of building resilience through nature-based CCA, I would argue the main point regarding a forced shift in planning traditions is the potential to encourage and embrace the approach of urban nature and NBT in urban planning for climate impacts.

Originally, resilience is *'the ability of a social or ecological system to absorb disturbances while retaining the same basic structure and ways of functioning, the capacity of self-organization, and the capacity to adapt to stress and change.'* (IPCC, 2007 in Tyler & Moench, 2012, p. 312), as elaborated in Section 2.1.3. The ability of the socio-ecological system to adapt to stress and change is relevant in the context of uncertain climate changes. A crisis, such as climate change, can be a lever toward the building of resilience, as a crisis moves the society forward with the ability to act on the crisis as a starting point for change for the better, instead of letting it "jump back" to the previously "normal" state (Fryd & Jørgensen, 2019). As described in Section 2.1, the impacts of climate extremes have become more evident, resulting in increased interest in building resilience (Elmqvist, 2014; UNFCCC, 2021). The crises of climate change and biodiversity are evident, and in the context of multifunctional nature-based CCA, the crises could contribute to 'a starting point for change to the better' instead of letting the system 'jump back' to business-as-usual procedures, as Fryd & Jørgensen (2019) and Frantzeskaki (2016) describe, such as the dominating CCA projects of conventional hard concrete structures.

What do the climate resilience principles comprise?

Tyler & Moench (2012) argue a solution to simplify is through the three principles of climate resilience: adaptive capacity of social agents, persistency to climate shocks and stresses, and transformability to change.

Persistency

Cities are linked across multiple components, including ecosystem services, physical infrastructure, and key services such as water, food, energy, shelter, communication, transport, etc. The building of system persistency ensures that the functionality of the interlinked urban system is maintained despite climate shocks and stresses. (Tyler & Moench, 2012). Climate shocks refer to certain disruptions of the system, such as extreme weather events like storm surges, and climate stresses are long-term stress such as average sea level rise and rise of temperatures (Ibid.). If the long-term persistence of the socio-ecological system is increased, the system can better deal with surprise (Tompkins & Adger, 2004; Walker et al., 2002 in Tyler & Moench, 2012, p. 318).

The adaptive capacity of social actors

Resilient actors are key to resilient systems, and thus the reason why adaptability is incorporated into resilience thinking (Folke et al., 2010; Frantzeskaki, 2016). Adaptability portrays the actors' capacity in a system to change any disturbance, thereby contributing to resilience by learning, adjusting, and combining knowledge and experience (Folke et al., 2010; Tyler & Moench, 2012; Walker & Salt, 2006). 'Actors' are defined as the following: *"Agents or actors in urban systems (...) include individuals (farmers, consumers); households (units for consumption, social reproduction, education); and private and public organizations (government departments or bureaus, private firms, civil society organizations)"* (Tyler & Moench, 2012, Chapter 2.2). The building of the adaptive capacity of agents is characterized by the crucial elements of responsiveness (act/ability to respond), resourcefulness (anticipate/awareness), and capacity to learn (adjust/inform) (Tyler & Moench, 2012).

Transformability

Transformability is the capacity to encourage and pursue opportunities for change and apply new knowledge that emerges (Tyler & Moench, 2012). Humans are great optimizers; however, optimization, in the long run, is not ideal when building resilience and sustainable change. Transformability is about taking a step away from business as usual (Walker & Salt, 2006) and instead promoting innovation and novelty (Folke et al., 2010). Field

et al. (2014) argues, with high confidentiality, that transformations in economic, technological, social, and political actions can be pursued to enable climate resilience and thereby sustainable development. One of the specific examples of categories mentioned by Field et al. (2014) to ensure the positive transformation is ecosystem-based options (Field et al., 2014). Walker & Salt (2006) and UNCCRN (2021) similarly argue that services of ecosystems and nature-based solutions are essential as actions to drive climate resilience.

Transformability seeks to profoundly renew and reorganize the socio-ecological system and can be defined as the capacity to create a fundamentally new system when ecological, economic, or social structures make the existing system untenable (Walker et al., 2004:5 Folke et al., 2010). This thesis claims that the current system is unsustainable as the trajectories to halt climate change and loss of biodiversity are insufficient (IPBES, 2019 in European Environment Agency, 2021, fig. 1.3; Randrup et al., 2020). Therefore, as Randrup et al. (2020) claim, change towards nature-based solutions and -thinking is called for.

Main points

I argue that a central point of the concept is that climate resilience, like the concept of NBT, advocates for transition in terms of a change in the way we plan for the impacts of climate change. The transition should move from 'predict and prevent' towards the building of the three aspects of resilience: long-term persistency to climate stresses and shocks, the adaptive capacity of the responsiveness, resourcefulness, and capacity to learn for social agents, and transformability to step away from path-dependent business-as-usual concepts towards change, which in the context of this thesis is toward NBA and NBT.

5.1.3 The concept of climate change adaptation

Climate change adaptation (CCA) can be defined as adapting to current and projected impacts from climate changes to avoid harmful effects on the human, natural, and urban systems while simultaneously providing benefits (IPCC, 2014). The different opportunities available for urban coastal CCA interventions are grey, blue, green infrastructures, or a hybrid approach (Kabisch et al., 2017).

CCA offers an approach for reducing vulnerability and enhancing the resilience of an area through managing risk associated with extreme weather- and climate-related events (European Environment Agency, 2021). The coastal risk related to climate changes in Denmark is often referred to as the climate challenges of the average sea level rise and the more extreme events of flooding from storm surges (Wiberg, 2019). CCA strategies to adapt to these climate challenges are, according to IPCC (1990, 2014), the three major approaches of 'protect, retreat, and accommodation,' as additionally described in Section 2.1.1. The three approaches, according to IPCC (1990), are explained as follows:

- *"Protection involves hard structures such as seawalls and dikes, as well as soft solutions such as dunes and vegetation, to protect the land from the sea so that existing land uses can continue."* (IPCC, 1990, p. 136)
- *"Accommodation implies that people continue to use the land at risk but do not attempt to prevent the land from being flooded. This option includes erecting emergency flood shelters, elevating buildings on piles, converting agriculture to fish farming, or growing flood- or salt-tolerant crops."* (IPCC, 1990, p. 135)
- *"Retreat involves no effort to protect the land from the sea. The coastal zone is abandoned, and ecosystems shift landward. This choice can be motivated by excessive economic or environmental impacts of protection. In the extreme case, an entire area may be abandoned."* (IPCC, 1990, p. 135)

The three approaches are relevant in terms of grey, blue, and green CCA infrastructure; however, the conventional defense systems, such as technical concrete structures, can harm the dynamics of the coastal

zones, although the application of CCA is perceived necessary for specific areas. These places should integrate NBS into future coastal modifications (Quintana, 2022), as especially the linkages between CCA measures and NBS, in this thesis termed NBA, create synergies to address climate uncertainties, climate-related hazards such as storms, floods, drought, etc., and long-term climate changes such as sea level rise, ocean acidification, etc. (European Environment Agency, 2021, fig. 1.2). As mentioned in Section 2.2, NBA can provide adaptation to climate impacts while simultaneously building resilience and providing benefits separate from adaptation (European Commission, 2019). The operationalization assessing the associated benefits, risk reduction from climate impacts, and strategic CCA approaches for NBA is described in the analytical framework in Section 5.2.1.

5.2 Analytical framework

This section expands on the previous Section 5.1 and displays the analytical guideline to answer the leading research question in Chapter 3 on building climate resilience in coastal CCA through the concept of NBT. Section 5.2.1 elaborates on mapping coastal Nature-based Adaptation options as an analytical context to answer the first sub-question in Chapter 3. Section 5.2.2 elaborates on mapping key principles and components for resilience building as an analytical context to answer the second sub-question in Chapter 3. The primary sources used are the climate resilience framework by Tyler & Moench (2012) and Nature-based Thinking by Randrup et al. (2020). Section 5.2.3 elaborates on the analytical operationalization of mapping barriers and opportunities concerning resilience building through the approach of NBT. The section builds on the journal article “Resilience Thinking: Integrating Resilience, Adaptability and Transformability” by Folke et al. (2010). Section 5.2.4 reflects upon further steps to take to ensure resilience for the selected case projects. This section provides an analytical context to answer the fourth sub-question in Chapter 3, and the section builds on the work by Folke et al. (2010) and the Ph.D. thesis “*Multispecies Design*” by Metcalfe (2015).

The included literature and theory for operationalization of mapping NBA, principles for climate resilience, and Nature-based Thinking, focus on the planning steps before the implementation phase. This is further elaborated in the scope of the thesis in Section 6.2.

5.2.1 Operationalization of creating a catalog for NBA

As previously stated in Section 5.1.1, the first step of NBT is to incorporate NBS and achieve a new balanced connection between anthropogenic and ecological values, which in this thesis will take the form of an analysis of options for CCA combined with NBS which constitutes the concept of ‘Nature-based Adaptation.’ The following section describes the analytical framework used to create a catalog of NBA options in Chapter 7.

5.2.1.1 Operationalization of strategic CCA approaches and climate challenges to NBA

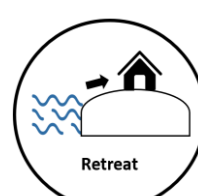
As described in detail in Section 5.1.3, IPCC’s strategic CCA approaches are the three approaches of ‘protect, retreat, and accommodation.’ Together they constitute the approaches used to assess the strategic potential of the different NBA typologies in the catalog in Chapter 7.



The icon of ‘protection illustrates the typologies able to act as protection measures.’



The icon of ‘accommodation illustrates the typologies that act as an accommodating measure.’



Typologies compatible with ‘retreat’ are illustrated by the icon of ‘retreat/avoid.’ According to Wiberg (2019), ‘avoid’ belongs here, as it refers to ‘no-build-areas,’ thereby avoiding risk in the first place.

In Chapter 7, the coastal climate challenges in Denmark take the point of departure in Wiberg's (2019) categories: average sea level rise and storm surges. According to this thesis, these climate challenges represent the climate stresses (sea level rise) and shocks (storm surge), which are essential to limit the influences according to the resilience principle of persistency. The catalog of NBA typologies in Chapter 7, therefore, distinguishes between the 'shocks' and 'stresses' in terms of the potential of the typologies to manage the pressure from these coastal climate challenges, as described in the following:



The sea level rise is a permanent pressure from the sea. The challenge constitutes sea level rise and land simultaneously subsiding (Wiberg, 2019) and therefore constitutes a long-term climate stressor. The icon is used to illustrate typologies that manage sea level rise.





















The storm surges are temporary pressure from rapidly rising sea to an extreme height (Wiberg, 2019) and therefore constitute a climate shock. With the rise in sea level, storm surges are expected to be more extreme in the future (Ibid.). The typologies that manage this challenge are illustrated with the icon of storm surge.

5.1.1.2 Framework for creating the catalog of NBA options

In addition to the three strategic CCA approaches and the two coastal climate challenges in Denmark, the catalog aims to explain the options of NBA typologies related to different criteria, parameters, and benefits. Therefore, the typologies are assessed based on the combined frameworks for the assessment of CCA typologies from the World Bank (2021) and Rambøll (2015), as none of the sources alone are sufficient to map coastal NBA. World Bank (2021) has published an open-source catalog of NBS for urban resilience, and Rambøll (2015) has published a report about Danish coastal CCA as a contribution to Realdanias "*The cities and the rising sea.*" The NBA catalog will consist of 'typology cards' assessed individually concerning the following sections:

Table 1: Framework for development and assessment of 'NBA catalog cards'

Criteria	Parameters
Principles for solution	<p>Data such as brief description, function, scale, and strategic CCA approaches with icon(s)</p> <div> <div>Protect </div> <div>Accommodate </div> <div>Retreat </div> </div> <p>Technical considerations:</p> <div> <div>Synergies with grey infrastructure </div> <div>Flexibility </div> <div>Combination of possibilities </div> <div>Potential of innovation </div> </div>
Visualization	Illustrations or examples of existing or pipe-line projects
Functions related to climate challenge	<div>  Storm surges </div> <div>  Sea level rise </div>

Sustainability indicators	<p>The icons are adapted from the catalog of World Bank (2021) and relate according to the source to the nine basis indicators of environmental, economic, and social sustainability, in this case associated with NBA.</p> <div> <div>  <p>Carbon storage and sequestration</p> </div> <div>  <p>Biodiversity</p> </div> <div>  <p>Resources production</p> </div> <div>  <p>Costs of land, construction, and maintenance</p> </div> <div>  <p>Savings or cost compared to traditional CCA measures</p> </div> <div>  <p>Stimulate local economies and job creation</p> </div> <div>  <p>Citizen's involvement/education/social interaction</p> </div> <div>  <p>Human health</p> </div> <div>  <p>Tourism/recreation/cultural heritage</p> </div> </div>
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5.2.2 Key components of urban climate resilience related to NBT

Tyler & Moench (2012) is the primary source for the components of the resilience principles for CCA. These characteristics of components should be seen as guidelines for factors representing resilience in a complex urban system, including for CCA (Tyler & Moench, 2012). In the context of NBA, it is relevant that the resilience principles address the nature-based concept. Thus the associations with NBT are based on Randrup et al. (2020).

Tyler & Moench (2012) argue a solution to simplify the operationalization of the concept of planning for CCA is through the conceptual approach of urban climate resilience and the three associated principles of adaptive capacity of social agents, persistency to climate shocks and stresses, and transformability to change (see Section 5.1.2). Recently the principles have come to imply the aspects of learning, flexibility, and change (Adger, Hughes, Folke, Carpenter, & Rockström, 2005; Antrobus, 2011; Berkes, Colding, & Folke, 2003; Fields, 2009; Prasad et al., 2008; Miller et al., 2010; Twigg, 2007 in Tyler & Moench, 2012, p. 312). According to this thesis, the adaptive capacity of agents is, therefore, associated with learning, persistency is associated with flexibility, and finally, transformability is associated with change. The following paragraphs address the components of the three principles of climate resilience and linkages to Nature-based Thinking, which constitute analytical components later used in Chapter 8 to assess the resilience building in the case projects.

Components of persistency

The building of persistency in the case projects will be assessed by the following:

Redundancy & modularity & flexibility: Redundancy and modularity imply a spare capacity for extreme or uncertain situations, including having multiple pathways to choose and various options (Tyler & Moench, 2012). Flexibility in terms of persistency relates to the system's preparedness and fragility or robustness to impacts of climate change shocks or stressors (Davoudi et al., 2013; Tyler & Moench, 2012).

- *How is the project taking different (uncertain) future climate scenarios into account?*
- *How is the project taking different CCA strategies (retreat, protect, accommodate) into account?*
- *Are Nature-based Adaptation a part of the project's pathways or options of interventions?*

Safe failure: The ability to absorb climate shocks and stresses to avoid destructive impacts (Tyler & Moench, 2012). Safe failure refers to climate uncertainty, as the persistency of a system should acknowledge uncertainty in all ways and continually allow for change and adaptation (Folke et al., 2010). The element of climate uncertainty specifically relates to the long-term approach of NBT (Randrup et al., 2020).

- *Has the project considered the impacts of climate change shocks and stresses?*
- *What is the time horizon for the project?*
- *Has the project considered Nature-based Adaptation as a safe failure?*

Components of adaptive capacity for social actors

Actors' behavior can be changed through learning and participation, and the adaptive capacity of actors to anticipate, act and adjust is a crucial aspect of resilience building. The strengthened adaptive capacity of agents is characterized by responsiveness, resourcefulness, and the capacity to learn (Tyler & Moench, 2012). Thus, in Chapter 8, the building of adaptive capacity in the case projects will be assessed by the following:

Responsiveness: (act/anticipate/foresight/ability to respond). The capacity to identify problems, anticipate, plan/organize, prepare, and respond to a disruptive event (Tyler & Moench, 2012).

- *Have the stakeholders been involved in the discussions of future climate change strategies?*
- *Is any responsive capacity regarding Nature-based Adaptation established through the project?*

Resourcefulness: (awareness). Capacity to mobilize resources and take action; share knowledge, and ability to collaborate with other agents and systems. (Tyler & Moench, 2012). Awareness building is the capacity of stakeholder involvement, dialogue, and co-design and is especially relevant to creating acceptance and demand for NBS (European Environment Agency, 2021). NBT calls for the transformative potential of bottom-up initiatives (Frantzeskaki et al., 2016; Buijs et al., 2019; Hajer et al., 2015 in Randrup et al., 2020 p. 4). The dimension between citizens and governance should be strengthened (Randrup et al., 2020), as good governance procedures encourage transparency, accountability/trust, responsiveness, information flows, and collaboration in decision-making processes (Frantzeskaki, 2016; Tyler & Moench, 2012).

- *Have the actors/stakeholders been identified?*
- *Have the stakeholders been involved or learned about the issues behind the project through collaborative decision-making or bottom-up initiatives?*
- *Have Nature-based Adaptation been a part of the decision-making process?*

Capacity to learn: (adjust/inform). Learning and adaptability relate to the increased adaptive capacity of social agents and are the ability to learn from past experiences, avoid repeated failures, and innovate/ learn new skills (Tyler & Moench, 2012). The role of governance and learning are significant aspects (Armitage, Berkes, & Doubleday, 2007 in Tyler & Moench, 2012, p. 312), with relevance to transparent information flows (access to credible information) and application of knowledge (Tyler & Moench, 2012). NBT challenges the contemporary understanding of wilderness to “allow new urban aesthetics beyond manicured and sterile grasslands” and therefore challenges the cultural preferences of urban nature (Randrup et al., 2020, p. 925).

- *Have the actors/stakeholders learned new skills regarding NBA?*
- *Have actors/stakeholders' cultural preferences for urban nature been challenged in the project?*

Components of transformability

The transformability of the case projects will be assessed by the following:

Embrace change and application of new knowledge: In this study towards NBA. Change and transformability are linked, as the fostering of resilience involves embracing change and pursuing potential transformative

opportunities that emerge (Davoudi et al., 2013; Tyler & Moench, 2012). Factors of transformability are embracing change through encouraging learning, shifts in perception, and subsidized experimentation (Folke et al., 2010; Walker & Salt, 2006, p. 147). To contribute to transformative change, the urban population must be physically, mentally, and emotionally connected with nature (Randrup et al., 2020).

- *Is the project embracing NBA?*
 - *If so – then how is this change perceived in the project? Have perceptions shifted?*

Rights and entitlement: The structures of privilege and entitlements enable groups to form and act (Tyler & Moench, 2012). In the case of NBT, this is relevant due to the right of nature itself, as ‘nature for nature’s sake’ is a central point (Randrup et al., 2020).

- *Is the project taking the rights of nature/ biodiversity into account?*

Transformative decision-making processes: The capacity of widely accepted transformative decision-making in a transparent and accountable way (Tyler & Moench, 2012), where in this case, NBA is an integrated part of the decisions as NBT calls for a turn from traditional landscape planning toward ‘wildscapes’ for urban nature. NBT calls for a shift “*where ecology becomes an integrative part of decision making.*” (Randrup et al., 2020, p. 924).

- *Has nature/NBA become an integrative part of the decision-making in the project?*

5.2.3 Operationalization of the perceived barriers and opportunities for NBA

The focus on resilience can broaden the scope to an understanding and accountability for society’s dimensions that generate barriers and opportunities for dynamic ecosystem landscapes and seascapes (Folke et al., 2010). Thus, understanding barriers and opportunities for socio-ecological system components can build knowledge on more profound, slower variables in the system that enhance or undermine resilience (Ibid.). The resilience-building concept can contribute to an analytical assessment of the barriers and opportunities perceived through the work in the selected case projects. The purpose of this analytical component of analyzing the barriers and opportunities of NBA can, as Folke et al. (2010) argue, contribute to an understanding of the dimensions in society that enhance or undermine the building of climate resilience.

The analysis in Chapter 9 of the barriers and opportunities for NBA, reflected upon in the case projects, will be assessed by the following analytical questions:

- *Which barriers have the case project experienced or expect to face related to NBA?*
- *Which opportunities have the case project experienced, or expect to face, related to NBA?*

Once the results of the parameters are identified, the results are relevant for the operationalization of how to enhance the climate resilience for both the selected case projects and, in general, for the Danish coastal cities, as the following Section 5.2.4 will elaborate on.

5.2.4 Operationalization on how to achieve climate resilience through NBT

The ‘second step’ in the concept of NBT is, as described in Section 5.1.1, to refocus the thoughts and discourse from NBS to NBT as a way “*for planners, designers, managers, and citizens to really embrace nature*” (Randrup et al., 2020, p. 921). The approach, as Randrup et al. (2020) argue, is a transformational ‘turn’ to discuss urban nature beyond anthropogenic benefits and instead stimulate a broader, more holistic understanding of nature-based approaches such as ‘nature for nature’s sake.’ Folke et al. (2010) argue that transformational change involves breaking down the “resilience of the old” and instead building the “resilience of the new.” In this context, I would argue that such a reflective analysis on how to build ‘new’ resilience should constitute a reflection on the main analytical findings from previous analyzes on how NBA projects, in general, could steer away from the perceived *barriers* and make use of the *opportunities* for the projects to establish the *building*

of, or achieve, climate resilience through *Nature-based Thinking*. A reflection method able to constitute ‘new’ resilience and able to include the ‘second step of NBT’ could be the development of a planning tool with the point in departure in NBT and the reflection cards from “*Multispecies Design*” by Metcalfe (2015).

Development of the planning tool of ‘reflective discussion-cards’

According to Metcalfe (2015), there is a need for a paradigm shift calling for the inclusion of a diversity of wild nature within human-oriented habitats. The work by Metcalfe (2015) represents a design practice capable of responding to the need of wild animals in urban areas while addressing questions of interaction between animal-humans. The principles of Metcalfe’s (2015, p. 105) *Multispecies Design* cards is to “*outline how a mindset for designing with and for wild animals departs from designing solely for humans.*” In the context of this thesis, the aim is not to create interaction with wild animals; it is instead to generate interaction with and change of perception of urban nature in general utilized through NBA measures. The planning tool of ‘reflective discussion-cards’ should create reflections on values for both nature, resilient coastal urban CCA, and citizens, as values are always experienced by someone/something, and as I agree with Metcalfe that: “*this is not to say that every feature in built environments should be enhanced for an ecological value, or made into a habitat for nonhuman species*” (Metcalfe, 2015, p. 115). This tool aims to open the discussion of the possibilities for the integration of resilient coastal urban NBA and specially to translate the second step of NBT into a planning tool that CCA projects could benefit from reflecting upon. The tool aims to challenge the recent prioritization of hard technical ‘protection’ structures and establish awareness of nature being a stakeholder in coastal CCA projects.

Principles of developing ‘discussion-cards’

The original ‘*Multispecies Design*’ consist of four principles (Metcalfe, 2015), as described in Table 2 below. The ‘*Multispecies*’ principles are “translated” to apply to the ‘reflective discussion-cards’ of this thesis in terms of translating ‘animals’ to ‘nature’ in the sentences. Furthermore, the element of climate resilience is integrated, as the new planning tool aims to push for and open the discussion for NBT as a means to build climate resilience.

Table 2: ‘Translation’ of principles for Multispecies cards to the ‘new’ discussion-cards

The principles of Multispecies cards	The translated principles of the reflective discussion-cards
Researching animals in a design context	➤ Researching nature in a design context for climate resilience
Designing human-animal interactions	➤ Designing interactions between human- nature- climate resilience
Treating animals as clients of design	➤ Treating nature as a client of design in building climate resilience
Designing like an ecosystem	➤ Designing climate resilience like an ecosystem

Furthermore, Metcalfe’s four principles include associated descriptions of relevant elements to reflect upon, which can be read in Appendix D. These are additionally to be used as an analytical guideline to develop the final planning tool of ‘reflective discussion-cards’, together with the reflective analysis on ‘how to build new resilience’ in the analysis in Chapter 10.

6 Methodology

First, Section 6.1 presents the philosophy of science with a focus on the scientific rationale of the field of sustainable planning, including ontological and epistemological considerations. Second, Section 6.2 describes the scope of the thesis. Third, Section 6.3 represents the concept of case study research and considerations behind the selection of case projects in Aabenraa, Assens, Vejle, and Svendborg. Fourth, Section 6.4 describes the methods, and rationale behind them, for each of the analysis chapters consisting of methods for data collection, data analysis, and belonging limitations.

6.1 Philosophy of science

This thesis seeks to understand the potential contributions of coastal nature-based CCA for enhancing the climate resilience of Danish urban environments. When investigating the concepts of climate resilience and Nature-based Thinking, the epistemological and ontological perceptions, reflections, and rationale are essential to consider (Farthing, 2016). Therefore, this section presents the epistemological concerns about adequate knowledge and the ontological concerns regarding the nature of knowledge (Saunders et al., 2013).

The planning and design research field for CCA relies on natural and social sciences. The knowledge and assessment from acknowledged climate change research should be regarded as value-free and objective. In this study, this aspect is therefore associated with the positivist-dominated field (Farthing, 2016). However, the contrast between climate science data to the field of planning for resilience is evident. When dealing with climate knowledge adaptively, the need for expertise on social, ecological, and technical processes, and the interplay between them, is essential. The way I conceive and approach the field of planning shows, according to Farthing (2016), features of the post-positivist positions that can have social constructivist features and therefore are subjective to a certain degree. As reality is socially constructed, the nature of knowledge depends on the researcher's background, perceptions, and framework of understanding (Farthing, 2016). In this case, my educational background within the problem-oriented field of sustainable urban- environmental- and energy planning plays an influential role in this thesis. As a soon to be urban planner, I believe that I should be an agent of change within the field, therefore pushing for a transition toward sustainable and resilient projects while additionally specifically acknowledging and mitigating the crises of biodiversity and climate change, which the aim of the thesis similarly builds on. One component is my background another is the background and reality of the interviewees that parts of the analysis rely on. Therefore, the study results depend upon the interviewees' professional yet subjective perceptions of CCA, resilience, and urban nature.

Planning for CCA is often managed by technical water boards running models and calculations and could be understood as rational planning (Boelsmand & Quitzau, 2021). However, the tradition of radical planning and business-as-usual in the field of urban CCA is no longer sufficient due to interdisciplinary and co-creative approaches winning through, and new 'fights' for the use of urban surfaces appear (Ibid.). In this context, I argue to dissociate from the tradition of solely radical planning, as today's planning concerning climate changes is far more complex and requires interdisciplinary and multifunctional approaches. In this regard, I would argue a transformation of the planning tradition is needed. Two concepts of many to accomplish transformation are the strategic approach of resilience thinking and Nature-Based Thinking (Randrup et al., 2020; Tyler & Moench, 2012). Climate resilience is a concept with several advantages when facing the complexity of uncertainty and requirements of adaptive planning (Walker et al., 2002 in Tyler & Moench, 2012, p. 312), as I would argue suits the field of CCA. The transformative aspect of NBT could be a springboard to truly push for resilience. Thus, this study suggests NBT as inspiration for rethinking the traditional logic of planning and reframing our

epistemological thinking to move beyond technical and anthropogenic solutions to instead focus on the balanced interactions between nature and people. (Randrup et al., 2020).

Therefore, this study advocates for the relevance of holistic resilience thinking, as the theory is seen as a catalyst for change towards sustainable and resilient projects in the socio-ecological landscape. The purpose of the study is not to measure or weigh the reality according to natural sciences; it is rather to test the concept of Nature-based Thinking and challenge the existing optimization and lock-in-tendencies for CCA, thereby navigating between existing socio-technical perceptions and potential and, in my opinion, preferable, futures.

6.2 Scope

This section elaborates on the delimitations and assumptions contributing to the report's scope.

Delimitations

This report focuses on coastal climate adaptation for Danish cities, meaning that the scope is limited to coastal CCA interventions applicable near built or urban environments in the Danish context. As the scope is specific to coastal CCA with proximity to urban areas, the report will solely focus on the particular future climate change challenges of higher storm surges and average sea level rise when researching potential options for NBA in the coastal setting.

Furthermore, the focus of this report is an investigation on how to build climate resilience through Nature-based Thinking with an emphasis on four contemporary case projects, meaning that the scope sets geographical delimitations. The case studies are specific to the Danish cities of Svendborg, Vejle, Assens, and Aabenraa. The selection of the case projects to a degree limits the scope of the report to a case-specific focus; however, the report aims to reach beyond the cases in an investigation of how to build climate resilience for coastal Danish cities in general with a starting point in the selected case projects. The chosen case projects also make it logical to focus solely on the vision/design/planning phases before the implementation or evaluation phase, as the projects are all in their infancy with a focus on the vision and design phases.

Assumptions

To assess how the selected case projects can experience the building of climate resilience, specific theoretical lenses have been worn due to the chosen definitions of the principles for climate resilience; however, there are several varied and contradictory definitions of resilience, and in general, an absence of frameworks for the operationalization of the concept (Klein, Nicholls, & Thomalia, 2002; Leichenko, 2011; Miller et al., 2010 Tyler & Moench, 2012, Chapter 1). However, the chosen theoretical and analytical lenses are assumed to be sufficient to assess the selected case projects.

Furthermore, this thesis assumes that the contemporary CCA projects, and the belonging planned interventions, are being built to last for decades, if not for a century, as decisions often shape the urban form for 50 years and beyond (Raven et al., 2018). Therefore, using the wording 'long-term' implies an assumption of a lifetime of 50 years or longer. This also means that the demand for robustness, resilience, and flexibility for the case projects is assumed to be relatively high, especially as the climate change projections are uncertain and all selected CCA projects have yet to begin the construction phase.

Lastly, the assumption that the case projects are interested in building climate resilience and investigating NBS is present in the case selection of the thesis. The case projects are all a part of the current campaign of Realdania called *"The cities and the rising sea,"* whose aim is to empower the participating cities to make long-term adaptation plans and resilient development so that they do not build themselves into new challenges (Realdania, n.d.-d). As elaborated on in the following Section 6.3, the case projects are all pioneer cases and thus assumed to be the 'most likely' to adapt to climate impacts using NBS in their CCA interventions.

6.3 Case selection

The following section presents why and how the case study method is chosen as part of the research, including a short description of each case project.

6.3.1 Why a case study?

To analyze how NBT in the field of coastal climate adaptation can contribute to the climate resilience of Danish coastal cities, it has been relevant to engage in 'real-life' cases in which CCA and NBA is on the agenda. As part of the problem formulation for this thesis, and as part of the aim to investigate urban areas 'readiness' to build urban resilience through Nature-based Thinking, it has been necessary to explore specific ongoing urban coastal CCA projects to provide knowledge on the field, including which challenges and opportunities the cities face in their contemporary work with NBA projects. To analyze this, a multiple case study research design has been chosen, investigating four Danish cases of Svendborg, Assens, Aabenraa, and Vejle. Initially, the cases came to my knowledge, in connection with preliminary data collection for the research design, through conversations with interviewees (see Appendices B.1, C.1, C.2, C.7, and C.8 for resumes of the talks). The interviewees mentioned the four cases to be ongoing projects as part of Realdania's current campaign, "*The cities and the rising sea*" (Realdania, n.d.-d), investigating NBS and long-term approaches to CCA.

6.3.2 What can a case study contribute to this thesis?

According to Flyvbjerg (2006), a case study is an in-depth study of a specific case in a real-world context. For an extended period, case studies have been viewed as a method incapable of generalization; however, these notions were disproved by Flyvbjerg (2006) in his article "*Five misunderstandings about case-study research*," in which he argues for unrightful misunderstandings of the case study as a method. Flyvbjerg (2006) argues that the generalizability of case studies can increase when a strategic selection of cases is made and provides four different types of strategic information-oriented case selection: the extreme, the critical, the maximum variation, and the paradigmatic case. In the case of this thesis, the objective is to achieve the greatest possible understanding of how Nature-based Adaptation, in general, can contribute to climate resilience for coastal Danish cities. According to Flyvbjerg (2006), when the objective is generalizability and delivering the most significant amount of information on a given problem, selecting a typical or average case is not the richest in information. Therefore an extreme or atypical case is preferable. Additionally, critical cases are preferable when the objective is to confirm or falsify a hypothesis. (Ibid.). Therefore, as the objective of this thesis is a generalization on behalf of cases 'most likely' to confirm or falsify whether Nature-based Thinking can contribute to climate resilience, the following paragraphs will elaborate on the selection of the four selected case projects and how they are based on preferences that embody both extreme and critical cases.

The extreme case is characterized as an *unusual* case, often containing and revealing large amounts of information as the case is either "*especially problematic or especially good*" (Flyvbjerg, 2006, p. 230). If the notions of the extreme case are to be applied to our problem analysis, the characteristic of an extreme case is an unusual case that is especially problematic or good, which in the case of the thesis's focus on climate change adaptations would benefit cases of unusual risk. In this matter, the cases of Vejle and Aabenraa, in connection with the implementation of the EU Floods Directive, have been designated as two out of 10 areas of extreme risk due to impacts from the sea, rivers, groundwater, etc. (Ministry of Environment of Denmark & Ministry of Transportation of Denmark, 2011). The fact that Vejle and Aabenraa are risk areas makes them extreme cases.

Following the previously mentioned objective of the thesis regarding the aim for generalization through the most significant amount of information, the applicability of the research is sought in the broader context of solely the designated risk areas. Thus, this carries the decision to not only focus on Vejle and Aabenraa but to

build the selection of cases on the main criterion of representation of *unusual contemporary* Danish CCA projects investigating the aspect of NBS. As mentioned previously, the four cases of Assens, Aabenraa, Svendborg, and Vejle are unusual, as they are all mentioned by interviewees to investigate NBS in ongoing projects. The argument that all four contemporary case projects are unusual makes all the cases extreme. However, the advantage of choosing these cases is not just that they are *contemporary*; they are additionally in their infancy and have therefore not yet proven whether their work contributes to resilience or not.

The case study of the four cases permits qualitative research and new knowledge that can be related to issues of similar character. However, the nature of qualitative research is context-dependent and must be understood as an indicator of patterns. (Richards, 2009). To use context-dependent knowledge, a formulation of a generalized hypothesis of the sort: *"If this is (not) valid for this case, then it applies to all (no) cases"* is valuable; thus, as the four case projects are context-dependent yet unusual, they can additionally be characterized as critical cases (Flyvbjerg, 2006, p. 230). According to (Flyvbjerg, 2006), critical cases can be either 'most likely' or 'least likely' to confirm or falsify the generalized hypothesis. Concerning this thesis, I consider the four case projects to be 'most likely' critical cases with the hypothesis: *"If Nature-based Adaptation is not addressed in the CCA projects of Vejle, Aabenraa, Svendborg, and Assens, in a way that could contribute to the building of climate resilience – then it is not addressed more comprehensively in other Danish coastal cities."* The four projects, as I predict, all are pioneer cases *"with exemplary value for other projects"* as Realdania (n.d.-d) describe, that have considered NBS and therefore are 'most likely' to adapt to coastal climate risk with the use of NBA. This creates an opportunity to examine the projects' approach and reflection on NBA in the urban coastal space. If this is not true, it will falsify the hypothesis and the theoretical assumptions.

6.3.3 Key insights from the four case projects

The following shortly defines the case projects. Parts of the section are based on interviews (cf. Appendix C).

Svendborg's CCA project constitutes a vision of the transformation of the harbor area with a combination of storm surge and cloudburst protection (SWECO, n.d.). The harbor is threatened by sea level rise and storm surges by a water rise of 1.4-2.0 m (Realdania, n.d.-b). The project constitutes a strategy and action plan seeking to qualify previous decisions taken in connection with a finished architectural competition: *"The Blue Edge."* (Nielsen, 2022, p.c.; Realdania, n.d.-b), where the winning proposal represents a +3.00 m storm surge lock that requires the funding of up to DKK 680 million. Municipal funds cannot finance this within a manageable number of years, which questions preconditions for the proposal. (Realdania, n.d.-b). The project's status is that they are reconsidering the previous choices of strategies and measures for CCA. However, no final political decisions are made. (Nielsen, 2022, p.c.; Korsgaard, 2022, p.c.).

Aabenraa's project constitutes a formulation and narratives of potential futures for the urban harbors. (Realdania, 2020). Feasibility, flexibility, risk management, added values, and robustness are keywords for the project. The vision is to integrate the coast more closely with the city and create valuable urban development. (Ibid.). The project aims not to make a final decision on CCA but rather a study of which climate strategies can be combined with different adaptation methods (Aabenraa Kommune, 2021). The project's status is that *"the report and developed narratives are delivered to the politicians. The status now is on the table of local politicians, as a decision must be made on the port's future development both as an industrial and commercial port and potential residential area."* (Mohr, 2022, p.c.).

Assens' project is a long-term sustainable development project for the coastal edge of the city. It is, in particular, investigating soft CCA measures such as the establishment of dune landscapes. Assens' project aims to support

the municipal goal of "wild urban landscapes" focusing on green areas. (Realdania, 2020). The design proposal of the project is a dynamic dune landscape that can be rebuilt in height in the future if the sea level rises, and the result thus constitutes a so-called no-regret solution (Realdania, n.d.-a). The *"Development project for nature-based flood protection of Assens' harbor"* was adopted as a framework for further work by Assens' City Council in August 2021 (Realdania, n.d.-a). Thus the municipality continues its work on nature-based CCA.

Vejle, like Aabenraa, is designated a ‘significant risk area’ and has been obliged to prepare a risk management plan (Vejle Kommune, 2020b), leading to the adoption of the *Storm Surge Strategy* in the year 2020 (Realdania, n.d.-c). The CCA problem in Vejle constitutes several elements: *"There are three main efforts: we must delay water inland so that we can hold it back when there is a high-water level down in the fjord. The second is to make a storm surge protection and secure up to elevation +2.0 m. The third is work with warning and control systems such as emergency preparedness elements."* (Geertsen, 2022, p.c.). The status of the pilot project is continuous work on adaptive storm surge protection, democratic dialogue processes, experiments with the development of saltwater ‘gardens,’ and using art as a method of citizen involvement. (Realdania, 2020).

6.4 Methods

This section will present the methods used in the chapters of each analysis. The following sub-sections will describe the data collection, method of research, and limitations of each chapter.

6.4.1 Methods for Analysis 1 – The NBA Catalog

The following sections describe the methods used in Chapter 7 to answer the first sub-question cf. Chapter 3.

Data collection

To map which nature-based typologies for CCA exist, a state-of-the-art review was conducted to identify all NBA typologies suitable for the Danish urban environment situated in the coastal zone. State-of-the-art reviews are a sub-type of the literature review and constitute an applicable method when the aim is to ensure the study builds directly on previous research that addresses current matters, and as the state-of-the-art review may offer new perspectives on issues (Grant & Booth, 2009). In this report, the traditional ‘keyword search’ for literature reviews is not the method used for data collection; instead, the first step of identification of materials builds on the conversation with Wiberg (2022, p.c.), in which Wiberg describes her recent review from 2019 of CCA interventions on behalf of the *"The cities and the rising sea"* project. Wibergs’ review builds on other identified appropriate reviews, which again builds on reviews and catalogs. In this manner, the snowball sampling methods have been the primary search tool to ensure that the reviews and catalogs used for the state-of-the-art review of this analysis all build on acknowledged previous research, which has helped overcome potential researcher bias in the identification of appropriate literature (Grant & Booth, 2009). Grant & Booth (2009) describe the state-of-the-art review as involving the steps of identification and synthesizing of the relevant research materials. Therefore, the following Table 3 constitutes the first step in identifying research materials. All in all, the source of Wiberg (2019) comprises the primary so-called “mother” reference, and the following 11 sources further reference each other.

Table 3: State-of-the-art review of NBA typologies	
Mapped platforms & reviews and reports	<p>The Danish references</p> <p>Wiberg, K. (2019). <i>Havspejlsstigning - Arkitektonisk kvalitet og typologier for løsningsrum i kystbyer</i>.</p> <ul style="list-style-type: none"> Constitutes of a review of 53 state-of-the-art CCA interventions.

	<p>Faragò, M., Rasmussen, E. S., Fryd, O., Rønde Nielsen, E., & Arnbjerg-Nielsen, K. (2018). <i>Coastal protection technologies in a Danish context</i>. In <i>Vand i Byer – Innovationsnetværk for klimatilpasning</i>.</p> <ul style="list-style-type: none"> • Constitutes of a state-of-the-art review of coastal protection technologies in a Danish context. <p>Rambøll (2015). <i>Udredning om tilpasning til havvandsstigninger</i>. Realdania.</p> <ul style="list-style-type: none"> • A catalogue of a number of different solutions for coastal CCA. <p>Quintana, C. O., Kristensen, E., & Petersen, S. G. G. (2021). <i>Kystsikring og tilpasning til stigende havvandstand: økologiske konsekvenser og innovative løsninger</i>. Syddansk Universitet, Odense.</p> <ul style="list-style-type: none"> • An evaluation of case studies of different NBS interventions and an assessment of options for coastal and marine ecosystem integration in coastal protection practices. <p>The international references</p> <p>Noble, I. R., Huq, S., Anokhin, Y. A., Carmin, J. A., Goudou, D., Lansigan, F. P., Osman-Elasha, B., & Villamizar, A. (2015). Adaptation needs and options. In C. B. Field, V. R. Barros, D. J. Dokken, K. J. Mach, M. D. Mastrandrea, T. E. Bilir, M. Chatterjee, K. L. Ebi, Y. O. Estrada, R. C. Genova, B. Girma, E. S. Kissel, A. N. Levy, S. MacCracken, P. R. Mastrandrea, & L. L. White (Eds.)</p> <ul style="list-style-type: none"> • IPCC's open-source report on CCA interventions. <p>World Bank (2021). <i>A Catalogue of Nature-Based Solutions for Urban Resilience</i>.</p> <ul style="list-style-type: none"> • Open-source catalog of NBS adaptation interventions. <p>Sweco, Bosch Slabbers, Deltares, Witteveen+Bos, KNMI, & Klimaat voor Ruimte. (n.d.). <i>The climate adaptation app</i>.</p> <ul style="list-style-type: none"> • Open-source catalog of CCA interventions. <p>European Environment Agency (2021). <i>Nature-based solutions in Europe: Policy, knowledge and practice for climate change adaptation and disaster risk reduction</i>.</p> <ul style="list-style-type: none"> • Open-source catalog of CCA measures on behalf of the European Commission. <p>McVittie, A., Cole, L., Wreford, A., Sgobbi, A., & Yordi, B. (2018). Ecosystem-based solutions for disaster risk reduction: Lessons from European applications of ecosystem-based adaptation measures. <i>International Journal of Disaster Risk Reduction</i>, 32, 42–54.</p> <ul style="list-style-type: none"> • Built on European Environment Agency (2022) and Estrella, M., & Saalismaa, N. (2013) <p>European Environment Agency (2022). <i>The European Climate Adaptation Platform Climate-ADAPT</i>.</p> <ul style="list-style-type: none"> • Open-source online catalog of CCA measures on behalf of the European Commission. <p>F. G. Renaud, K. Sudmeier-Rieux, & M. Estrella (Eds.), <i>The Role of Ecosystems in Disaster Risk Reduction</i>. United Nations University Press.</p> <ul style="list-style-type: none"> • Chapter 2; Estrella, M., & Saalismaa, N. (2013). <i>Ecosystem-based disaster risk reduction (Eco-DRR): An overview</i>. • Chapter 3; Hettiarachchi, S. S. L., Samarawickrama, S. P., Fernando, H. J. S., Ratnasooriya, A. H. R., Nandasena, N. A. K., & Bandara, S. (2013). <i>Investigating the performance of coastal ecosystems for hazard mitigation</i>.
<p>Criteria used for selection of materials</p>	<p>The source should have a finished catalog of identified interventions for CCA and NBA or a review of NBA/CCA of identified solutions from other reports.</p> <p>The sources should preferably be Danish or European.</p>

Data Analysis Methods

After identifying the relevant literature, the second step of a literature review, according to Grant & Booth (2009), involves synthesizing the materials to assess the current state of knowledge and possible priorities for future research. This literature is synthesized into two quantitative analyses: (1) the selection of 18 NBA typologies in Table 7 and (2) the development and assessment of the 18 ‘NBA catalog cards’ in Section 7.1. The ‘catalog cards’ are developed to resemble an actual catalog in which the reader can “scroll back and forth.” The purpose of this was to create an easily-read description of each identified NBA typology, to help the reader understand the typologies’ benefits and disadvantages from each other. The purpose has not been to assess the effectiveness of the typologies; it has been the identification, description, and visualization of the differences and potentials which NBA interventions can contribute to the urban coastal space. The analytical methods of the synthesized material are described in the following Table 4.

Table 4: Selection and assessment of NBA typologies – the creation of the ‘NBA catalog’.	
Criteria used for selection of typologies	<p>NBA interventions, or CCA where NBA/NBS can be integrated.</p> <p>Typologies should be present in one or more sources described in Table 3.</p> <p>The typologies should be coastal, urban, nature-based, or possible to add natural values to, finally applicable in a Danish context. Therefore typologies such as the use of buildings/concrete structures as flood defense raised height difference between street level and ground flood, sluices or storm surge gates, or ‘safe grounds’ for extreme flood events (tsunami) are ruled out as these measures are helpful in ‘urban’ settings however are not nature-based or applicable in a Danish environment.</p>
Method for development and analysis of ‘cards’ in the ‘NBA catalog’	<p>To analyze the 18 typologies and create 18 ‘cards’, a combination of theoretical and analytical notions, quantitative document analysis, and qualitative interviews with relevant professionals were used.</p> <p>The theoretical and analytical notions used as a frame to assess the 18 selected NBA typologies is the analytical framework for ‘catalog cards’ defined in In addition to the three strategic CCA approaches and the two coastal climate challenges in Denmark, the catalog aims to explain the options of NBA typologies related to different criteria, parameters, and benefits. Therefore, the typologies are assessed based on the combined frameworks for the assessment of CCA typologies from the World Bank (2021) and Rambøll (2015), as none of the sources alone are sufficient to map coastal NBA. World Bank (2021) has published an open-source catalog of NBS for urban resilience, and Rambøll (2015) has published a report about Danish coastal CCA as a contribution to Realdanias “<i>The cities and the rising sea.</i>” The NBA catalog will consist of ‘typology cards’ assessed individually concerning the following sections:</p> <p>Table 1 in Section 5.1.1.2., which constitute the following analytical elements:</p> <ol style="list-style-type: none"> 1) Principles for solution (icons for strategic CCA approaches, typology description, and icons and associated descriptions of technical considerations. 2) Visualization of the typology 3) Icons of relevance for climate challenges (storm surges and sea level rise) 4) Descriptions and associated icons are based on the nine fundamental indicators of environmental, economic, and social sustainability associated with NBA, which stems from the definitions from the source of the World Bank (2021). <p>These analytical elements were analyzed through document analysis of the sources identified in the state-of-the-art review. Document analysis is a research method that comprises a systematic procedure when evaluating or reviewing documents (Bowen, 2009). In this analysis, the document analysis was used to review all selected state-of-the-art sources, thereby providing data and evidence</p>

	<p>on the context of each of the four elements, just described as the analytical framework, for each of the typologies, which led to the development of the ‘NBA catalog cards.’</p> <p>The qualitative interviews with relevant professionals within the field of climate change adaptation in Denmark contributing to the analysis of the ‘catalog cards’ are the following interviews:</p> <p>Wiberg (2022, p.c.). Associate Professor, Cand. arch. MDL, Ph.D. A resume of the conversation can be read in Appendix C.8.</p> <p>Wiberg was considered a source of knowledge due to her recent work on Realdania’s <i>“The cities and the rising sea.”</i> The main contribution from the conversation with her was the “primary mother-source” for the state-of-the-art review and suggestions from her side to look into specific projects used to visualize the typologies in the ‘catalog cards.’</p> <p>Sørensen (2022, p.c.). Manager, Danish Coastal Authority. A resume can be read in Appendix C.7. Like Wiberg, the interview with Sørensen contributed to suggestions of sources to look further into, which have been used to visualize typologies in the ‘catalog cards.’</p>
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Limitations

The state-of-the-art review has certain limitations, mainly as the analysis has not completed a systematic review, which means the reliability of the research and therefore identification of all possible NBA typologies could be limited, which again could mean that other relevant typologies than the identified 18 may have been excluded in the process. Furthermore, according to Grant & Booth (2009), a general perceived weakness for state-of-the-art reviews is the aspect of time-bound material, meaning that the surveying depends on the interest of the topic within the time in which the reviewed research was conducted. In this case, the subject of research, which in recent studies of NBA and CCA typologies, is highly represented in the ‘recent and current’ examination, which constituted the state-of-the-art review to comprise 11 sources of interest conducted between the year 2013 and the year 2022. Furthermore, the study could have limitations regarding the analysis of the four analytical elements in connection with each of the 18 typologies, which was assessed through the document analysis of the identified state-of-the-art sources. Especially limitations could be present in the case of the technical considerations, possibilities to handle climate challenges, and the ‘sustainability indicators’, as there are several approaches to assess the capacity and potential of interventions, as there are methods to evaluate sustainability. However, the purpose of the analysis was never to create a complete data set for co-benefits or technical features; it was instead to create ‘catalog cards’ which could illustrate a general, easily-read, and comparative assessment of each typology.

6.4.2 Methods for Analysis 2 – Assessment of climate resilience in the case projects

The following sections describe the methods used in Chapter 8 to answer the second sub-question cf. Chap.3.

Data collection

The interviewed agents in the analysis are identified based on their contemporary contributions to the work in the four case projects or their general contributions within the field of CCA in Denmark. Eight semi-structured interviews were set up to gain information and reflections from key agents within the field and case projects. The semi-structured interviews conducted with the municipal employees were based on an interview guide which can be read in Appendix A. The interviewees: Wiberg, Dehlbæk, Sørensen, and Andersen, are four professionals within the field of this thesis and have been interviewed with the purpose of preliminary data collection in the research design phase of the thesis. The interviewees: Larsen, Korsgaard, Nielsen, Mohr, and

Geertsen, are five municipal employees all working on the individual case projects of Assens, Aabenraa, Vejle, and Svendborg. The interviewees and their contributions to the research are described in Table 5 below.

The data collection has further taken place through observation in a workshop and public hearing in Svendborg; see Table 6 below (see minutes in Appendix B). Additional to this, the data collection build on online municipal publications regarding each case projects, and the material from Realdanias' *"The cities and the rising sea,"* as all four case projects are a pilot-project within this campaign. Lastly, the results of Chapter 7 are used as data to investigate which NBA typologies the case projects intend to integrate into the contemporary case projects.

Table 5: Interviews used as part of the research

Interviewee	Position & profession	When & where	Contributions to the report	Resume
Katrina Wiberg	Associate Professor Cand. arch. MDL, PhD	February 8 th , 2022 Telephone call, and email-correspondence	Contributed to the selection of case projects, the state-of-the-art review, and suggestions of Danish and international NBA projects of interest for Chapter 7.	Appendix C.8
Christian B. Dehlbæk	Employee in Team Climate and Water, Region Midtjylland	February 18 th , 2022 Teams meeting, email-correspondence	Contributed to the selection of case projects.	Appendix C.2
Kaija J. Andersen	Coastal Technician, Danish Coastal Authority	March 10 th , 2022 Telephone call, and email-correspondence	Contributed to the selection of case projects, and contact information on municipal employees working with the projects.	Appendix C.1
Carlo Sørensen	Manager, Danish Coastal Authority	March 10 th , 2022 Telephone call, and email-correspondence	Contributed to the selection of case projects and suggestions of Danish NBA references for Chapter 7.	Appendix C.7
Katrine J. Larsen	Biologist, Environment & Nature, Assens Municipality	March 28 th , 2022, Teams-interview.	Contributed with knowledge and reflections of the case project of Assens.	Appendix C.5
Trine Korsgaard & Anna Als Nielsen	Program manager for the municipal climate actions, Svendborg Municipality Project manager of "The Blue Edge", Svendborg Municipality	February 2 nd , 2022 Svendborg Municipality	Contributed with knowledge and reflections of the case project of Svendborg. Anna Als facilitated the possibility of my participation in the DAPP workshop in Svendborg.	Appendix C.4

Niels-Peter Mohr	Consultant for Planning & Development, Aabenraa Municipality	March 23 rd , 2022 Teams-interview.	Contributed with knowledge and reflections of the case project of Aabenraa	Appendix C.6
Ulla Pia Geertsen	Climate coordinator in the department of Urban, Landscape, and Climate, Vejle Municipality	March 30 th , 2022 Teams-interview.	Contributed with knowledge and reflections of the case project of Vejle.	Appendix C.3

Table 6: Workshops and hearings attended as part of the research

Workshop/ public hearing	When & where	Contributions to the report	Minutes
DAPP Workshop for the case project of Svendborg: "The Blue Edge"	March 22 nd , 2022 In Fremtids-værkstedet, Svendborg	DAPP workshop facilitated by The Council of Technology on behalf of Svendborg Municipality. Contributed with knowledge on contemporary strategic discussions of CCA in Svendborg. When data is used from the minutes from this workshop, the reference is cited as follows: (DAPP workshop, 2022, App.B)	Appendix B
Public hearing in Svendborg about the "Harbor-park" site within the case project	March 21 st , 2022 In Fremtids-værkstedet, Svendborg	The public hearing facilitated by the municipality contributed with recent knowledge on part of the site of the case area where Svendborg Municipality have discussed options for NBA. However, no public mentions of NBA or any final decisions concerning CCA of the specific site in the harbor area.	No minutes included in the Appendix

Data Analysis Methods

To analyze the data collected for the analysis, the combination of theoretical and analytical notions from Section 5.2.2 and qualitative research based on answers from interviews and document analysis were used.

The interviewees were interviewed in Danish through the semi-structured guideline in Appendix A; the interviews were transcribed in Danish. The questions for the interview were based on the three principles for climate resilience as the analysis similarly is based on these principles and associated components as described in Section 5.2.2. Quotations from the transcribed interviews used in the research were translated into English and sent to the municipal interviewees. They then confirmed the wording and the context of the quotes in the text before sending the verified version back, whereafter the analysis was corrected. The confirmation from interviewees of quotes and context in the study is also why the entire transcribed versions of the interviews are not present in the Appendix. When referring to interviewees' quotations, the reference will include 'p.c.,' which means personal communication. Document analysis was used to systematically evaluate documents (Bowen, 2009). The document analysis research was used to provide context on the components described in the analytical framework through reviews of public documents from Realdania, the municipalities of the case projects, and minutes from public hearing and observations in the workshop (Appendix B).

Limitations

The use of mixed methods was chosen to ensure the validity of the results and reduce personal bias from interviewees (Bowen, 2009). However, the more or less semi-structured interviews could constitute personal bias from both interviewees and through my role as interviewer. My background in sustainable planning could have influenced the conversations as the interviews by decision were semi-structured, allowing for the

discussion to be more open dialogue and reflections between the interviewee and interviewer. Similarly, the personal bias of the interviewees could have affected the results of data collection; however, to ensure credibility and validity of the results, the interviewees have checked and confirmed their own quotations. The decision of a semi-structured interview guideline stems from the wish for results with a level of comparability between sources, yet still with the possibility of the interviewees presenting their perceptions of the topic.

6.4.3 Methods for Analysis 3 – Perceived barriers and opportunities for Nature-based Adaptation

The following sections describe the methods used in Chapter 9 to answer the third sub-question cf. Chap.3.

Data collection

Identical qualitative data collection protocol as explained in Section 6.4.2 for the “Analysis 2 – Assessment of climate resilience in the case projects”.

Data Analysis Methods

The data analysis method used for this analysis consists of a combination of the theoretical and analytical notions from Section 5.2.3 and the identical methods of the semi-structured interview guide used in Analysis 2, as described above in Section 6.4.2.

Limitations

Similar to the limitations described in Section 6.4.2 just above, the personal bias of interviewees and interviewer could influence the results of the conversations about perceptions of barriers and opportunities for NBA interventions in the case projects. The results of the analysis were sought subjective to a degree, as the purpose of the study was to understand the perceived contemporary issues and potentials for NBA in the four cases as to understand the more profound and slower variables in the local, regional, and national socio-ecological system which could lead to the success or failure of the nature-based approach being accepted in Denmark. Thus, a limitation for the analysis could be the reliability and validity of the perceptions, as the results are, in fact, subjective and reflective, and as there could exist other perceptions of the matter elsewhere in Denmark.

6.4.4 Methods for Analysis 4 – Development of ‘reflective discussion-cards’

The following sections describe the methods used in Chapter 10 to answer the fourth sub-question cf. Chap.3.

Data collection

The data collection builds on the initial results from analyses 1, 2, and 3, and therefore no further data have been collected, although Metcalfe’s (2015) “*Multispecies Design*” is used as a framework (cf. Section 5.2.4).

Data Analysis Methods

The analysis constitutes a qualitative reflective analysis to address the main findings of previous analyzes. Reflective analysis is, in this thesis, understood as “*a reflective conversation with a unique situation*” (Schön, 1983, p. 130 in Fischler, 2012, p. 321), meaning to investigate the situation of the field, push the boundaries of the field and question the roles within it (Fischler, 2012). Therefore, the reflective analysis builds an assessment of the main findings on how to make use of the *NBA catalog cards* developed in Chapter 7, how to build the *principles for resilience* with a basis in the case areas assessed in Chapter 8, and finally, how to take advantages of the *opportunities* and prevent or overcome the *barriers* identified in Chapter 9.

The method behind the construction of ‘reflective discussion-cards’ build on the principles of the “*Multispecies Design*” by Metcalfe (2015) and constitute a “translation” of Metcalfe’s design for animals to instead focus on

Nature-based Thinking and building of climate resilience. The decision to develop similar discussion-cards as Metcalfe (2015) stems from my aspiration to create an alternative planning tool, which is experimenting rather than rational, and which, identical to aspirations from Metcalfe, builds on navigating the focus towards nature being an actual stakeholder. The decision to choose Metcalfe (2015) as inspiration for the development of the tool additionally stems from the aim of the analysis to constitute the “second step” of NBT, which according to this thesis, as described in Section 5.2.4, is the transformative step away from a mindset of designing solely for humans in the urban environment (Metcalfe, 2015; Randrup et al., 2020). Likewise, my aspiration builds on developing a tool that can create a room for participatory design and conflicts of interest and contribute to navigating the discussion of alternative futures and alternative design/planning for resilient NBA projects. The purpose of the discussion-cards is to develop a planning tool that can activate and inform citizens and politicians or create interdisciplinary debates within a municipal administration. The actual development of the ‘reflective discussion-cards’ is built around and inspired by the translated principles and associated discussion elements from Metcalfe, as can be read translated in Table 2 and the original description in Appendix D. Therefore, Metcalfe’s principles and associated discussion elements (see Table 2 and Appendix D) constitute the very frame of the new planning tool. The results of the reflective analysis of the main findings are applied as reflective questions in the tool were assessed relevant.

Limitations

Parts of the planning tool is based on the results of the previous analyzes, and therefore the limitations for these chapters are present in the reflective discussion-cards. Furthermore, as the tool builds on a translation of Metcalfe’s (2015) work to a context of climate resilience and Nature-based Thinking, there could be several limitations regarding the final layout of the planning tool, especially as the approach from Metcalfe solely focuses on animals. In contrast, this thesis focuses on a more holistic combination of the technical-ecological-social context of urban climate adaptation. However, the tool is developed to constitute a reflective and experimenting method. Therefore, it is an experiment to create a different view of urban nature. As Metcalfe (2015) also argues, the purpose of the cards is that *there is no wrong way to use them*.

7. The NBA catalog

The aim of this analysis, cf. Section 5.1.1 is to examine ‘the first step’ of NBT to investigate how coastal urban NBA can incorporate anthropogenic and ecological values through the creation of a catalog of NBA typologies.

7.1 State of the art review of NBA typologies

Resilience constitutes the elements of transformability, which cf. Section 5.1.2 deals with the capacity to step away from business-as-usual and towards novelty and innovative solutions, which this thesis claims could take the form of Nature-based Adaptation. Therefore this analysis identifies, through a state-of-the-art review, which coastal NBA typologies could be suitable near built environments in a Danish context. As described in Section 6.4.1, this state-of-the-art review is built on selected Danish and international catalogs and comprehensive literature reviews of typologies for NBA and CCA. The following Table 7 represents the 18 identified NBA typologies and belonging sources which have included the associated typology in their research. The sources identified are used to assess each NBA typology in the following catalog.

Table 7: Overview of identified NBA typologies through the literature review

Typology		Sources
1	Amphibious and floatable constructions	(Sweco et al., n.d.), (Wiberg, 2019), (Faragò et al., 2018), (Noble et al., 2015), (European Environment Agency, 2022).
2	Elevated terrain/ raising land on shore and coast/ Artificial hills on shore	(Sweco et al., n.d.), (Wiberg, 2019), (Faragò et al., 2018), (Rambøll, 2015), (European Environment Agency, 2022).
3	Constructions built on piles	(Sweco et al., n.d.), (Wiberg, 2019), (Faragò et al., 2018).
4	Nature-based seawall/ rock walls/ breakwaters on shore/ revetments	(Quintana et al., 2021), (European Environment Agency, 2021), (Faragò et al., 2018), (Hettiarachchi et al., 2013).
5	Dike	(Sweco et al., n.d.), (Wiberg, 2019), (Faragò et al., 2018), (Noble et al., 2015), (Rambøll, 2015), (European Environment Agency, 2021), (European Environment Agency, 2022).
6	Levee	(Sweco et al., n.d.), (Wiberg, 2019), (Faragò et al., 2018), (Noble et al., 2015), (Rambøll, 2015), (European Environment Agency, 2021).
7	Groynes/ artificial headlands	(Faragò et al., 2018), (Hettiarachchi et al., 2013), (European Environment Agency, 2021), (European Environment Agency, 2022).
8	Temporary/ mobile constructions	(Sweco et al., n.d.), (Wiberg, 2019).
9	Temporary accept of flood	(Wiberg, 2019).
10	Managed retreat/ realignment/ relocation of buildings and functions	(Sweco et al., n.d.), (Quintana et al., 2021), (Wiberg, 2019), (Faragò et al., 2018), (Noble et al., 2015), (McVittie et al., 2018), (European Environment Agency, 2021), (European Environment Agency, 2022).
11	Coastal vegetation in the streetscape/ shorescape and/or seafloor	(Sweco et al., n.d.), (Quintana et al., 2021), (Wiberg, 2019), (Faragò et al., 2018), (Noble et al., 2015), (Estrella & Saalismaa, 2013), (Hettiarachchi et al., 2013), (Rambøll, 2015), (World Bank, 2021), (European Environment Agency, 2021).

12	Salt meadows/ salt marshes/ coastal wetlands/ tidal flats	(Wiberg, 2019), (Quintana et al., 2021), (Noble et al., 2015), (Estrella & Saalismaa, 2013), (Rambøll, 2015), (World Bank, 2021), (European Environment Agency, 2021), (European Environment Agency, 2022)
13	Barrier islands/ offshore breakwaters/ offshore sea- beds	(Wiberg, 2019), (Faragò et al., 2018), (Estrella & Saalismaa, 2013), (Hettiarachchi et al., 2013), (European Environment Agency, 2021), (European Environment Agency, 2022).
14	Artificial and/or natural reefs/ other submerged structures	(Wiberg, 2019), (Estrella & Saalismaa, 2013), (Hettiarachchi et al., 2013), (Rambøll, 2015), (World Bank, 2021), (European Environment Agency, 2022).
15	Sand/beach nourishment/ Sand motor/ mud motor	(Wiberg, 2019), (Quintana et al., 2021), (Faragò et al., 2018), (Noble et al., 2015), (Hettiarachchi et al., 2013), (McVittie et al., 2018), (Rambøll, 2015), (World Bank, 2021), (European Environment Agency, 2021), (European Environment Agency, 2022).
16	Artificial and/or natural dunes and protections of dunes	(Wiberg, 2019), (Faragò et al., 2018), (Estrella & Saalismaa, 2015), (Hettiarachchi et al., 2013), (McVittie et al., 2018), (Rambøll, 2015), (World Bank, 2021), (European Environment Agency, 2021), (European Environment Agency, 2022).
17	Change in functions/ businesses from land-based to sea-based/ aquaculture	(Wiberg, 2019), (Quintana et al., 2021), (Noble et al., 2015).
18	Coastal and/or urban forests	(Estrella & Saalismaa, 2013), (World Bank, 2021).

7.2 The NBA Catalog

The following *NBA catalog* takes a point of departure in these 18 NBA typologies identified as suitable in a Danish context. The following ‘catalog cards’ presents an analysis of each identified typology with the point of departure in the analytical framework described in Table 1 in Section 5.1.1.2.

The sources used to analyze each typology and thereby create ‘cards’ are defined above in Table 7 for each identified typology. Therefore, the references will therefore *not* be mentioned throughout the catalog; this is done to create an ‘easily read’ card as the “receivers” of the cards could be both citizens, politicians, and municipal administration. Therefore, the language and design of the cards aims to embrace a multitude of stakeholders. However, if a source is explicitly mentioned in a ‘card,’ then the reference is different from the sources identified in the state-of-the-art review. The visualizations of the typologies are built on Danish and international cases that are realized or in the pipeline.

Amphibious and floatable constructions



An amphibious or floatable construction is built to flood by an anchor and therefore not supported by a fixed foundation. These can be buildings, piers/jetties, small and large urban districts, farms, and other water-related industries. Floating constructions constitute a new way of living in and with the sea and coastal areas, also known as blue urbanism (Beatley, 2018 in Wiberg, 2019, p. 45). Amphibious constructions rest on the ground level and only float during rare occasions when the water rises.



Technical considerations

Floating constructions are a well-known typology that can be scaled up and down from small constructions to whole communities living on the water. The bottom level of the entire construction should be at least 1 m from the sea bottom to maintain good water quality. Infrastructure should be specially designed and withstand expectations of fluctuating water levels.



Proposal of redevelopment in Vejle, DK (Vejle Kommune, 2020a)

Benefits and suitability considerations



Floating constructions accommodate natural processes and enhance a new urban development of how to plan for and with nature with benefits for both wildlife and humans.



Often floating urban environments can be combined with water-related businesses such as seaweed or fish farms.



Floating constructions can contribute to recreational purposes and citizens' involvement, especially if the structure is built with urban features like farming or housing. The accommodating typologies can contribute to a change of mindset for citizens related to innovative urban development and the sea.



Floating neighborhood, Buenos Aires, Argentina (BY-SA 4.0 in Wiberg, 2019, p. 46)

Elevated terrain/ raising land on shore and coast/ artificial hills/terps on shore



Constructed elevated area where the surroundings are allowed to be flooded. Can increase the difference between water levels and construction. In the Wadden Sea area, an inland terp concept is a historical approach to elevated terrain in the landscape. Artificial islands can be reclamation from the sea. The typology is especially relevant for storm surges, as infrastructure for the terps will experience difficulty due to sea level rise.



Technical considerations:

Often terps are elevated terrain to protect buildings. The hydrological and topographical premises are highly relevant to consider when raising land. The scale of the typology varies from islets for some buildings to medium/large islands that support entire communities and cities. Land raising can significantly impact the existing landscape, and geotechnical calculations are relevant to assessing land subsidence risk.



Elevated terrain, Køge Coast, DK (KOMPROMENT, n.d.)



Historical terps for built environments (Wiberg, 2019)

Benefits and suitability considerations



The terp concept consists of soil; however, the typology does not necessarily provide benefits for biodiversity unless combined with the typology of vegetation or others.



Artificial hills require land, materials, and construction. Combining artificial islands with urban development can be a method of financing flood protection. In most cases, this typology has a low cost compared to types of grey coastal defense typologies.



The terp concept is a historical typology for coastal protection, which is still present in the Wadden Sea area.

Constructions built on piles



Constructions are raised, making it possible for water to flow underneath. This way, combined land use is possible, making room for water and urban structures, although this typology generally decreases spatial availability. As a construction, the typology can be efficient for sea level rise and storm surges; however, the typology is not sufficient against sea level rise or storm surges for existing urban built areas.



Technical considerations:

The 'first floor' can act as alternative activities when buildings are on piles; in the case of NBA, this should be a natural environment. The typology is only NBA if combined with vegetation and natural landscapes. Piles should be constructed or drilled into a stable and robust soil layer.



Illustration of buildings on piles (DLANDstudio, n.d.)



Illustration of buildings on piles (DLANDstudio, n.d.)

Benefits and suitability considerations



Can increase space for natural dynamic landscapes, thereby benefiting local biodiversity and habitats.



Individual and district constructions on piles with natural landscapes are a field under development that could constitute job creation and savings compared to traditional CCA measures.



Constructions on piles could bring tourism and recreational values and require the involvement of actors. Buildings can negatively influence the aesthetic landscape by acting as a privatized barrier to the sea.

Nature-based seawall/ rock walls/ breakwaters on shore/ revetments



Seawalls can have traditional features with alternative 'rough' surfaces designed with the potential for biodiversity; the surface area is given a topography with holes, cracks, depressions, and rock pools. Onshore, breakwater construction is often engineered measures sufficient to withstand severe waves and floods. The structures do not aid beach development and are not enough alone against sea level rise. Nature-based seawalls can also characterize stone or oyster-filled gabions, cavities in seawalls, or metal sheet piling recreating intertidal habitats in the urban shorelines.



Technical considerations:

Concrete interventions do not contribute to carbon sink and are materials with larger carbon footprints than natural interventions. There are several innovative NBS solutions to sea walls with different surface textures mimicking rocky shores.



The project, "Coastalock" provide coastal defense while simultaneously providing habitats for marine organisms to colonize it, San Diego Bay, US (Crook, 2021).



Concrete blocks and rock pools in sea walls (EConcrete & Marineff in Quintana et al., 2021, p. 15).

Benefits and suitability considerations



When sea walls are established to make room for nature, it has the potential to stimulate high biodiversity.



Compared to traditional CCA, the options have similar land use and are identical to or require more cost than conventional seawalls.



Often, constructions that enhance natural life in the urban environment can constitute a strong engagement from citizens, especially in the case of involvement of surveillance of species (Marineff in Quintana et al., 2021, p. 14)

Dike



Green dikes are often used as coastal protection measures and can add additional recreative and biodiverse functions to the landscape. There are several types of dikes: primary and secondary protective lines or rings on land, ocean-dikes built in the sea, floodable dikes with a secondary dike further inland, overtopping-proof dikes designed to withstand overtopping by waves, 'super dikes' which are intended unbreakable. Urban environment and natural features can be built on top of the dike. However, the super dike is only cost-effective in large metropolitan areas. Examples of dikes are the Danish Ribe Dike and Lolland Dike (Rambøll, 2015).



Technical considerations:

Green dikes are a hybrid solution of nature-based solutions and hard structures. Dikes are static and hard solutions and are often combined with other NBA typologies, such as dynamic typologies like sand nourishment. Implementation time 5-25 years and lifetimes of more than 30 years.



(Above) Dikes near urban and industrial area, Lauwersoog, NL. (Below) Den Helder, NL. (own photos, 2021)

Benefits and suitability considerations



Green dikes are traditional dikes with vegetation as the surface layer.



A dike is, green or not, a traditional CCA measure, thereby associated with the cost of conventional dikes.



Dikes can have both benefits, such as recreational and tourism purposes, as dikes can have urban and spatial consequences such as reduced scenic views and reduced connection to the sea, as the urban environment is 'hidden' from the sea.

Levee



Elongated artificial vegetated construction, similar to dikes. Green levees are a hybrid solution of NBA and hard structure. Super levees are identical in construction to the super dike and are likewise built unbreakable and have the potential of several added functions/values.



Technical considerations:

Green levees are a hybrid solution of nature-based solutions and hard structures. Levees are a static solution often used in urban coastal environments. They are usually constructed of clay and sand, with concrete or rocks on the water facing the outer slope to protect against waves. Implementation time 5-25 years and lifetimes of more than 30 years.



Pipeline project in Manhattan, New York City, US (BIG, n.d.).



Terraced levee in Fredericia harbor (Realdania By & Byg, 2016).



Buildings on a super levee in Japan (Kinori, 2004 in Wiberg, 2019)

Benefits and suitability considerations



Nature-based levees constitute a top layer of soil that can benefit biodiversity.



Levees, just like dikes, are considered traditional CCA measures and can be used for infrastructural needs. A levee requires coastal land allocated for the purpose, and the goal of nature-based values is an added layer to the construction, therefore, expected additional cost.



Levees can be constructed for several recreational purposes benefitting humans.

Groynes/ artificial headlands



A groyne is a shore protection structure constructed perpendicular to the shoreline into the ocean to protect strategic points. Effective against coastal erosion and reduction of wave energy for storm surges. Efficient to accumulate long-short drifting sand or mud. Groynes can act as permanent and temporary typologies. Groynes are cost-efficient as protection and can provide mooring, safety, and berthing for vessels in ports.



Technical considerations:

Static typology resulting in dynamic sand/mud accumulating landscape. Self-growing potential. A series of groynes can act together as a system to protect the shore. Often structures are built of rock, concrete, sandbags, steel, or timber. Rock groynes are generally preferred as they are more durable and efficient in absorbing wave energy due to the permeable setting. Groynes can negatively affect sediment transportation alongshore, causing downdrift erosion; therefore, geotechnical analyses should be made.



Proposal of groynes in Vejle, DK (Vejle Kommune, 2020a)



Artificial headland on beach (World Bank, 2021)

Benefits and suitability considerations



Groynes can create favorable barriers for natural values, and submerged groynes can provide substrates for species, thus improving biodiversity.

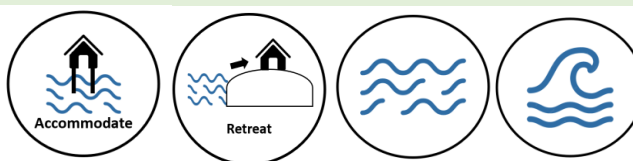


Construction costs depend on structure dimensions and the suitability of the material used for the typology. In the Netherlands, groynes cost about EUR 3,000-15,000 per running meter.



Both positive and negative sides are present in the typology for local landowners and communities. Wrongly installed groynes can lead to downdrift erosion, impacting properties and affecting tourism. Similarly, groynes can also efficiently protect properties and recreational and tourism interests.

Temporary / mobile constructions

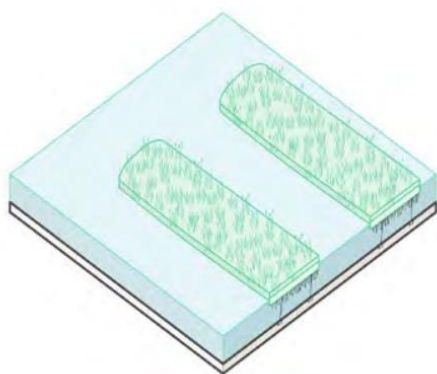


Dismountable and temporary constructions as options for flood-prone locations. Mobile structures can move over time or due to risk from storm surges or long-term issues of sea level rise.



Technical considerations:

The constructions should be able to move or dismount or act as temporary options in the urban landscape. This typology is flexible as it can be relocated, combined with other typologies and grey structures, and constitutes innovation potential.



Floating mobile wetlands (World Bank, 2021)



Mobile housing being moved (DanDavidCook in Wiberg, 2019, p. 51)

Benefits and suitability considerations



Constructions that are mobile or temporary, such as the typology of floating structures or aquaculture, are incredibly efficient for biodiversity enhancement and resource production.

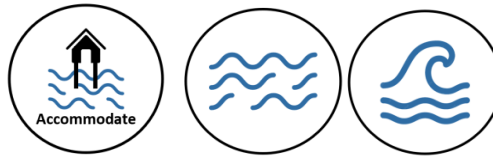


Mobile constructions can contribute to changes in business and housing which can create tourism business. Temporary and mobile constructions can move and therefore do not require the same level of protection as permanent structures in the landscape.



Temporary and mobile housing can create recreational and tourism opportunities, moving and developing over time, while the flood is an accepted risk. This typology can bring education and innovation in how to accept risk in the urban development and learn to live in and with the sea.

Temporary accept of flood



Accept of risk of flood in the urban development temporarily. Therefore, the typology is strategic and combined with other typologies such as floatable/amphibious constructions, flood-prone constructions, buildings on piles, etc.



Technical considerations:

Technical considerations depend on scale and types of combination with other typologies.



The realized project Yanweizhou were previously dominated by a concrete wall criticized to destroy the natural ecosystems. Now the area constitutes terraced ecological embankments allowed to flood. Yanweizhou Park in Jinhua, China. The left photo is at an average water level and the right photo is during a flood (Hobson, 2015).



Pipeline project for flood-prone park, Randers, DK (Randers Kommune, 2020).

Benefits and suitability considerations



Areas constructed to flood can provide biodiversity and habitats as well as carbon storage.



As areas are built to flood, no protection measures are needed, and costs can be saved for certain areas. Maintenance is required.



Areas built to flood can have recreational, tourism, and social/educational benefits. This typology can bring education and innovation in accepting risk in urban development and learning to live in and with the sea.

Coastal and/or urban forests

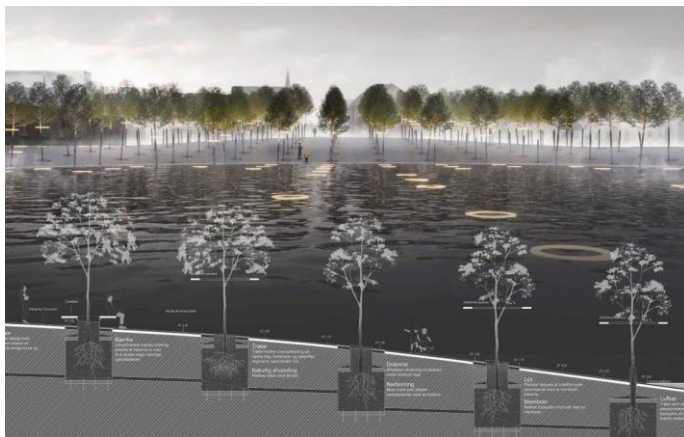


Coastal forests, in particular with dunes, wetlands, seagrass beds/meadows, and reefs, are effective as coastal protection. Both afforestation (new forests where there in a period have been none) and reforestation (replanted forests on recently deforested land) are two approaches that serve multiple purposes such as soil and water protection and biodiversity conservation and act as coastal protection in terms of reduction of the wave energy from storm surges.



Technical considerations:

A key challenge for this typology is land-use change and the various actors involved.



Proposal of coastal forest for Vejle Fjord (Vejle Kommune, 2020a)



Proposal of coastal forest for Vejle Fjord (Vejle Kommune, 2020a)

Benefits and suitability considerations



Climate change and forest ecosystems are closely connected, as forests can act as an efficient carbon sink and generally delivers biodiversity conservation. Trees strongly influence the quality of water.

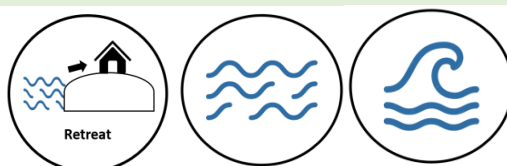


Trees often have a lifetime of 25 years or more if situated in surroundings with enough space for growth. When located in an urban environment, forests require land, construction, and maintenance, which can create jobs. In general, forests require a long implementation time and involve several actors.



Urban forests provide shade and vegetation, increasing human health.

Managed retreat/ realignment/ relocation of buildings and functions

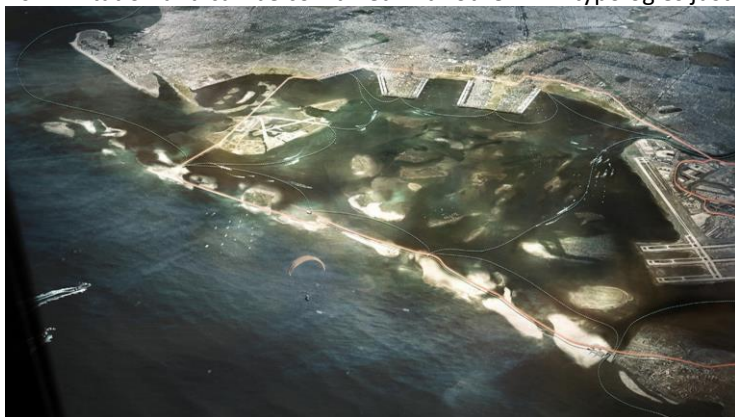


Relocation of vulnerable utilities, housing, and infrastructure to move further inland in flood prone locations to minimize risk from sea level rise and storm surges. Managed retreat is a strategic decision often driven by disasters, markets, or is plan-driven (Plastrik and Cleveland, 2019, pp. 10–20 in Wiberg, 2019). Often, this typology creates new space for other typologies such as room for areas designated for flood and space for new uses of the previously occupied coastal zones. Retreat is a strategic typology often highly relevant and incorporated in the long-time perspective and can be established early in the process by ‘avoid’ areas of non-construction zones in the landscape. Managed realignment can involve breaching, removal, or relocating of coastal defenses such as dikes.

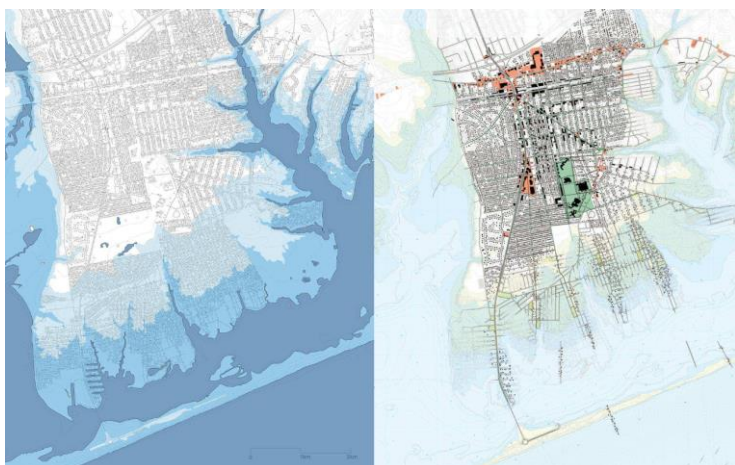


Technical considerations:

Managed retreat is a ‘soft’ NBA typology, and is likely to receive stronger public support if designed in long-term perspectives. The typology can be controversial and result in strong opposition. The approach is favorable in long-term risk-limitation and can be combined with other NBA typologies just as grey infrastructure.



The Bight Project is a pipeline project of managed retreat of low-lying areas as coastal NBA. Jamaica Bay, Tri-State Area, US. (Drake & Segal in DLANDstudio, n.d.)



(Left) The Mastic Beach area on Long Island with present buildings and risk of flood. (Right) Proposal of retreat of the town with partially phased out buildings. (Segal & DLANDstudio in Fryd & Jørgensen, 2019, p. 30)

Benefits and suitability considerations



Managed retreat create space for other typologies such as vegetation buffers, wetlands, dunes, etc., providing benefits for biodiversity and the environment/climate.

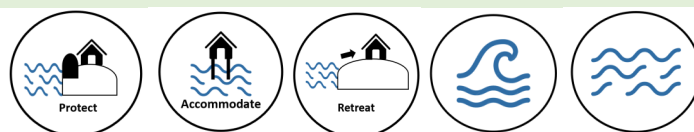


One approach for this typology provides compensation or support for owners of areas or buildings whose property is threatened and forced to resettle further inland. In the long run, savings are present in the ‘avoid’ approach with examples of minimum distance requirement of construction to shorelines. In areas with low population density, the cost of ‘retreat’ could be significantly lower than grey or green protection measures. The price depends on specific sites and values concerned to be at risk.



Retreat is beneficial for recreational purposes and human health, as the risk of storm surges is highly stressful for humans. Political and community discussions of the typology are highly relevant for citizens’ involvement and education of future climate change impacts; however, they are likely controversial.

Coastal vegetation in the streetscape/ shorescape and/or seafloor

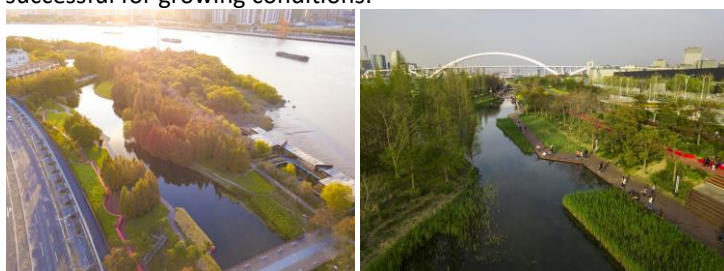


Green areas can contribute to coastal and fluvial floods and reduce the heat island effect. The plants should be drought and salt-resistant and preferable to native species. Vegetation can constitute revegetation and the creation of new vegetation and resemble green and blue infrastructure. Coastal vegetation on its own and in combination with other typologies are effective against storm surges, sea level rise, and coastal erosion. Bioengineered solutions can enhance vegetation growth, such as planting mats and planted seagrass meadows. Vegetation is critical for reducing erosion, waves overtopping and flooding. Vegetation can recover after storms. Especially eelgrass (*Zostera Marina*) has enormous potential with several valuable benefits.



Technical considerations:

Investing in and building urban nature requires integrated and intelligent approaches to management, urban design, and strategic planning, including local considerations of vulnerabilities and exposure to climate hazards. Implementation time is 5-10 years with a lifetime of more than 25 years. Species selection is crucial, as invasive species can hurt local biodiversity. Species should generally resemble and adapt to the local environment and the projected climatic conditions concerning the plant's lifetime. Planting mats can be a biodegradable product proven highly successful for growing conditions.

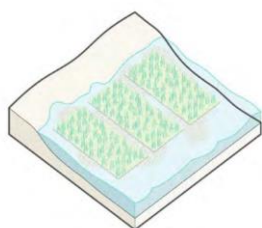


In Shanghai, a nature-based project has been realized for climate adaptation of a part of the port area in the city, the so-called Houtan Park. The realized Houtan Park, Shanghai, China (Turenscape, 2009).

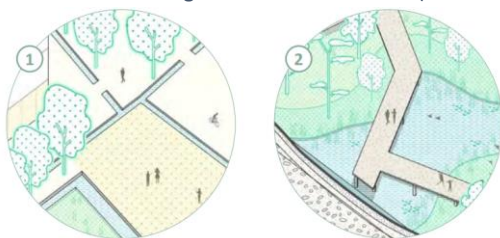
Benefits and suitability considerations



Benefits include increased urban biodiversity and higher environmental qualities in urban areas. Vegetation can provide resources. Coastal vegetation such as eelgrass has proven to be more than three times as efficient as average Danish forests for carbon storage.



Planting mats to establish vegetation in the seafloor (World Bank, 2021)



Coastal urban wetlands (World Bank, 2021)



Studies on cost suggest financial benefits. Managing urban nature can be a complex process subjecting conflicting agendas regarding infrastructure, housing, economy, etc.



Urban and coastal vegetation is beneficial for recreational purposes and, combined with urban gardening/coastal gardening, could benefit social interactions and community involvement, increasing human health. The planting of seafloor vegetation can likewise engage local communities.

Salt meadows/ salt marshes/ coastal wetlands/ tidal flats



The typology of a coastal wetland is positioned in the zone between sea and coastline. Wetlands / floodplains can contribute significantly as protection against damage from storm surge and sea level rise. Wetlands/tidal flats store water and release it slowly and reduce the speed and height of storm surge and tidal waves. Effective to a general reduction of wave energy/heights and reduction of erosion from storms and tides. It creates a buffer against saltwater intrusion and is efficient in trapping sediment and organic matter, thereby building soil elevation.



Technical considerations:

The typology is often used to replace hard structures of coastal defense in managed realignment, and the option is flexible as mud nourishment can be added manually and naturally. This typology has many advantages compared to other technical CCA and NBA, as the need for hard coastal defenses declines, and the need for inland dikes can reduce heights. The main difficulty of the typology is changed land use. Implementation times vary based on the extent of the site, and regular maintenance may be required.

The pipeline project “Holwerd aan Zee” constitute a dike breach and wetland restoration at the Wadden Sea (Sloth, 2022).



Visualizations of Holwerd aan Zee (Adema Architecten, n.d.).

The pipeline project of the ‘resilience district’ proposal for the Greater Boston Metropolitan Area consist of berms, levees, floodable parks, and constructed wetlands (Berger et al., 2020).



Proposal of CCA in Boston Harbor, US (LCAU in Berger et al., 2020).



Proposal of redevelopment in Vejle Fjord, DK (Vejle Kommune, 2020a)

Benefits and suitability considerations



Coastal wetlands are critical intertidal habitats and provide biodiversity, contribute to water purification and better water quality and carbon sequestration (12 times more efficient than a Danish forest (Quintana et al., 2021)), and can be a buffer against salt intrusion. Wetlands provide services and resources such as nurseries and feed for species, raw materials, food, and medical resources.



The cost of coastal defense and erosion protection can reduce significantly, as less maintenance of hard structures is required. As the wetlands are efficient as a buffer for storm surges cost of damage due to floods and waves from the sea can be limited. The changed land use could affect the economic activities of farmers, residents, etc. However, the wetland habitats have valuable commercial interest (nursery, spawning, feeding area for species. There can be a significant monetary value of services of wetlands.



Beneficial for eco-tourism and recreation, which increase human health. If the project impacts Natura2000 sites, it may include public participation, information, and consultation, especially when the typology requires managed retreat.

Barrier islands / surfacing offshore breakwaters

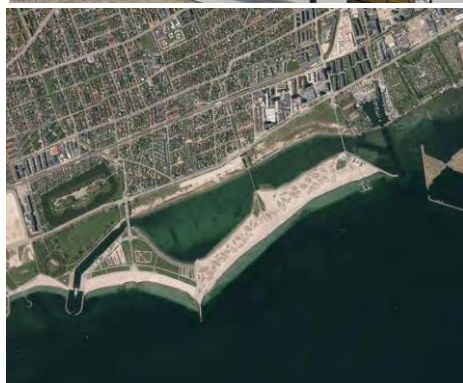


They are positioned in the coastal zone as barrier islands providing wildlife habitats or barrier island parks for recreational purposes. It can be artificial and self-growing, often dynamic, and non-porous. Natural barriers with associated plant communities can act as a barrier against storm surges, coastal erosion, wave overtopping, and dissipate wave energy.



Technical considerations:

Barrier islands are engineered islands in the coastal landscape and require construction and maintenance.



*Photos of Amager Beach park, Copenhagen, DK. (Above: (Tengbjerg, 2018),
Below: (Københavns Kommune, 2018)*



Photo of the realized barrier islands in Køge Coast, DK (Rambøll, 2015)

Benefits and suitability considerations



Barrier islands can constitute valuable wildlife and biodiversity habitats such as Natura2000.

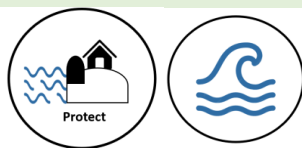


Barrier islands require land and expenses for construction and maintenance. The annual operation cost of Køge Coast is 10 mio. DKK (Westh, 2018 in Faragò et al., 2018, p. 34). Barrier islands can also significantly reduce the direct flood impact costs due to storm surges.



Recreation, tourism, and human health are benefits of barrier island parks. If constructed for recreational purposes, barrier islands can experience conflict with communities if too much seaweed reduces the aesthetic attractiveness, as Køge Coast has experienced (Skjerning, 2017 in Faragò et al., 2018, p. 35).

Artificial and/or natural reefs / other submerged structures / offshore sea-beds

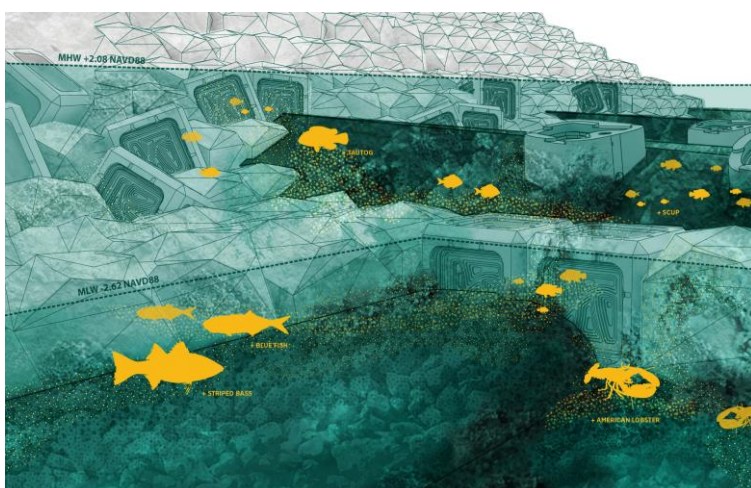


They are positioned as shallow or deep barriers in the coastal zone. Effective against wave energy, reduction of wave heights, and reduction of erosion from storms and tides. Reefs can act as a barrier to waves. However, the characteristics of the reefs are essential concerning the potential of dissipation of energy: length of the reef, depth of waves above the reef, geometry, and material.

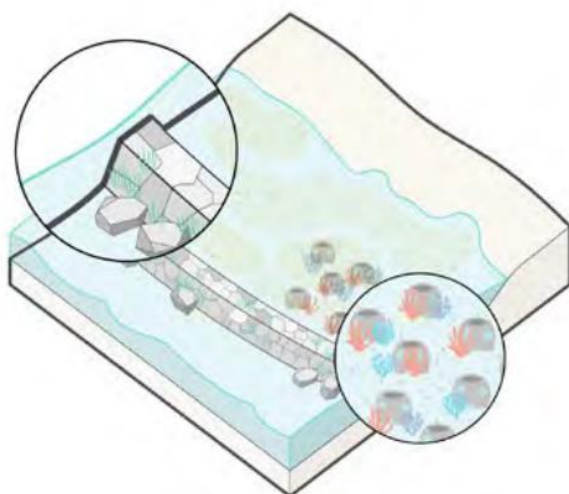


Technical considerations:

Reefs or other submerged forms can be hard structures that offer substrates for ecosystems and softer versions such as shellfish reefs or seagrass meadows—dissipating up to 95% of the wave energy. Offshore sea-beds offer natural defense against waves, coastal erosion, and storm surges. Self-growing potentials. Under-surface breakwaters have a long lifetime of 30-50 years of rock structures.



Living Breakwater project, Staten Island, US (New York State, n.d.)



Artificial reefs and submerged structures (World Bank, 2021)

Benefits and suitability considerations



Reefs contribute to the natural creation of other reefs, coastal vegetation, and oyster/mussel banks, revealed efficient to clean the water.



Maintenance can often be saved as reefs can self-grow due to natural materials being moved by wind and current. In the Netherlands, artificial reefs are around EUR 15,000-35,000 per running meter. Construction costs are high, but maintenance is low.



Reefs can contribute to ocean-related recreational and leisure activities such as diving and fishing. While acting as a breakwater, the leeward side of the reef can be popular for watersports.

Artificial and/or natural dunes and protections of dunes



Natural or artificial dunes are a dynamic typology on beaches along coastal zones. It can be a recreated beach park construction or a naturally strengthened dune landscape. With associated plant communities, dunes can, if managed well, act as a barrier against storm surges, sea level rise, and dissipate wave energy.



Technical considerations:

These measures are a 'soft' NBA typology and are usually combined with other CCA typologies, especially beach nourishment. Artificial dunes are engineered structures often brought from an external source area and shaped by bulldozers or dynamic dune nourishment. Dune landscapes do not have many synergies with grey infrastructure as human activities often worsen erosion. The typology is flexible as the landscape can be raised in height by sand or mud nourishment. Implementation time is 1-5 years; life-time is 5-25 years which can be strengthened with the nourishment typology.

Køge Coast is a realized NBA project where dikes, terrain-raised beach meadows, and beaches are included as protection from sea level rise, storm surges, and cloudbursts (Realdania By & Byg, 2016).



The realized artificial dunes at Køge Coast, DK (Køge Kyst, n.d.)

Dragør Municipality plans to use natural processes such as CCA in the form of sandbanks, saltmarshes, dikes, etc. (Dragør Kommune, 2020; Realdania, 2020).



Pipeline project for artificial dune landscape in Dragør, DK (ARKITEMA & COWI, 2020).

Benefits and suitability considerations



Often dune construction represses the natural function of dunes and can lead to a succession of vegetation and loss of natural values behind the construction areas. This can be counteracted if using a sufficient land area to generate natural values and vegetation.



Land loss can be a controversial issue for the construction of artificial dunes. In general, implementation costs are low; however, ongoing maintenance is required, which could stimulate job creation. The typology is often cheaper than hard defenses such as dikes.



Dune construction can provoke conflicts of interest over land use: landowners may be eager to preserve sea views conflicting with the safeguarding of the area. The typology can raise awareness of local stakeholders and tourists. In general, vegetation and natural landscapes increase the recreational and tourism value, improving the quality of life for the local community.

Sand/beach nourishment /Sand motor / Mud motor

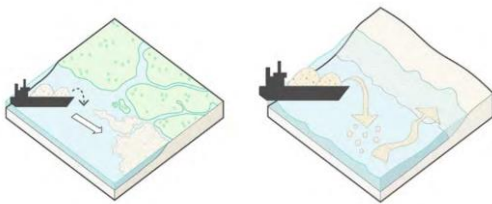


Sand nourishment is a dynamic nourishment typology added, often by ship, to beaches, salt marshes, or shorefaces, along coastal zones allowing wind and tidal effects to distribute it along the shore. Dune thatching of organic materials such as dune grass planting, braided branches, or seagrass can stabilize and accumulate sand if added to the beach. The construction of seaward-facing fences can increase foredunes and act as a barrier against waves. The Dutch sand motor approach is a well-known example of a sand drift strategy. The sand motor combines sand nourishment, a built dune landscape, and barrier islands and is positioned in the coastal zone between the sea and a primary dike construction inland. A mud motor technique can gradually increase salt marshes' growth by adding dredged mud spread out on the tidal area near the shore or marsh.



Technical considerations:

Nourishment is a 'soft' NBA typology and always complements dune or marsh landscapes. Nourishment typologies can be efficient against coastal erosion in the form of both surfaces (wind) and marine erosion. Dune nourishment is a flexible option that can strengthen the dune landscape and increase safety from sea level rise. There are several options for the innovation of this typology.



(Left) Mud motor. (Right) Sand nourishment (World Bank, 2021)



Sand motor, NL (Rijkswaterstaat in World Bank, 2021, p. 234)



Guérande, France (Mesnage in World Bank, 2021, p. 232)

Benefits and suitability considerations



The nourishment can increase and decrease the values of the habitats, as the habitat and vegetation of the landscapes, on the one hand, are preserved, though, on the other hand, nourishment can alter the dunes' natural functions, thereby reducing natural dynamics and values.

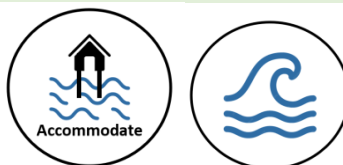


In general, the implementation cost of all these measures is low as the material used is cheap. However, lifetime is limited unless ongoing maintenance involves labor costs, which can create jobs again. According to (European Environment Agency, 2022), dune nourishment is cheaper in the long run than hard defenses such as dikes. Sand nourishment can positively influence housing prices (Panduro et al, 2017 in Faragò et al., 2018, p. 39).



Fencing and thatching can limit access to the sea and disturb public use and natural visual aspects, influencing tourism negatively. Nourishment can also preserve eco-tourism and recreational values, improving the quality and health of human life. Citizens' involvement and education can experience benefits when local and volunteering efforts undertake nourishment types such as grass planting.

Change in functions/ businesses from land-based to sea-based / aquaculture



Agriculture or other types of functions change towards aquaculture. Examples such as seagrass/kelp forests, oysters, and mussels. Aquaculture gardens are not sufficient as sole measures against sea level rise or storm surges, although they can limit the influences of waves from storm surges. Fjord gardens, sea gardens, belt gardens, sound gardens, and maritime gardens – many names for the same concept. (Havhøst, n.d.).



Technical considerations:

Aquaculture often is associated with grey structures, as the availability of the gardens otherwise would be limited. Implementation time 1-5 years, lifetimes are variable.

The pipeline project in Vejle includes the proposal of mussel and seagrass farms (Vejle Kommune, 2020a).



Proposal for pipeline project in Vejle Fjord, DK (Vejle Kommune, 2020a)

Benefits and suitability considerations



Increasing the presence of vegetation or mussels will increase the water quality. Increases local biodiversity and improve environmental qualities in urban areas.



In community-based coastal gardening, the cost of purchasing crops is for the community, while the municipality could practice maintenance.

When growing more new saline produce, more food will be available during droughts in agriculture, while new jobs are created.



Aquaculture can be both more extensive farming and more miniature community-based gardening. Community farming can be used as recreational areas and public meeting places, including eco-tourism.



In Denmark, several coastal gardens are being established (Above) Aquaculture in Lemvig, DK, and (Below) Ebeltoft, DK (Havhøst, n.d.)

7.3 Main points of the NBA catalog

The analysis of the 18 'catalog cards' of NBA typologies demonstrates several suitable options for urban and coastal CCA interventions that can represent a nature-based approach. The typologies are often suitable when combined, such as the joint typologies of dunes, vegetation, groynes, and sand nourishment, or managed retreat, which constitutes space for other solutions such as vegetation, temporary solutions, or salt marshes, or the combination of 'accept of flood' that bring options for innovative types of urban/natural landscapes.

Several typologies are well-known historical options, such as dike/levees, terps, groynes, artificial dunes, sand nourishment, and barrier islands. However, going through the 18 options of NBA, new, innovative, and flexible solutions are present such as the typologies of acceptance of flood, managed retreat, aquaculture, sand motor, mobile and floating constructions, urban marshes, and the various options of coastal vegetation.

In total, there are four options of the strategic CCA approach of 'retreat,' eight of 'accommodation,' and ten of 'protection.' Although 'retreat' is the strategy represented by the least typologies, it is highly relevant in an uncertain climate, especially regards building resilience. The fact that 'accommodate' and 'protect' has nearly the same number of typologies is interesting, as especially 'protection' is the conventional approach in Denmark as described in Section 2.1.1, and since there are as many qualifying options of NBA that constitute 'accommodation,' this could push the tradition of CCA towards other strategies just by actively using a nature-based approach. Furthermore, some of the typologies are relevant for more than one strategic CCA approach, such as the typology of coastal vegetation that is applicable for all three approaches, the typology of salt meadows which is suitable for 'retreat and accommodate,' and the typology of temporary/mobile is convenient for 'accommodation and retreat.'

The NBA typologies represent a wide range of opportunities for added values as illustrated by the icons of environmental, economic, and social sustainability indicators, technical considerations, and abilities to cope with the Danish coastal climate challenges of sea level rise and storm surges. In general, the analysis demonstrates that the NBA typologies have great potential to limit climate impacts while founding added values such as carbon sink, increased biodiversity, new businesses, and job creation such as innovative resource production through aquaculture, tourism, outdoor recreational activities, and finally increased human – and natural – health. This demonstration of added values, suitability in the urban coastal landscape, and applicability in terms of climate challenges constitute values that the NBA can create in the "meanwhile" before a climate hazard of storm surges and sea level rise is underway. This leads to the NBA typologies being classified as no-regret solutions (Wiberg, 2019). The no-regret potential is vital as several NBA options are flexible and modular and can be developed over time as the future experience, projections, and uncertainties of climate risks shift.

Several illustrations of realized and pipeline NBA projects present a resilience-based approach, especially in international cases such as Resilient Boston Harbor and Living Breakwaters (Wiberg, 2019). According to Wiberg (2019), the NBA vocabulary presents aspects of resilience such as blue urbanism and dynamic approaches such as 'accommodation' and 'accept of flood,' which creates annotations of new relations between the urban and coastal environment in which the impacts from the sea is a natural consequence of living at the coastal zone. The vocabulary contributes to breaking down the traditional 'protection' approach to create awareness and appreciate the dynamic and temporary options in which the urban environment lives in and with the water.

However, one thing is how international cases are tilting towards resilience thinking; another is how the NBA approach is used in Denmark in contemporary CCA projects to enhance resilience building. Therefore the following analysis will assess the potential resilience building in Danish contemporary NBA projects.

8. Assessment of climate resilience in the case projects

Climate resilience, cf. the theoretical Section 5.1.2, constitutes the three key principles of adaptive capacity, persistency, and transformability, which Tyler & Moench (2012) argue are necessary characteristics to build to ensure resilience in a complex urban system such as coastal CCA projects. As this thesis investigates the connection between climate resilience building, based on Tyler & Moench (2012), and the concept of NBT, based on Randrup et al. (2020), the following analysis aims to assess the fundamental principles of resilience related to NBT. To analyze these principles in a contemporary Danish context, the case projects of Assens, Aabenraa, Vejle, and Svendborg, as described in the case selection in Section 6.3, will be assessed based on the interviews conducted with the project managers, reports from Realdania and the associated municipalities, and observations in a public hearing and internal municipal workshop in Svendborg, as described in the methodology Section 6.4.2. The assessment aims to understand whether climate resilience is being developed in connection with Nature-based Thinking in the four urban coastal case projects.

With the point in departure in the analytical framework of climate resilience explained in Section 5.2.2, the analysis constitutes three sections of research on each of the three key principles for the four case projects of (1) transformability to change, (2) persistency to climate shocks and stresses, and (3) adaptive capacity of social agents. Each key principle constitutes analytical components, as described in Section 5.2.2. Therefore, the following three sections of analysis assess these components and the linkages to Nature-based Thinking.

8.1 Transformability of the case projects

Transformability is first and foremost associated with change (Tyler & Moench, 2012). As described in Section 5.2.2, transformability constitutes the following three components: (1) Embraced change and application of new knowledge, (2) Rights and entitlement, and (3) Transformative decision-making processes. The associated analytical questions used to assess these components for each case project are defined in Section 5.2.2.

Assens

Assens embraces NBA in their project, thereby pursuing change and applying new knowledge. The project is the only pilot project that purposefully pursues a soft nature-based landscape solution to the coastal climate adaptation challenge (Realdania, 2020). From the start, Assens has aimed to embrace nature-based coastal protection where possible (Realdania, n.d.-a). *“The basic idea is to work with the natural processes. (...) With [the method of] DAPP² and in the project, we have played with the solution of nature-based coastal protection - a minimum of hard constructions and as much soft coastal protection.”* (Larsen, 2022, p.c.). The quote indicates a local perception of NBA as an approach able to play and experiment with, which indicates a will to embrace new knowledge from the field of Nature-based Adaptation. The project is mentioned to constitute the following NBA typologies: *“(...) it will be a combination of dikes, sand, dunes, groynes, and more - but we will have a minimum of concrete and floodwalls. (...) We would also like to work with nature-based solutions on both sides of the harbor gate”* (Larsen, 2022, p.c.). As described in the quote, various NBA typologies are sought to be implemented in the project, as illustrated in Figure 5 below and compared to the developed ‘catalog of NBA’ in Section 7.2, the case project refers to the following typologies: *Sand dunes, sand nourishment, groynes, dikes, salt marshes, sea walls, reefs, vegetation.*

² ‘Dynamic Adaptive Policy Pathways’ is a strategic method to identify pathways of adaptation. It is developed by Deltares, NL, and adopted by The Danish Coastal Authority (The Danish Coastal Authority, 2020).



Figure 5: Illustration of the case project for Assens (Assens Kommune, 2021b).

Regarding rights and entitlement of nature itself, Assens aims to embrace added values of nature in the project: *"We try to focus on both recreational utilization and biodiversity."* (Larsen, 2022, p.c.). Furthermore, the municipality of Assens has decided on several goals that the project must constitute: biodiversity, access to nature, pleasure-fishing, maritime pleasure activities, recreational coastal protection, outdoor life at sea, holiday homes, and bathing opportunities (Assens Kommune, 2021a).

Regarding whether nature is a part of the project's decision-making, the nature-based solutions are widely accepted in the decision-making process from both a political, administrative, and citizens' point of view; however, there is a more significant wish for a nature-based dike solution rather than a dune landscape from the side of the citizens: *"Everyone agrees that there are problems and that something must be done. But we disagree on which solutions to choose. And there, I think maybe NBS is a bit 'dangerous' still - what is this type of measure and what does it require - people are only yet familiar with what a dike is, and people have gotten used to seeing groynes at the shorelines and floodwalls in the urban coastal landscape."* (Larsen, 2022, p.c.). However, the dike solution is not seen as a long-term sustainable solution by the municipality: *"The idea of nature-based solutions stems from the municipal administration to investigate if you could do something other than making a traditional dike. You can easily make a dike and retreat this dike inland, but at some point, the average sea level rise will reach this dike."* (Larsen, 2022, p.c.). Larsen elaborates on this problem: *"I think the current project needs to be optimized (...) maybe it will instead be a combination of what the citizens out there want - something with dikes closer to the buildings while we also create coastal protection scenery outside. So we do not compromise on the nature-based"* (Larsen, 2022, p.c.).

Aabenraa

In Aabenraa, the case project constitutes a report of four future scenarios of the development of the harbor, and two of four scenarios contain proposals with soft coastal protection and Nature-based Adaptation, whereas two out of four focus on traditional hard CCA interventions (Aabenraa Kommune, 2021). This indicates that the project embraces new knowledge on NBA in half of the scenarios and is willing to examine if nature could be a part of the future urban development. Various NBA typologies are sought to be implemented in the two future scenarios, as illustrated in Figure 6 and

Figure 7 Figure 5below. Compared to the developed 'catalog of NBA' in Section 7.2, the case project refers to the following typologies: *Sand dunes, levees, salt marshes, sea walls, vegetation, and managed retreat.* (Aabenraa Kommune, 2021).

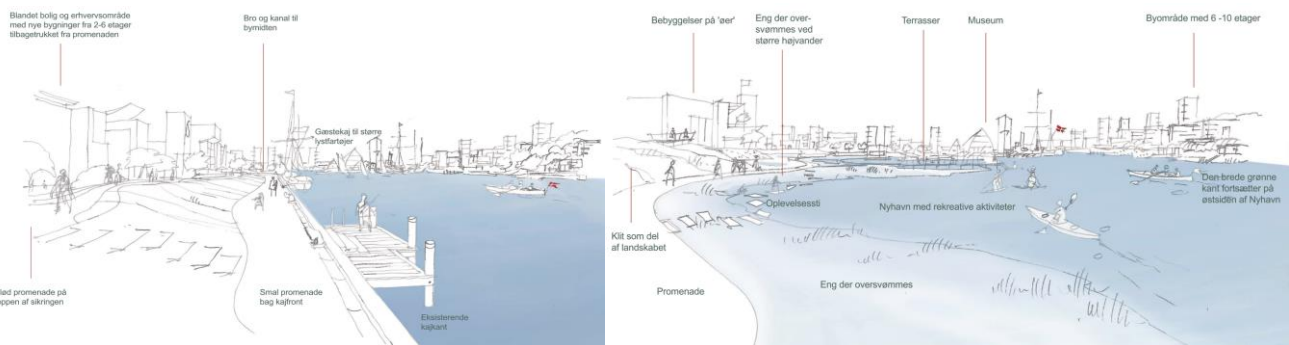


Figure 6: (Left) Soft levee combined with retreated buildings in the Aabenraa harbor area (Aabenraa Kommune, 2021).

Figure 7: (Right) Soft edge in the Aabenraa harbor area (Aabenraa Kommune, 2021).

Regarding the rights and entitlement of nature, the case project embraces the idea of NBA in the future urban environment through the two nature-based scenario proposals; however, nature is perceived as problematic and not necessarily integrated into the urban environment for the sake of nature itself: *"Natural processes (...) they are difficult to create inside a city", "Ports are incredibly expensive to build - and you need the land. Giving this area to nature is a difficult matter (...) Here in Aabenraa, we are already surrounded by beautiful nature and beaches, so there is not a need"* (Mohr, 2022, p.c.). The quotation indicates that NBA contributing with 'nature-for-nature's sake' is not perceived as needed in Aabenraa, as they "are already surrounded by nature."

Regarding nature being an integrative part of decision-making in the project, there is a clash of a more local matter regarding the local perception that "there is no need" for more urban nature through the case project, which could make the decision-making tilt towards the other two future scenario-proposals that do not constitute NBA. In addition, the nature proposed in the two scenario-proposals is mainly seen as an aspect in the decision-making that can create discussion: (...) [The] *narrative* [soft edge scenario] *is a nature-based 'retreat' scenario that mentally helps to fertilize the debate, but it is not a scenario that has a chance to become something in Aabenraa.*" (Mohr, 2022, p.c.). One local reason for this, as Mohr (2022, p.c.) elaborates, is the potential clash between NBS and existing pollution in the port area: *"How do you handle pollution, etc. because you cannot 'let loose' when there are steel sheet walls [that keep the pollution inside] and 11 m water depth"* (Mohr, 2022, p.c.). This testifies that NBA for Aabenraa Municipality has been used as a narrative that can contribute to 'mentally open the debate' to new approaches to climate adaptation, but that some solutions of NBS combined with the strategy of 'retreat' have not yet been seen as feasible.

Vejle

In the case project of Vejle, the focus has directly embraced the development of NBA, such as urban saltwater landscapes, as well as resilient and nature-rich storm surge protection (Realdania, 2020). In addition, Vejle Municipality has started three tracks in connection with the development of CCA for storm surges. The three tracks deal with: how to create a shared understanding of water concerning the threat from the fjord's sea level, a shared understanding of nature concerning opportunities for nature-based storm surge protection, and how art can contribute to new angles on the issues. (Realdania, n.d.-c). In connection with the art track, an open idea competition was announced for innovative, recreational, and nature-based proposals for CCA (Realdania, n.d.-c). The competition led to four recommendations that the Municipality continues to work on (Vejle Kommune, 2020a), which indicates a local perception that NBA constitutes a suitable approach for the case

project and that new knowledge on NBA is embraced. Figure 8, Figure 9, and Figure 10 below illustrate the four winners of the idea competition, and compared to the developed 'catalog of NBA' in Section 7.2, the case project refers to the following typologies: *Salt marshes, floatable constructions, accept of flood, managed retreat, coastal forest, levee, dike, aquaculture, rock reefs, and breakwaters* (Vejle Kommune, 2020a).



Figure 8: Winner of the idea competition in Vejle. (Philipsen, Wiliamson & Brando in Vejle Kommune, 2020a).



Figure 9: Second and third place in the idea competition. (Houser & Johansen; Gamborg/Magnussen in Vejle Kommune, 2020a).

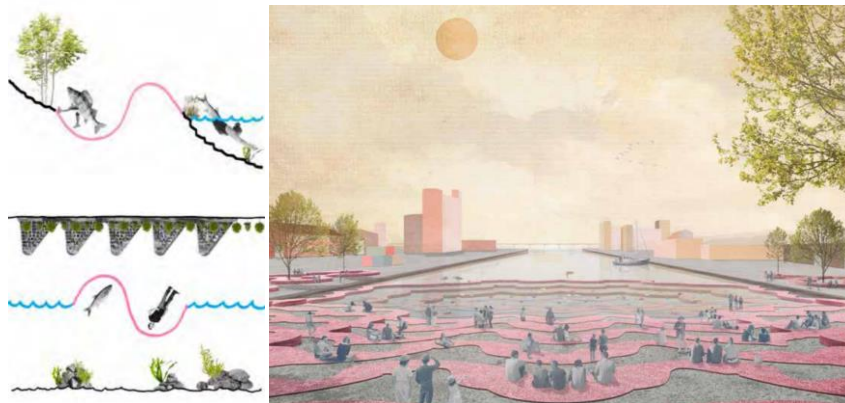


Figure 10: Fourth place in the idea competition in Vejle. (SUPERFLEX in collaboration with BALDIOS in Vejle Kommune, 2020a).

Regarding the rights and entitlement of nature, the proposal aims to provide space for nature above and below the water, which should constitute a natural zone of coastal vegetation and rocky landscape on land and vegetation such as eelgrass and reed forest acting as underwater breakwaters (Vejle Kommune, 2020a). The aim is to change the perception of water and reassess the quayside as a separating space (Ibid.). Therefore, the goal is mainly anthropocentric and does not solely regard nature as having the right of space for nature's sake.

Due to the winning proposal of the idea competition, nature is being integrated as a part of the decision-making in the project and experiments with nature-based possibilities, and the membrane idea is being further developed: "We are working on nature-based solutions and a geo-cell membrane, something they have in the

Netherlands (...) we have made some structure and are working with it on the shore and in the water, and we use natural materials such as sand and planting, etc. That which can both seem like something recreational but at the same time can slow down the sea level rise in an extreme event and hold the water back. In some places, the water also may well enter the city. (...) There are many things to consider - because can we make something grow at all in these cell membranes? It's something they've tried in the Netherlands; they have some preliminary experience (Geertsen, 2022, p.c.). Furthermore, Vejle focuses not only on the experimentation with NBA in the CCA project but also on the development of other nature-based solutions: "We will investigate how to work with salty nature but also freshwater nature as there is freshwater flowing from 'behind' as well. In connection with the Storm Surge Strategy, we have worked on a few different things - and I think we will reconsider these ideas and initiatives in the future and actually consider whether it should be even more nature-based - if it turns out that climate adaptation can be done with nature." (Geertsen, 2022, p.c.). In addition to the experimentation with nature, the purpose of the competition was to raise the level of understanding for the citizens about storm surge protection and to ensure that the solutions did not constitute the 'business-as-usual' tendencies that for Vejle are considered harmful for both resilience building and city livability (Vejle Kommune, 2020a). This purpose indicates that the case project of Vejle embrace nature as being a part of the decision-making.

Svendborg

The latest development on the case project of Svendborg constitutes a new strategy and action plan to qualify previous decisions taken in connection with the architectural competition "*The Blue Edge*." (Nielsen, 2022, p.c.; Realdania, n.d.-b). Previous decisions build on an idea catalog prepared in collaboration with citizens where a focal point has been to embrace nature in the form of 'beautiful nature and oases in the city,' and where the role of nature is mentioned as the gateway to the sea, scenic landscapes, public access to the water, and specific nature in the form of two existing beach areas (Svendborg Kommune, 2017b). Additionally, the architectural competition's program required that nature be included as an attractive element in the urban space, including the exposure of the creek 'Kobberbækken,' which should "create new nature" at the harbor (Svendborg Kommune, 2017a). However, in the recent work of the case project "*The Blue Edge*," nature has played a minor role in the proposals. Only one in four architectural project proposals constitutes NBA in the form of a beach meadow in the inner harbor basin, as illustrated in Figure 11 below. Furthermore, in the latest development of the case project, the municipality points out that: "NBS was on the table as a proposal (...) with the suggestion of elevated terrain laid out as a park. But the project group could not see this method applied at Svendborg Harbor without changing the entire use of the harbor. It has not been possible to find references on NBS realized in urban harbor environments, where the area must continue to be used as a port with commercial ships, shipyards, and as a ferry port." (Nielsen, 2022, p.c.). This quote indicates that NBA has been discussed; however, nature is not on the drawing board in the further planning. The premise for and applicability of NBA in the urban environment is also questioned: "But the question is whether nature-based solutions is what you want to use the harbor for, it may not necessarily be the solution you want to use here." (Korsgaard, 2022, p.c.).

The politically selected proposal for the CCA project solely embraces nature in the form of preserved beaches and a harbor park with a green look similar to the illustration in Figure 12 below (Svendborg Kommune, 2018b). Compared to the 'NBA catalog' in Section 7.2, the NBA typology used in Svendborg is, therefore: *an artificial beach*, although a technical construction is meant to be positioned behind the beach (Svendborg Kommune, 2018b). Consequently, it cannot be argued that the latest development of the case project of Svendborg pursues or embraces change related to NBA.

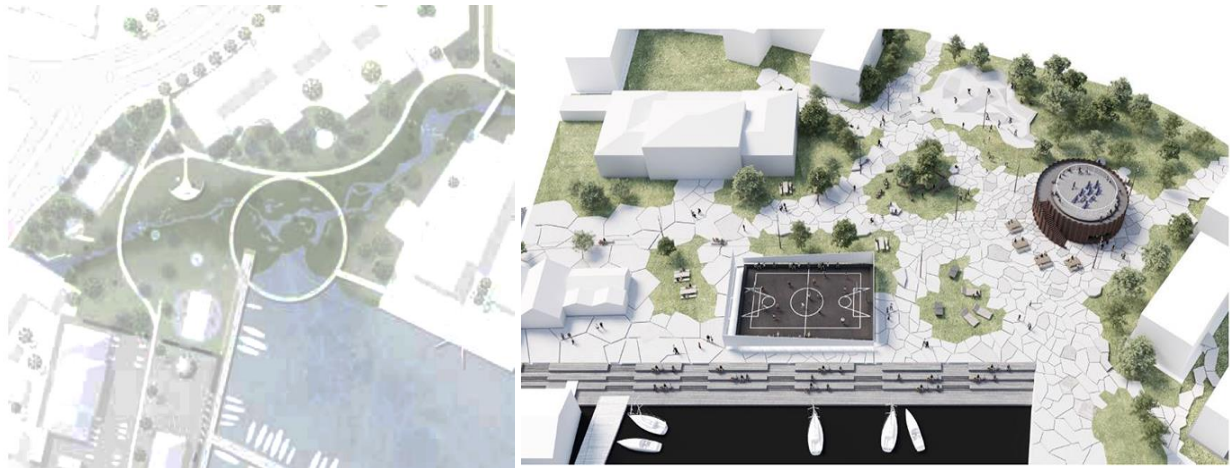


Figure 11: (Left) Illustration of a beach meadow park in inner Svendborg harbor (Sleth Architects in Svendborg Kommune, 2018a).

Figure 12: (Right) Winning proposal for the 'harbor park' (Svendborg Kommune, 2018b)

Regarding the rights and entitlement of nature, the local politicians in Svendborg have been tasked with assessing the criteria for developing the case project. In this connection, the following criteria have been selected: *clear contribution distribution, secure cultural heritage, recreational, modulable, aesthetic, something that works (solutions that have been tested, tested, seen before), the continued opportunity for port business, continued ferry operations and to secure the port environment*. Other criteria such as *biodiversity, water as an asset, several purposes for climate adaptation*, and the *possibility of giving up land* were initiating criteria not chosen in the final selection round (DAPP workshop, 2022, App.B). This indicates that biodiversity was considered to be given a 'right' in the planning of the case project, however, decided against.

"Some things would have to be pushed for nature-based solutions to come through [as a part of CCA] and be integrated inside the urban harbor area." (Nielsen, 2022, p.c.). This quote indicates that NBA is an approach that is perceived difficult for Svendborg to allocate space for and actively integrate into further development. Furthermore, this indicates that NBA has not become an integrative part of the decision-making in the project.

8.2 Persistency of the case projects

Persistency is first and foremost associated with flexibility (Tyler & Moench, 2012). As described in Section 5.2.2, the principle of persistency to climate shocks and stresses constitutes the two components (1) Safe failure and (2) Redundancy & modularity & flexibility. Associated analytical questions used to assess the case project's potential building of persistency are described in detail in Section 5.2.2.

Assess

Decisions for the project are for the municipality confirmed through the use of the DAPP method: "It was really clear when we had been through DAPP that we could already start on the coast - something had to be done here no matter what." (Katrine Juul Larsen, 2022, p.c.). In doing so, the municipality now can legitimize the need to increase climate persistence. However, a dilemma is mentioned concerning this: "What is a bit tricky with climate projections is that the water levels of the future are not greater than the storm surge heights of the past, and these historical storm surges do not appear in the high water statistics for the future. Our advisers however use both references and projections - they add an expected sea-level rise on the references, for example from the year 1872 when the water rose by about 3 m. (...) And then the advisers tell us that we must secure above level + 3.0 m. And then it starts to hurt." (Katrine Juul Larsen, 2022, p.c.). The dilemma stems from the climate

projections from 'Klimaatlas'³ being considered insufficient by the hired consultants and therefore the estimated +2.75 m that is currently planned does not live up to the advice of consultants. However, the use of long-time horizons, the DAPP method, discussions with consultants about projected impacts from climate changes, prove that the project consider safe failure in terms of climate uncertainty and are planning to avoid destructive impacts. The case project furthermore considers NBA as an option of safe failure: *"It's also about creating space and area through the project so that we can rebuild it later on to adapt it to future climate changes"* (Katrine Juul Larsen, 2022, p.c.), meaning that it is not necessary to establish the entire required elevation of the landscape from the start as the project is planned so that the height can be increased over time (Assens Kommune, 2021a). This approach proves building of persistence based on NBT in terms of flexibility and modularity, as the decided protection level of +2.75 m is acknowledged as an uncertain scenario, and as the project are modular, which constitute spare capacity.: *"(...) we do not compromise on the nature-based, nor do we compromise on creating the space and room for us to raise the dunes/landscape later. (...) But we must not cut ourselves off from having to create space and be able to expand them in the long term. There may have to be a transition period where citizens have to get used to it being something different."* (Larsen, 2022, p.c.).

The project has been politically chosen as part of a larger plan for flood protection of Assens (Assens Kommune, n.d.). *"No matter what we did if we wanted to preserve Assens as a place that does not just become a swamp because it is so low, then the solution is a gate in the harbor. (...) An estimate is that it will take 20-25-30 years before that gate comes. (...) This is the long-term strategy we are working on."* (Katrine Juul Larsen, 2022, p.c.). The project thus focuses on 'protection,' long-term sustainable solutions, and flexibility (Realdania, 2020). Flexibility amounts to elevating terrain and buildings: *"We are working to raise the terrain of the port area in general, so all the terrain is at +1.8 m (...). It gives us a little more time to plan concerning the future. (...) We have requirements in the area for the buildings to be built in +2.5 m or for the building to withstand getting wet. (...) we cannot confirm to those buildings that in 25 years, we expect a harbor high-waterrate - and therefore, we cannot say, 'so you just build at elevation +1 m, and then it goes super well.' Because there are years in between where much can change."* (Larsen, 2022, p.c.).

In terms of redundancy and the use of the three CCA strategies, the project includes pathways from the DAPP method: *"There are two roads to go related to climate adaptation of the city: protect the old historic city center (...). The other way is to protect the city along the entire coast. (...) Protection is the cornerstone of the whole project."* (Katrine Juul Larsen, 2022, p.c.). This indicates that 'protection' has been chosen as the primary CCA strategy, in addition to raised urban terrain. The strategy of 'retreat' is mentioned as challenging: *"Retreat' is just a difficult word in the context we have at the moment (...). It is difficult because right now we have areas near the port that are actually not very built up, and in principle, they should remain that way, but there are money and development opportunities in getting more life and more housing at the harbor. People want the water. We want development and the whole development strategy is to turn the city towards the water - that is simply the motto of the city."* (Katrine Juul Larsen, 2022, p.c.). 'Retreat' and 'accommodation' are thus not considered suitable strategies, as the city's motto literally is a development of urban housing in the harbor.

Aabenraa

The perspective for the project is the year 2121, and the climate forecasts used are sea-level rise up to 1 m as well as extreme events with elevations up to +2.5 m, +3.35 m, and +3.35 m, where the latter is based on a historical water level rise in the year 1872 (Aabenraa Kommune, 2021). The case project's use of climate

³ 'Klimaatlas' is made by the Danish Meteorological Institute (DMI, 2022). Assens uses the 'Klimaatlas' data in their planning for CC (Larsen, 2022, p.c.).

forecasts has led to new understanding and considerations for Aabenraa municipality in work with climate adaptation: *"In the 2015 EU Directive Risk Management Plan, it was decided to raise the protection level to +2.5 m. And that should be enough for the next 100 years. (...) Now we have made this pilot project and it shows that +2.5 m may not be enough. So the question is: should we immediately go up to +3.5 m or will one prepare for it to be expanded to something taller in the future? The +2.5 m is already decided politically. (...) But in contrast to the year 1872 [extremely impactful storm surge], there are now sewers and electricity and infrastructure in the city, and huge sums of money are lost if you do nothing."* (Mohr, 2022, p.c.). This quote testifies to the project acknowledging long-time uncertainties and considerations of safe failure to avoid destructive climate impacts. The quotation indicates reflections of safe failure related to "prepare for it to be expanded to something taller"; however, NBA is not directly mentioned as the approach to ensure this.

The case project describes four narratives concerning CCA strategies for local urban development. One narrative deals with 'protection' and adaptive planning to the uncertain climate changes, another narrative deals with the development of housing at the harbor that can withstand floods, the third narrative deals with flexible 'protection' options, and the last narrative deals with 'accommodate' and 'retreat' interventions where urban and industrial parts of the harbor are 'given up' to nature. (Aabenraa Kommune, 2021). In this case, the redundancy and modularity are considered in the project; however, NBA is not described as a measure integrated to ensure these components; it is merely an outcome in terms of 'retreat.' The purpose of developing adaptive narratives has contributed to enhancing the understanding of redundancy and flexibility that can contribute to persistence for the area: *"We are pretty sure that we now have to make a strategic plan for adaptive climate adaptation. (...) The fact that it is adaptive must mean that we want to ensure that you do not make a dead-end solution that turns out not to hold and which cannot be further developed."* (Mohr, 2022, p.c.). However, the developed narratives of CCA strategies are pointed out to constitute problems concerning the desired urban development: *"You can easily raise the whole problematic coastal terrain and secure the city. But one also wants to be close to the water. So the urban architecture does not 'speak' to the climate adaptation model. Natural processes probably do to a greater degree, but they are difficult to create inside a city. There is always someone who owns these areas and if you have to buy them and let them flood, then it is expensive."* (Mohr, 2022, p.c.). This quote testifies to a potential clash between perceptions of needed urban development and the use of 'accommodation and retreat,' as these strategies are perceived as a constraint in the context of architecture, financing, and the desire for proximity to water.

Vejle

For Vejle municipality, especially the method of DAPP has contributed to safe failure discussions in terms of long-term thinking and adaptive approaches to avoid destructive climate impacts: *"Concerning the [method of] DAPP - it made us divide the strategies into phases - and because we are aware of future climate change, urban and technological developments - we could investigate which adaptive paths we are actually able to walk and what approaches and roads we have to work with in the long run - so we do not get to shoot ourselves in the foot. (...) It was a good way to talk to the politicians about these issues. At one point in the past, we talked about building a dam out on the fjord, but now instead we work with a safety zone up to elevation +2.0 m. To gain some time. Then we have a solution now and here - and we can work further with what it really is we need in the long run."* (Geertsen, 2022, p.c.). This discussion has also contributed to the Storm Surge Strategy for the city that has been prepared to handle a 100-year event in 100 years which is projected to be an event of +2.37 m. (Vejle Kommune, 2020b). The Storm Surge Strategy is based on long-term planning where elevation +2.0 m must be secured in 2025, elevation +2.5-3.0 m in the year 2050, and elevation +3.0 m in the year 2070. The CCA measure in the year 2070 must constitute a nature-based storm surge barrier located in the fjord. (Vejle

Kommune, 2020b). It is also pointed out that it is likewise climate stressors that must be planned for: *"The general seawater rise must be considered in the planning, not just storm surge because suddenly the average sea level is higher and then what about the linked groundwater rise and the outflow of the rivers."* (Geertsen, 2022, p.c.). This quotation, together with the plans for long-term adaptive planning in the form of NBA structures, proves that the case project of Vejle can consider safe failure and acknowledge long-term uncertainties while integrating NBA as part of the projects' pathways.

The case project works with flexibility through the use of combined 'retreat' and 'accommodation' strategies where the previous coastal zone in the city is adapted to a terrain accepted to flood by acting as a kind of membrane, as seen in Figure 8 above, and where water is invited into the city thereby creating space for the landscape to get wetter gradually (as seen in Figure 9 and Figure 10). (Vejle Kommune, 2020a). In this way, the project builds robustness and preparedness and calculates for uncertain climate.

In terms of redundancy and modularity, Vejle has previously focused on 'protection' although has shifted focus: *"We have worked our way away from the risk management plans from 2015 where there were primarily suggested hard protection solutions such as concrete walls, etc. on how we could secure ourselves out by the fjord. (...) In the beginning, we talked about holding the water from the sea back from entering the city - but now we have moved on to a different agenda and accepted that it is not the only solution and that the water should instead be invited into the city. So there will be room for water inside the city."* (Geertsen, 2022, p.c.). 'Accommodation' in the form of inviting the water into the city is, therefore, the chosen strategy for long-term planning; however, 'retreat' is also seen as an option that should be discussed: *"We must definitely optimize in relation to how we built. For example, we have in the past filled up the fjord and continued to build in the low-lying area, and there it is important to think about climate change. The question is in the 'long long run' - to talk about the strategies for 'retreat' for the city and move the buildings away."* (Geertsen, 2022, p.c.).

Svendborg

The case project's time horizon is the year 2100, and as the harbor already is threatened by sea level rise and storm surges by a water rise of 1.4-2.0 m (Realdania, n.d.-b), the project uses different climate projections (RCP4.5 and RCP8.5) to calculate for future impacts, which has led to the requirement for a level of +3.00 m (for the year 2100) and possibilities for measures up to level +5.00 m on yet longer-term (DAPP workshop, 2022, App.B). Svendborg Municipality is aware that the preconditions and the need for CCA will change in step with urban development (Realdania, n.d.-b) and is also aware that there are different possible CCA strategies to choose from: *"we have to deal with the water on the surface, either we have to adapt buildings, or hold the water back, or give up on some of it. "The Blue Edge" is about robustness."* (Nielsen, 2022, p.c.). This quote indicates, together with the discussions of long-term options in the DAPP workshop (App. B), that the case project is considering safe failure to avoid destructive impacts while acknowledging climate uncertainty. However, NBA is not considered a piece in the puzzle to increase safe failure (DAPP workshop, 2022, App.B).

Regarding redundancy, flexibility, and modularity based on NBT, the discussion of long-term planning focus on implementation of an external storm surge barrier, a laissez-faire approach, changed land use so that the terrain can cope with floods, retreat into the land, and abandonment of particular sub-areas (DAPP workshop, 2022, App.B), which are options that could integrate NBA typologies. Several of the plans discussed throughout the DAPP workshop (App.B) deal in particular with 'protective' measures; however, strategies for 'retreat' and 'accommodation' are by the participants termed 'laissez-faire solutions,' which in this context refers to not implementing coherent protection initiatives for a sub-area. However, all strategies that were selected for further development at the DAPP workshop contain elements of 'protection' and have names such as: "outer

line - as soon as possible," "outer line - as late as possible," and "inner line," although one of four is named "invite the water in" and contain a combination of strategic measures for 'accommodation' and 'protection.' (DAPP workshop, 2022, App.B). No 'retreat' options were mentioned as a strategy. The final strategy has not been chosen (DAPP workshop, 2022, App.B). These decisions on CCA strategies prove a focus on redundancy; nevertheless, the case does not consider NBA as part of the variety of options to ensure redundancy nor flexibility or modularity. Furthermore, neither nature, biodiversity, nor multifunctionality has politically been chosen as criteria for the project. In the DAPP workshop, NBA was shortly discussed concerning Assens' initiatives on dune landscape or a form of beach meadow area (DAPP workshop, 2022, App.B); however, as the port environment is sought preserved and suitable references on NBA in harbors were perceived impossible to find, the proposals were taken off the table.

8.3 Adaptive capacity of agents in the case projects

Adaptive capacity is first and foremost associated with learning (Tyler & Moench, 2012). As described in Section 5.2.2, the adaptive capacity of social agents constitute the following components (1) Resourcefulness, (2) Responsiveness, and (3) Capacity to learn. Associated analytical questions used to assess the potential building of adaptive capacity of agents in the case projects are described in detail in Section 5.2.2.

Assens

In Assens, the building of awareness and, therefore, resourcefulness has been an essential part of the agenda, as the development project has involved politicians, as well as interested and affected citizens and landowners through public participation: *"Many [agents] agrees that this [NBA] project can be super cool - we take care of flood protection and the erosion that is out there, and we also create a recreational landscape with activities and space."* (Katrine Juul Larsen, 2022, p.c.). The fact that Assens has proven the capacity to mobilize resources and act to embrace NBA in partnership with local agents indicates the building of adaptive capacity based on the NBT of the administration, politicians, and citizens. Furthermore, plans to establish co-design and public involvement in the further work are confirmed (Assens Kommune, 2021a). The participation of agents in the CCA discussions indicates an ability to build responsiveness for stakeholders involved, contributing to increased adaptive capacity related to the future impacts of the changing climate. The responsiveness of the municipality and the associated ability to learn from the project is also being proven: *"We have a project proposal, but we also know that this is not what ends up being realized. We need to discuss the project with the landowners and find compromises. We completed a hearing this summer; it is probably the project in the municipality that has received the most hearing responses in a long time. So it really is something that people care about a lot. I can understand that very well."* (Katrine Juul Larsen, 2022, p.c.). This indicates that the municipality is aware of potential conflict between stakeholders and proves a willingness and ability to respond to the identified issues and reconsider the realization of the project without compromising on the nature-based approach. Furthermore, knowledge from the project is being utilized by citizens elsewhere in Assens: *"Right now there are very active local citizens in the area that is outlining how the beach can be used over there. In this way, some of the experience we have from stage 1 [the case project] can be used in further development of climate adaptation for other stages."* (Katrine Juul Larsen, 2022, p.c.). This quotation indicates that the local agents have proven the capacity to learn from the NBA focus, thereby increasing their adaptive capacity.

Aabenraa

In the case project of Aabenraa, there has not been stakeholder identification or political or citizen involvement in connection with the development of scenarios and narratives, and no follow-up presentation nor discussion of the scenarios for the citizens is planned (Mohr, 2022, p.c.). Therefore, this indicates that no awareness and

resourcefulness are built due to the project for agents other than the municipal administration. However, according to Mohr (2022, p.c.), the goal of the project was the development of different urban CCA strategies, which has been achieved: *“the narratives have first and foremost contributed to us getting someone else to write that urban coastal climate adaptation is complicated and that there are different views on this issue. The narratives are not ‘so noble’ in the sense that one can choose one over the other right now.”* (Mohr, 2022, p.c.). Therefore, it is still up to the politicians to take a position on Aabenraa's future coastal CCA as *“We are not done with it, the report is not city council approved, however, it is noted by two committees before being handed over to Realdania and the Ministry of the Environment.”* (Mohr, 2022, p.c.). These quotations indicate that NBA has not yet been an integrated part of the decision-making, although politicians have “noted” the case project. Furthermore, the building of capacity of responsiveness to climate impacts of the local agents is not perceived as a part of the case project, as: *“There will be some technical solutions that we who work with the case must make sure are incorporated - it will not be a decision for the citizens whether to ensure +2.5 m or +3.5 m or whether to think adaptively. It will not be a common affair to decide this.”* (Mohr, 2022, p.c.).

Locally, the city council have the finished report of the case project, although it is questionable whether any of the politicians will read it or increase their capacity of learning from it: *“I do not think there are quite a few politicians who have actually read them [the report on future CCA scenarios/narratives]. Of course, it's a shame when you do a piece of work. (...) What is important now is how the city council gets all this urban transformation and climate protection made an agenda in Aabenraa. That's what it takes.”* (Mohr, 2022, p.c.). This quote indicates that the agenda of the case project has primarily been to open the discussion for the city politicians to various forms of CCA and urban development; however, it is relevant that the municipal planner does not have faith that the narratives are being read by local politicians, causing a question whether any agents have increased their capacity of learning in the context of the case project.

Vejle

Regarding the building of awareness, and thereby resourcefulness, several public processes and initiatives have, since the work started in 2011, involved citizens, politicians, as well as knowledge, and educational institutions, through workshops, public meetings, happenings, study trips, etc. (Vejle Kommune, 2020b). Citizen involvement is regarded as important in the city's management of CCA: *“It is incredibly important to involve citizens and politicians, it is something we have done from the beginning of the climate adaptation projects and therefore for many years now. We have had several citizen meetings and public meetings, and flood has been a focus for a long time. We have actively encouraged it a lot. We have also had Business Cups with businesses and others who could propose things, and Hackathons with educational institutions.”* (Geertsen, 2022, p.c.). In addition to the involvement of the citizens, there are several other purposes concerning the activation and awareness building of agents: *“Really, it is important for us that they [citizens] understand the challenge of the climate changes that are happening and how we try to solve it - and when the cloud bursts or storm surge comes that they are aware that there may be flooding and that the future may, in fact, look different. In this way, the citizens can understand that if we do nothing about this problem, then the hazards actually become dangerously impactful - and that we, therefore, have to act on it.”* (Geertsen, 2022, p.c.). In addition, the case project explicitly aims to create resilient urban development with the focus areas of climate resilience, social resilience, co-creative city, and digital city (Vejle Kommune, 2020b). Building social resilience builds on the two key elements of increasing citizens' awareness of climate issues and creating a common identity for protection against storm surges (Realdania, 2020). Geertsen (2022, p.c.) elaborated further on this: *“Social resilience for the citizens is what we really want to create with the climate adaptation developments also with the future residential areas. The Storm Surge Strategy contains many general thoughts on resilience. But those who live*

here must be a part of it; it is important that they tap into these challenges and solutions.” (Geertsen, 2022, p.c.). The goal of building social resilience in the form of responsiveness and awareness is thus a goal for Vejle.

Furthermore, the case project has focused on the aspects of dialogue (Realdania, 2020). Initially, the local lack of knowledge of future climate and the CCA strategies was considered a challenge in Vejle. Therefore, the project initially consisted of organizing an open dialogue process to ensure involvement (Realdania, n.d.-c). This indicates that agents could have increased their capacity to learn, as the municipality has worked actively with the participation of citizens both in the form of a digital citizens lab, dissemination installations, walk’n’talks, pop-up city planning laboratory, and works of art to increase NBA awareness at the fjord (Vejle Kommune, n.d.). Municipal reflections in connection with the relevance of the involvement in the consultation period are the following: *“What is important is also to get the climate adaptation projects communicated to the citizens. It is incredibly important to get it communicated so that people understand the problem - in everyday life; you cannot see that the soccer field we have built is, in fact, for cloudburst protection. Citizens must also know it and be aware and ready when the extreme event comes. Citizens need to be resilient too. In connection with the citizens’ meeting on the risk management plan, we have for example, arranged water walks and told about how it all connects so that the citizens can get an understanding of what they actually live in.” (Geertsen, 2022, p.c.).*

Svendborg

In connection with the case project’s architectural competition, *“The Blue Edge,”* Svendborg Municipality carried out a dialogue and involvement process for citizens, associations, leisure users, and companies (Svendborg Kommune, n.d.). The result was a catalog of ideas to qualify the program for the later established architectural competition on which the most recent development of the case project was built (Svendborg Kommune, 2017b). In connection with these citizen participation processes, a focus from the citizens was ‘more greening’ opportunities in the harbors’ development with reflections of desire for urban nature and the promotion of biodiversity (Svendborg Kommune, 2017b). The identification and involvement of agents indicate that the case project has increased the general awareness and assumably responsiveness to the climate impacts through co-design processes. The initial focus from the citizens on the greening of the harbor is noteworthy when aware that the case project at the present state does not plan to integrate new NBA options as described in Section 8.1 about the transformability of the case project.

Furthermore, the case project has had an explicit goal of professional, political, and citizen-oriented competence development (Realdania, n.d.-b). Politicians have been involved in the DAPP process, among other examples, in selecting criteria for the case projects’ development. However, no citizens were engaged during the DAPP workshop period (DAPP workshop, 2022, App.B). However, citizens’ dialog and involvement in connection with further development of the case project is planned to take place, although this will happen after the DAPP method is complete (DAPP workshop, 2022, App.B), therefore mainly increasing the capacity of learning for the municipal administration and politicians. Consequently, the responsiveness and learning of the citizens regarding NBA measures has not been actively built in the recent period of the case project, although the project initially had a goal of competence development for both professionals, politicians, and citizens.

8.4 Main findings of the assessment of climate resilience in the case projects

The analysis of Chapter 8 answers the sub-question 2 in Chapter 3, which constitutes an assessment of whether contemporary Danish projects for urban coastal CCA interventions are building resilience in connection with the concept of Nature-based Thinking. To answer this question based on the theoretical and analytical principles of building resilience related to NBT, the approach, reflections, and perceptions of urban and coastal NBA interventions were studied for the four case projects of Assens, Aabenraa, Vejle, and Svendborg, which were

initially chosen as the focus of research. As described in the case selection in Section 6.3, the case projects are characterized as unusual in their decision to consider nature-based solutions in their CCA projects, thus weighing as being four cases 'most likely' to adapt and build resilience to coastal climate risk in connection with NBT. The following outline describes whether the cases are the most likely to build resilience based on NBT.

Are the case projects building transformability based on Nature-based Thinking?

The case project in Assens embraces change towards NBA and actively works to push the CCA project toward mainly NBA typologies such as dunes, groynes, reefs, nourishment, vegetation, etc. Furthermore, the case of Assens gives increased biodiversity a high value in the project and claims that all stakeholders agree on the adaptation project being nature-based. Therefore Assens is assessed as building transformability based on NBT.

The case of Aabenraa embraces the idea of NBA as an approach in the planning for future climate risk by actively creating two of four future scenarios to constitute NBA; however, when it comes to the contemporary perception, nature is not considered 'needed' in the project and is rather perceived as a fertilizer of the debate of general future development than a realistic approach in the local environment. Therefore, Aabenraa is building transformability, however, mainly due to embracing nature in their scenarios.

The case project in Vejle directly embraces the implementation and further development of NBA. However, the purpose of the project is not building nature for the sake of nature, although nature is already a part of the decision-making as experiments of NBA are underway. Therefore the case of Vejle can be assessed as building transformability based on Nature-based Thinking.

The case project of Svendborg initially focused on nature as part of the CCA project of the harbor; however, as the case has developed, the NBA proposal of an urban salt marsh was decided against, meaning that the sole NBA typology used in Svendborg is beaches. Therefore the case of Svendborg cannot be assessed as building transformability based on Nature-based Thinking.

Are the case projects building persistency based on Nature-based Thinking?

In the case project of Assens, persistency is being built based on NBT as the focus is flexibility and modularity due to the possibility of rebuilding the nature-based typology of the sand dunes. There is, however, a perceived conflict within the inner urban harbor area between CCA strategies of 'retreat and accommodate' involving NBA and the political and local wishes for urban coastal development.

In the case project of Aabenraa, the redundancy and modularity are considered in the project due to long time horizons, climate uncertainty, and CCA strategies are part of the frame of the project, which in itself can built persistency. However, the persistency is not based on NBT. This is due to similar perceptions of conflict as in Assens, regarding the conflict between perceptions of nature-based 'retreat' and need for urban development.

In the case project of Vejle, in terms of persistency based on NBT, the project consider nature an integrated part of the variety of options in the future pathways. The project considers long time-horizons and climate uncertainty and plans for all three CCA strategies in the development, meaning that the case project can build persistency based on NBT.

In the case project of Svendborg, persistency, in general, is being built as the municipal manager describes the project as being about robustness, long-time horizons are included, as well as the acknowledgment of climate

uncertainty. However, the persistency is not being built due to NBT, and therefore Svendborg is not persistent in terms of this specific approach.

Are the case projects building the adaptive capacity of agents based on Nature-based Thinking?

In the case project of Assens, the adaptive capacity of agents has been increased through citizen participation and co-design. Mainly, the focus on flood protection through NBA measures has contributed to increased learning and knowledge-sharing between agents. The adaptive capacity of agents is likewise being built in other coastal urban sites, as experiences from the case project are being used to change perceptions of the NBA measures in other projects that aim to reduce the impacts of the climate.

In Aabenraa, the awareness or responsiveness of the case project itself, or the NBA possibilities otherwise integrated into the project, have not been increased for others than the municipal administration. The case project aimed to develop CCA strategies for the urban coastal areas for politicians to “make climate protection an agenda in Aabenraa” however, the municipal manager doubted the politicians had read the project report. Therefore, the case project of Aabenraa cannot be assessed as increasing the adaptive capacity of agents.

In Vejle, the building of social resilience through awareness and responsiveness through a focus on the NBA has been on the agenda for more than a decade, and citizens’ participation and co-design is a significant part of the case project, which again is increasing the capacity to learn and acquire new knowledge for agents while building responsiveness to understand and act on the future climate challenges projected in Vejle.

In the case of Svendborg, the general adaptive capacity has been built due to the involvement of citizens in the early stages of the design phase and since further citizen participation is planned to take place. However, the awareness, responsiveness, and capacity to learn for the citizens are not being built directly in connection with the concept of NBT, as the citizens are mainly being involved when the municipality and politicians take the decisions in terms of CCA strategies and criteria for the development of the case project.

9. Perceived barriers and opportunities for Nature-based Adaptation

The analysis identifies the perceived opportunities and barriers in the case projects related to NBA integration in the urban coastal areas. The operationalization of opportunities and barriers built on the analytical framework in Section 5.2.3 and the interviews of municipal managers and the DAPP workshop participation in Svendborg, previously used in Chapter 8. The purpose of the assessment is to provide an understanding, as Folke et al. (2010) describe it, of dimensions, values, and probable more profound slower variables, in society that enhance or undermine resilience building. In this case, the dimensions and values in the case projects are perceived by the managers to generate barriers and opportunities related to the integration of NBA.

9.1 Perceived opportunities for NBA

The case projects will be assessed according to the analytical questions: Which perceived opportunities have the case projects experienced or expected to face related to the NBA?

NBA as a multifunctional and transformative approach

NBA is, in general, regarded as an opportunity to ensure a transformative approach to the ongoing work of CCA in the case projects, and especially the case areas of Assens perceive NBA as a way to step away from the business-as-usual and traditional approaches of dikes and investigate new opportunities: *“The idea of nature-based solutions stems from the municipal administration to investigate if you could do something other than building a traditional dike”* (Larsen, 2022, p.c.). Therefore, the use of NBA constitutes a step away from traditional thinking toward a changed approach when planning to reduce risk of climate challenges. Furthermore, the approach of NBA is reflected upon as a step towards valuing nature's qualities as a multifunctional value in the urban landscape: *“That's what the [two NBA] narratives operate with - green areas and places to walk - it's a contribution to the city and not just for those who live there.”* (Mohr, 2022, p.c.). This indicates NBA is perceived as an opportunity in the urban environment to create added values.

NBA as a tool to increase awareness

In Vejle, the municipal manager agrees that nature constitutes multifunctional values. Nature is further seen as a means to educate, bring awareness, and build adaptive capacity for the citizens: *“When we ask people why they move to Vejle - then nature is the reason. So if we get some more nature out here in the fjord - which also provides some other opportunities and experiences - you can see how the water actually moves - the citizens get more answers to these phenomenon - there are tides, etc. and there are opportunities out here for wetlands, some which are wet once in a while and some that are dry and sometimes it's all wet. These differences are exciting. And it will be able to build resilience because it can build consciousness.”* (Geertsen, 2022, p.c.). Furthermore, Vejle perceives NBA as a means to open up the discussion on mitigating climate issues and whether or not the CO₂ footprints of CCA measures should be considered in the design process: *“Concerning climate change and avoiding the large sea-level rise, we simply have to make sure to stop CO₂ emissions. It is also relevant to look at the CO₂ footprints of these solutions for CCA. Because basically, it's easiest to build a concrete wall - it's faster and cheaper too. But what about the CO₂ footprint of that concrete wall compared to the Nature-based Adaptation options?”* (Geertsen, 2022, p.c.).

The approach of adaptive planning

The four case areas have all either finished or are underway using the methods of Dynamic Adaptive Policy Pathways (DAPP). DAPP is used as a strategic tool to investigate how adaptive planning for CCA could contribute to the projects (The Danish Coastal Authority, 2020). The interviewed managers all positively experienced DAPP as a tool to open the discussion in the field of urban coastal CCA: *“The DAPP tool is about wiping the slate clean*

and making sure all the possible solutions are on the table. All these solutions are then being filtered with the tool of criteria for what the solutions should constitute. (...) The DAPP tool is used by many municipalities to ensure the decision-making is made from many different considerations.” (Nielsen, 2022, p.c.). When mentioned that the tool of DAPP is about *all possible solutions*, the approach of using DAPP, therefore, expectedly encourages a discussion of Nature-based Adaptation.

Furthermore, the case projects experience the adaptive planning as a tool to strategically discuss flexibility and modularity for different pathways, including NBA pathways: *“What we got out of the DAPP process was a road and approach we worked concerning the dynamic adaptation approach - it made us divide the strategies into phases (...) Now through the DAPP process, we had to discuss how we could work further if we went out of the different paths.”* (Geertsen, 2022, p.c.) and *“[The] DAPP method have helped us to become more clear about what is indisputable in our strategies and initiatives. (...) We are more clear on what action options we have ahead”* (Larsen, 2022, p.c.). These quotations indicate that different approaches and pathways are discussed in the case projects, and since especially Assens and Vejle confirm a continuation of the work on NBA, as concluded in Section 8.4, the DAPP process is proven to be able to integrate NBA as an adaptive element.

The case projects are additionally able to see the benefits of the adaptive perspectives in terms of increased legitimization of the projects and the decisions for NBA and further confidence in the long-term decision-making: *“(...) In this way, we have a holistic description that we have some challenges. (...) Now it is no longer an official in the municipality who is the “no-sayer”. Now it is a project where finances, emotions, urban development, and everything is in the pot, and this helps to legitimize that you have thought about all aspects.”* (Mohr, 2022, p.c.). Furthermore, the decisions, for NBA and in general, have proven relevant to reflect on the local reality and political landscape: *“The DAPP method is a reality check for the municipality”* (Participant, DAPP workshop, 2022, App.B) and *“The DAPP process has been applicable to politicians. And also concerning being confident and confident in the decisions that are made”* (Geertsen, 2022, p.c.).

9.2 Perceived barriers for NBA

The case project’s perceptions of barriers to NBA will be assessed by the analytical question: *Which perceived barriers have the case project experienced or expect to face related to NBA?*

Future uncertainty for climate projections

Several municipal managers from the case projects mention that planning for the uncertain climate is problematic: *“It is complex and difficult to know if you are doing the right thing.”* (Larsen, 2022, p.c.), *“It is definitely very complex.”* (Mohr, 2022, p.c.) and *“It is complicated.”* (Geertsen, 2022, p.c.). One of the main contributions to the complexity is the long-term climate projections, as especially long-term estimates are uncertain. The case areas experience challenges in determining the future impacts NBA should be able to withstand: *“What is a bit tricky with projections is that the water levels of the future are not greater than the storm surge heights of the past, and these historical storm surges do not appear in the high water statistics for the future.”* (Larsen, 2022, p.c.) and *“In 2019 we got new maps where we used new [the latest research on] climate scenarios - it turns out that the climate scenarios of the future are based on statistics and history - a 100-year event in 2100 was estimated to +2.44 m back in the year 2012, and now the year 2019 a 100-year event in the year 2115 is estimated to be +2.30 m. And that's because we've not had such major incidents since - so the statistics are changing - and suddenly, it does not look like the future projection is getting as bad as it did only six years earlier. Can you see the issue here? And try to tell the politicians and citizens- they suddenly think it's going the right way with the climate. However, what one can hold on to is a historic event added with*

the expected average sea level rise of the future." (Geertsen, 2022, p.c.). As the quotes indicate, estimating which climate projections the NBA interventions should be able to handle is perceived a frustrating challenge due to internal differences and disagreement on how to calculate climate impacts correctly: by the historical experiences or by the projected statistically calculated scenarios.

The uncertain long-term horizons, although often used as an argument favoring modular NBA interventions, are perceived as contributing to a conflict due to clashes in perceptions of the need for the measures. This is the case even when interventions increase the climate resilience: *"The focus is on protecting the entire city, and it is long-term - we think 100-200 years ahead - something that protects in the future. This time perspective is different from the [citizens'] landowner perspective (...) who maybe owns their houses for only 10-20 years. This is one of the major clashes in relation to long-term and nature-based solutions."* (Larsen, 2022, p.c.) and *"What you do in 100 years, I think the politicians are a little indifferent to, they just prefer not to be the ones doing something wrong."* (Mohr, 2022, p.c.). These quotations indicate that the conflicts often lie in communicating climate uncertainties with the citizens and politicians. These agents are not seen as able or interested in having a long-term perspective.

Barriers regarding the strategic CCA approaches

The perceived barriers for NBA are similarly present regarding the use of the different CCA strategies 'retreat, accommodation, and protection'. Especially the strategy of 'retreat' is for the case areas seen as a complex or almost impossible decision: *"Retreat - it's going to take a few years to talk about it. But there will come a time when we'll have to talk about that. But the political landscape is not ripe for it yet - not local politics at least. I think that is general in Denmark."* (Larsen, 2022, p.c.) and *"The trend of 'retreat' there are many expensive agendas that speak against - because you must have secured the city one way or the other, and if you give up these areas to the sea [and thereby the nature] where you actually have the space to build the security on - then you have a big minus in the economic side of it. (...) Here in Aabenraa, you cannot give up areas and just 'let them go' - then the pollution flows out into Aabenraa fjord; you are also obliged not to let that happen. Right now, it is encapsulated inside the steel sheet walls. Furthermore, you would have to deal with water depths of 11 m in Nyhavn."* (Mohr, 2022, p.c.). The quotations indicate that retreat is perceived as an 'unripe' approach within the political landscape and as the financial stakes to "let go" of the urban coastal areas together with perceived issues of pollutions are conflicting with the integration of NBA.

Furthermore, the use of the word 'protection,' which is used by all four case projects, is mentioned as a barrier to the NBA. Vejle reflects on this issue, and the use of the word 'protection' as the 'go to' word used for 'adaptation' in general, and that this could create unintentional expectations and potentially contribute to favoritism of traditional hard structures often used as protection for CCA: *"When we use the word protection, it also creates an expectation. (...) because we just use the word protection as a general word for adaptation. (...) However, I often say 'protection to a certain level."* (Geertsen, 2022, p.c.).

Financing NBA

One of the main barriers in terms of NBA is perceived as the financing of interventions: *"Right now, we are working on getting the nature-based solution priced, and it is not cheap. (...) I'm shocked when I see what these [NBA] can cost - the solutions with concrete walls are cheaper - but then you have to consider what [added values] you actually get with these solutions?"* (Geertsen, 2022, p.c.). The fact that the case area of Vejle has experienced unforeseen prices of the NBA interventions testifies to it being a potential conflict; however, as Geertsen mention, the decisions on interventions should consider wishes for added values. The other case

areas, however, also experience or expect challenges of how to finance the long-term projects that NBA often are: *“One thing is what we think is a super good idea; another is what we can raise funding for. (...) For our municipality, this is a huge development project.”* (Larsen, 2022, p.c.) and *“Economic conditions are the main challenge to a narrative of nature-based solutions because to afford coastal climate adaptation; you have to sell building plots. And it must make sense locally.”* (Mohr, 2022, p.c.). These quotes testify to a clash between making space for NBA and financing the interventions, which are often funded through sold building plots in the same harbor area that requires climate change adaptation. The issue of the need to finance the projects by selling coastal building plots is further exacerbated in cities where the development is perceived as “slow”: *“It is the economy in these urban coastal housing projects that must lift the economy in the coastal climate protection projects. You have to use urban transformation as a lever to make these solutions. (...) To make it financially viable, it requires someone willing to invest - and it's probably not billions of DKK that will be invested in Aabenraa as the payback period is not fast, so it is probably not Aabenraa that is the first choice. Aabenraa is one of the places where development is relatively slow.”* (Mohr, 2022, p.c.). The challenges of ensuring finances this way create a paradox as the sold areas are at risk of climate challenges. In Aabenraa, they also connect the issues of finances with the nature-based approach of ‘retreat’: *“There is always someone who owns these areas and, if you have to buy the areas and let it flood - then it is expensive.”* (Mohr, 2022, p.c.).

A tool to finance the coastal CCA interventions in Denmark is the ‘distribution of financial distribution’⁴. This tool makes it possible for municipalities to ensure a financial contribution from citizens if they gain “safety” from the interventions. (Kystdirektoratet, 2019). However, the tool is met with mixed experiences and approaches in the case areas. In Svendborg, concerns are raised that an expensive project might be hard to ‘sell’ if the citizens themselves are to pay: *“Contributors depend on sub-areas or whether you take it all at once. It is difficult to have an overview of which strategy is easiest to distribute contributions with - the politicians probably also want that understanding. One great project is perhaps the hardest to get through [accepted] because it is the most expensive one.”* (Participant, DAPP workshop, 2022, App.B). Vejle has decided on a political level not to use the tool: *“We have not decided on making a distribution of financial contributions for citizens on this project. And we have discussed this with our politicians. (...) Money must therefore be set aside for this project, you could say.”* (Geertsen, 2022, p.c.), and Assens have decided to wait until the entire city has CCA measures before distributing the payment for the NBA project: *“(...) of course, the citizens are preoccupied with this (...) you may only distribute the payment to those who benefit and get something useful from the project. There are first benefits for everyone [in the entire city] the second you put a gate in the harbor inlet. (...) Distribution of financial contribution is very complex in this type of project.”* (Larsen, 2022, p.c.). As the quotes indicate, the financial contributions are seen as complex, and the tool is not yet used as a payment method for the projects. Furthermore, not all citizens are aware of this tool: *“Most citizens think it is those who build and the municipality who will take care of the finances.”* (Mohr, 2022, p.c.). This indicates a barrier for NBA as the projects cannot be afforded to implement by the municipalities alone. At the same time, the citizens expect this to be the case.

With all aspects of financial issues in mind, it is relevant to consider whether the models used to finance these projects are, in fact, the most favorable ones. The economic matters seem rather silo-oriented between the administrative departments or in terms of persuasion of citizens and politicians to believe in the need for adaptation in general. As Geertsen mentions (2022, p.c.), NBA projects could constitute multifunctional values. Therefore, I would argue, the financing of the interventions could benefit from an interdisciplinary dialog, potentially contributing to a multidisciplinary financing model.

⁴ Also known in Danish as ‘bidragsfordeling’.

Inexperience with nature in the CCA projects

Another barrier in terms of the integration of NBA in the urban coastal environment is the perceived inexperience with the approach compared to the experience with conventional CCA measures: *"You cannot control nature in the same way as conventional systems - you do not know if it works yet. We do not know if it works with what we are planning out there - and we also hope it will look good, however, we do not know that yet. (...) And how are operation and maintenance expected to be? Whereas the hard surfaces we know are trustworthy to a certain degree, and you roughly know what it costs and what guarantees there are. It is difficult to get guarantees with nature-based solutions compared to the guarantee of building a concrete wall. Nature-based solutions provide more operation unless they can 'take care of themselves,' (...). And that's what we need to investigate."* (Geertsen, 2022, p.c.) and *"It really depends on whether we can get that nature created and get some experience."* (Geertsen, 2022, p.c.). This indicates that Vejle, although aiming to integrate NBA in their project, highlights the challenges and insecurities regarding nature as still being a very new and inexperienced field compared to the already tested conventional types such as hard concrete structures. In connection with the DAPP workshop in Svendborg, the politicians decided that one of the criteria for final interventions in the case project should be *'something that works (solutions that have been tested or seen before)'* (DAPP workshop, 2022, App.B). Therefore, the attitude in Svendborg doesn't align with the integration of NBA as cases such as Vejle testify that they still lack experience and guarantees of NBA being reliable.

A clash of perceptions of NBA

Another barrier in terms of NBA is how the different social actors perceive nature and NBA in general: *"It is also the sand and dunes that there are very skeptical opinions about. They [citizens] do not understand how sand can keep water out. They are skeptical of sand drifting - one can understand that too. There are lots of challenges here we do not fully know yet."* (Larsen, 2022, p.c.) and *"Something else is the citizens - they have to be part of the decisions - and we want it to be wild and not so polished - and of course, there are different opinions here. It is also our goal with NBS in relation to the more traditional solutions to try to put something more 'wilderness' into development projects so that nature in the areas should not all be mowed grass landscapes. (...) It depends if the citizens can relate to this goal, but the trend of wild nature and the Danish concept of 'wild on purpose' has become more acceptable recently - there has been a shift here. We have run projects with landowner associations where they themselves have built freshwater pools and some wild nature, and we have made campaigns. The urban nature does not have to be maintained and polished and freshly cut grass."* (Geertsen, 2022, p.c.). These quotations indicate that the barrier due to different perceptions of NBA stems from differences in knowledge and opinions of urban nature.

Prioritization of urban and industrial space versus NBA

The barrier is not solely the lack of experiences and the perception and acceptance of NBA and trends of the urban wilderness; it is additionally the conflict of prioritization of space for certain activities: *"The toughest and biggest clash with nature-based solutions and coastal cities is space. As soon as you get close to the harbor areas, there is just not much space. (...) If nature-based solutions should be implemented inside the harbor, then the basin needs to be filled up in some areas - and are we interested in that? I do not know at this point. It's probably what's the biggest challenge in many projects in coastal cities."* (Larsen, 2022, p.c.) and *"But the question is whether nature-based solutions is what you want to use the harbor for, it may not necessarily be the solution you want to use here."* (Korsgaard, 2022, p.c.) These quotations indicate that the NBA is perceived to take up too much space near urban/industrial areas and therefore is not seen as possible in the redevelopment of especially harbors. The references of which 'solutions' and 'interests' are sought in the urban/industrial coastal areas question whether there are wishes or possibilities to integrate NBA in the projects.

Furthermore, Vejle mentions the space conflict regarding the need for housing: *"We also have the challenge that we have a large influx of people, and where should people live, they want to live inside the city, and it makes it further complicated."* (Geertsen, 2022, p.c.). Whereas Aabenraa describes the conflict as dependent on the local mentality: *"You have to think long-term and do something that fits into Aabenraa's culture - but you also have to challenge the culture a bit. However, I believe the existing culture is not for such a large climate adaptation project [the NBA narratives]."* (Mohr, 2022, p.c.). Finally, Assens experiences conflicts between citizens' short-term wishes for the landscape and the municipal long-term nature-based wishes: *"What makes it difficult is all the feelings involved in a project like this. Everybody understands the climate problem well, but there are different opinions about the solutions. From the municipality's point of view, the focus and purpose are not to protect one coastline from flood events, it is rather on protecting the city of Assens, and in that context the project is the first stage of the long-term plan for flood protection."* (Larsen, 2022, p.c.).

As the barrier to finances, so could this barrier of perceived disagreements between local urban development preferences be a subject of silo-oriented approaches and -thinking for citizens, the municipal administrations, and the politicians. Svendborg reflects on this issue: *"Some things would have to be pushed for nature-based solutions to come through and be integrated inside the urban harbor area."* (Nielsen, 2022, p.c.), and the perception that "some things have to be pushed" for NBA to be an acceptance in the urban development, in this case, a harbor, indicates a need for an interdisciplinary dialog concerning what NBA could contribute.

9.3 Main findings

The perceived opportunities and barriers for NBA reflected upon in the case projects, are relevant to understand to acknowledge which aspect of the current projects can enhance and undermine the building of resilience.

Which perceived opportunities have the case project experienced, or expect to face, related to NBA? How does this enhance or undermine resilience? The interviewees mentioned a perceived opportunity is the link between NBA and the adaptive way of planning. Adaptive planning, in these cases the DAPP method, is perceived as a method contributing to adding long-term and strategic perspectives, which are reflected as being especially beneficial in legitimizing decisions behind paths for NBA, as nature-based interventions often are superior in the long run in terms of modularity and flexibility. The long-term and adaptive planning for NBA are components that enhance climate resilience. Furthermore, the perceived opportunities are mentioned as the potential of multifunctional and transformative values that NBA constitutes and the ability of NBA to increase awareness. NBA is noted as being a constructive approach to step away from path dependency and ensure sustainable urban transformation in the name of enhanced nature qualities and possibilities, opening up the discussion of the CO₂ footprint of CCA measures. The components of awareness, transformability and natural attributes building as a value themselves contribute to climate resilience.

Which perceived barriers have the case project experienced or expects to face related to NBA? How does this enhance or undermine resilience? The cases seem to aim toward sustainable projects; however, they are deeply planted in a path-dependency approach, especially the use of the 'protection' as the primary strategic CCA approach. The integration of all three strategic CCA approaches is perceived as challenging, and concerns are being raised about whether the politicians and citizens are ready to face the consequences of especially 'managed retreat.' The perceived barrier of the application of 'accommodation and retreat' could undermine the building of resilience. Furthermore, future climate uncertainty is perceived as a barrier to NBA interventions. The challenge lies in the dissimilar advisory for and use of climate history and climate projections. The uncertainty in the long-term decision-making creates a barrier to the acceptance of NBA as a tool in the toolbox.

NBA is often chosen due to the benefits of modularity and flexibility regarding uncertainty; however, as the case projects struggle to decide on the uncertain 'predict' element in their 'predict-and-prevent' tactics, then NBA will not be acknowledged for its benefits, which again will undermine the building of resilience.

The barrier to financing the NBA interventions is a general concern for the municipalities. The finances of implementation and maintenance of coastal NBA are uncertain as the approach is perceived fairly new within the field of CCA, as well as the general financial issues of CCA, nature-based or not, concerning distributions of financial contributions amongst the citizens and conflicts between politicians, citizens, and planners not seeing eye to eye on the necessity of finding finance for long-term horizons. This could undermine the building of resilience as finances always will be a significant part of decision-making, and if finances of long-term decisions are ruled out, then the concepts of NBA and resilience are challenged.

Yet other perceived barriers, which further undermine the building of resilience, are the contemporary challenges of NBA in terms of inexperience, clash of perceptions, and lock-in thinking concerning the prioritization of activities such as industry in the urban coastal space. Experiences of the NBA approach in the urban coastal landscape are perceived as limited, and NBA is mentioned as challenging due to lack of guarantees of trustworthiness of the interventions, lack of references of realized urban interventions, lack of willingness, and perceived necessity to transform traditional urban or industrial space, and clashes of acceptance and prioritization of urban nature from politician, municipal administrations, and citizens.

10. Development of 'reflective discussion-cards'

This analysis constitutes the development of the planning tool of 'reflective discussion-cards,' which builds on (1) reflections of the coupled results of the *NBA catalog cards* developed in Chapter 7, the assessment of the *principles for resilience* with a basis in the case projects assessed in Chapter 8, and finally the results of the *opportunities* and *barriers* identified in Chapter 9, and (2) the analytical framework in Section 5.2.4 with the point in departure in Metcalfe's (2015) original principles for "Multispecies Design." This section aims to reflect upon how to push the boundaries within the field of climate resilience and Nature-based Thinking and investigate and question the results of the analyses in terms of which elements would be relevant to reflect or discuss for stakeholders present in urban coastal development projects.

10.1 Reflections on results from previous analyzes and Metcalfe's principles for Multispecies Design

The development of the NBA catalog cards in Chapter 7 resulted in identifying and assessing 18 NBA typologies. These typologies constitute the 'first step' of the NBT framework, as the catalog present how nature can be a facilitator for climate resilience in the urban coastal context. The analysis of NBA typologies indicates a variety of options with different technical, economic, environmental, and social indicators. *Main reflections to integrate into the 'reflective discussion-cards': Use of the 18 catalog cards to discuss how to achieve the 'first step' of NBT.*

The assessment of the case projects' capacity to build resilience due to the integration of Nature-based Adaptation in Chapter 8 resulted in the main findings that Vejle and Assens manage to implement transformable nature-based projects that build climate persistence while also building adaptive capacity for their relevant social agents. However, the cases of Svendborg and Aabenraa did not enhance the building of resilience concerning the integration of the NBA. *Main reflections to integrate into the 'reflective discussion-cards': The integration of reflection upon the three principles of the concept of climate resilience in connection with NBT; transformability (embrace change and new knowledge, the entitlement of nature beyond 'solutions,' nature as a stakeholder in decision-making), persistency (modularity, flexibility, redundancy, safe failure), and adaptive capacity (responsiveness to climate impacts, resourcefulness, awareness, and ability to learn/ inform/adjust).*

The assessment of perceived opportunities and barriers for NBT and climate resilience in Chapter 9 resulted in several relevant findings concerning the contemporary perceptions from professionals working on the case projects. The perceived opportunities are the appropriate link between NBA and long-term adaptive planning for resilience, as NBA is often positively associated with long-term processes that can be modulated over time. Other opportunities are the potentials which NBA typologies constitute; transformative building of resilience, multifunctional, environmental, climate mitigating, and social awareness increasing values. The barriers to the concepts are, however, perceived as various. A barrier is perceived as being the path-dependency of the use of 'protection' instead of also using 'accommodation and retreat,' while another barrier is the long-term uncertainty of projected climate changes resulting in reluctant integration of long-term resilience focus through the use of flexible NBA typologies. Another significant barrier is perceived as being the finances of NBA as the long-term cost and maintenance of the interventions are experienced as a conflict in the decision-making between strategic planners and more short-sighted citizens and politicians. The final barriers are perceived as the contemporary inexperience with NBA, lock-in prioritization of traditional uses of coastal urban space, and clashes of acceptance for wild urban nature. *Main reflections to integrate into the 'reflective discussion-cards': How to take advantage of the perceived opportunities for NBA of long-term adaptive modularity/flexibility and the potentials of transformability, climate mitigation, natural values, multifunctionality, and social awareness. How to overcome the perceived barriers for NBA of the path-dependency of protection, the long-term*

uncertainty of climate changes, the financing of NBA, the perceptions of urban natural wilderness, the inexperience of NBA, and the prioritization of traditional aesthetics and industry in the harbors.

The development of the planning tool of 'reflective discussion-cards' is developed to provide a tool for discussion on how nature can facilitate change towards climate resilience and constitute the transformative step away from a mindset of designing solely for humans in the urban environment (Metcalf, 2015; Randrup et al., 2020). With this in mind, the 'reflective discussion-cards' are developed to push for the two steps of NBT: (1) The discussion on how to integrate nature in the planning for urban climate resilience, and (2) the reflection on how nature can be acknowledged as a 'client' in the urban space. The following steps indicate which principles, based on Metcalfe (2015), the 'reflective discussion-cards' build on:

Step 1

Researching nature in a design context for climate resilience.
Designing interactions between human-nature-climate resilience.

Step 2

Treating nature as clients of design in building of climate resilience.
Designing climate resilience like an ecosystem.

The purpose of the analysis is to investigate what kind of planning tool could advance and lift the discussion between municipal divisions, local politicians, and involved citizens about urban climate resilience and the relevance of Nature-based Thinking; furthermore, the purpose is to create "no-failure" cards as Metcalfe (2015) likewise argues: 'there is no wrong way to use the cards.'

Main reflections to integrate into the 'reflective discussion-cards': There is no wrong way to use the cards; they are designed to open a discussion and constitute a reflection on the concepts of climate resilience and Nature-based Thinking. The two steps and associated principles are the four main principles of the planning tool.

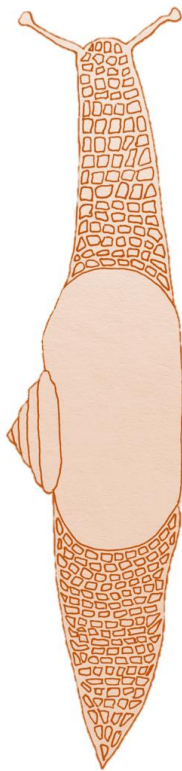
The following two sections constitute the finished planning tool of 'reflective discussion-cards,' built on the mentioned main reflections from previous analyses and the two steps of Nature-based Thinking.

Step 1: Researching nature in a design context for climate resilience

Learning the science of resilient Nature-based Adaptation

Look at the *18 NBA catalog cards*, read books, and papers, watch films, and talk to scientists studying urban nature, climate resilience, and Nature-based Adaptation.

How can you embrace change and new knowledge for Nature-based Adaptation, climate resilience, and urban nature in the project?



Identify nature spokespeople

Where possible, identify nature spokespeople capable of speaking on behalf of nature and the NBA approach throughout the design

Multispecies and multifunctional design

Spend time with your nature clients in the field.

Investigate the eco-socio-technical interaction between nature, humans, and objects of climate adaptation, and investigate the need for persistence to sea level rise and storm surges of the urban NBA interventions.

What need does the Nature-based Adaptation project have for long-term modularity, flexibility, redundancy, and options for safe failure?

Proxy interviews

Interview people studying urban nature, climate resilience, and Nature-based Adaptation.

Ask them to talk about and on behalf of nature.

Somatic design research

Explore the resilient Nature-based Adaptation constructions from the perspective of nature.

Learn the biological and ecological facts of coastal nature above and below the sea.

Use experimentation through imagination, movement in the place, pace, and height of nature, role-playing, or other means that could encourage the world's view from a perspective of nature.

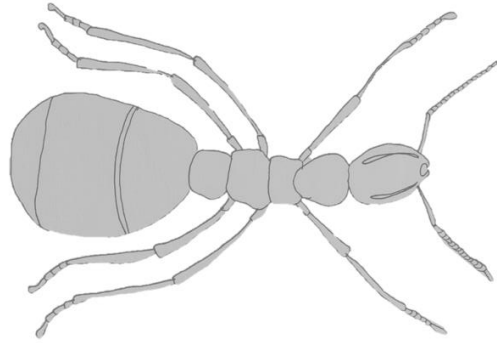
Step 1: Designing interactions between humans, nature, and climate resilience

Representing nature in resilient climate adaptation

Can your chosen Nature-based Adaptation typologies help make the presence of urban wildlife/wilderness more visible in the climate adaptation project in cities?

Can it highlight the needs of nature?

Can it highlight the benefits of living amongst nature?



Focusing on mutually beneficial interaction

How does your Nature-based Adaptation design benefit both nature and citizens?

How can the interaction contribute to building adaptive capacity for social agents in terms of resilience to climate changes (responsiveness of citizens to climate

Address existing perceived/cultural opportunities

Nature-based Adaptation could be advantageous for long-term adaptive planning. How can the design be advantageous in the long term? Can the design be adaptive, modular, and flexible?

Nature-based Adaptation could be advantageous in terms of climate mitigation, natural values, multifunctionality, transformable design, and social awareness. How could your design contribute to these aspects?

Which further opportunities could you picture for Nature-based Adaptation in the urban coastal space?

Address existing perceived/cultural barriers

Nature-based Adaptation could experience challenges due to financing the implementation and maintenance. How could your design help overcome this? Are there any interdisciplinary solutions to finance the project?

Nature-based Adaptation could experience challenges due to cultural preferences of climate 'protection' interventions and the long-term uncertainty of climate changes. How could your design also investigate the NBA typologies associated with 'accommodation and retreat'? How could the NBA design play a role in uncertain and long-term climate changes?

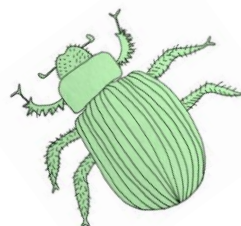
Nature-based Adaptation could experience challenges due to different perceptions of urban natural wilderness, inexperience with the designs, and potential conflicts within the urban/industrial harbor areas. How could your design challenge cultural/traditional preferences and misconceptions regarding urban nature in the coastal urban areas? How could your design play a role in building experience?

Which further barriers could you picture for Nature-based Adaptation in the urban coastal space, and how could the design overcome these?

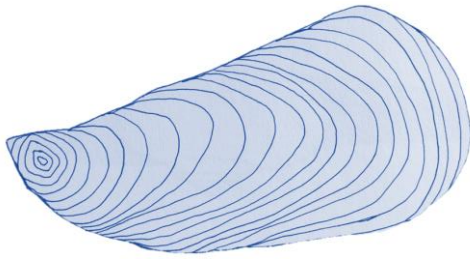
Seeking synergies and co-benefits

Nature-based solutions and services can provide benefits for human habitats. When looking at the 18 NBA typologies and the associated sustainability indicators, which synergies could your design establish between nature and humans?

Can you think of other synergies or co-benefits not directly connected with the typology in the 'catalog cards' which could be integrated into the design?



Step 2: Treating nature as clients of design in building of climate resilience



Extending responsibilities

Extend the same respect, responsibility, and space to the client of nature as you would to the human clients.

How can wild nature in the NBA project experience entitlement and move beyond being a 'solution' or a 'service'?

Participatory nature design

Nature will modify and interact with the design of Nature-based Adaptation, consider this, and design for these interferences.

How can you create a participatory design for nature, and how can you encourage 'nature-for-natures-sake'?

Identifying needs

Identify the needs of the nature you are designing for in the Nature-based Adaptation project.

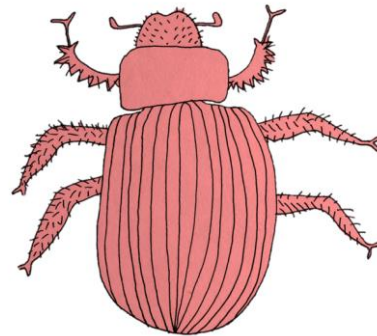
What is missing, or creating a risk, in human habitats for nature to thrive?

Representing nature in the design process

Create nature personas and include them in stakeholder interaction maps of your project.

While prototyping, assess the designs also from nature's perspective.

How can nature become a stakeholder in your decision-making process?



Step 2: Designing climate resilience like an ecosystem

Open-ended design

Consider your design of Nature-based Adaptation as part of an ever-changing system where the outcome is never final or in control.

Is the design resilient in terms of being able to change according to processes such as climate change, weather, and ecological?

Ecology of reference

Consider the ideal ecology of reference for the design of Nature-based Adaptation.

How could you design for similar features of the ecology of reference?

Connectivity

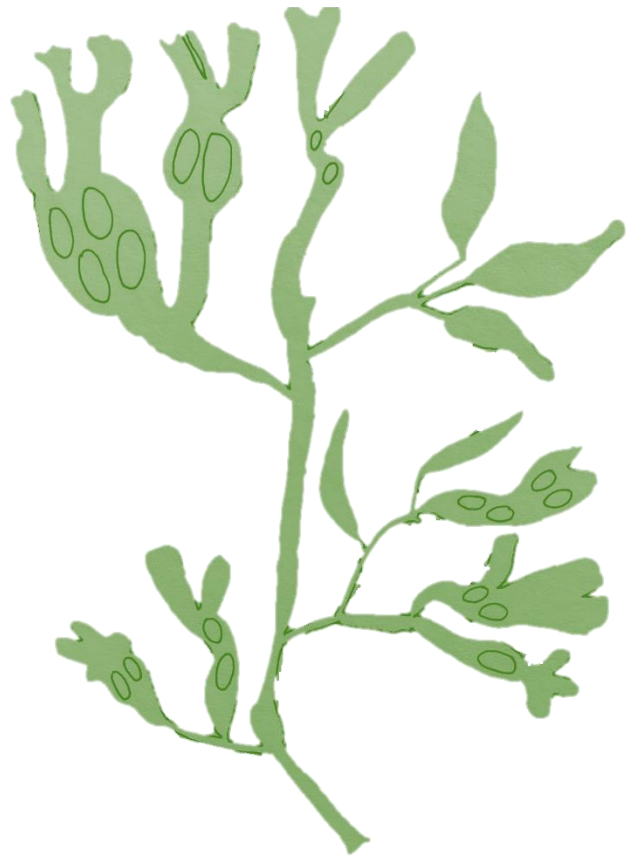
How can your design of Nature-based Adaptation increase habitat connectivity?

How can the design help connect otherwise separated green areas in the urban environment?

Embrace complexity

Consider how to embrace and include the complexity of the form and materials in your design, as this can lead to more biodiversity.

How can you embrace and encourage the complexity and change of nature in the long run?



11. Discussion

The chapter on the discussion of results and findings of the research is divided into three sections: (1) the discussion of results and main findings, (2) the discussion on the limitations of the research, and (3) the reflection and discussion on the points of attention from the research and recommendations from the thesis.

11.1 Discussion of results and main findings

The state-of-the-art review of Nature-based Adaptation relevant in a Danish urban and coastal context identified 18 typologies representing all the strategic CCA approaches of ‘protection, accommodation, and retreat.’ In total, four typologies represent the approach of ‘retreat,’ eight of ‘accommodation,’ and ten of ‘protection.’ More than half of the typologies represent the approach of ‘protection,’ meaning that the dominance of this strategy is a continuation of the past and present dominance of hard protection measures as problematized in Section 2.1.1. However, the approach of ‘accommodation’ is associated with almost as many typologies as the approach of ‘protection,’ which indicate a focus on NBA could contribute to the development of measures other than protective aspects. The review shows that four typologies are associated with ‘retreat,’ indicating that the approach is underrepresented in the typologies due to cultural and spatial challenges. Furthermore, the NBA typologies present state-of-the-art urban coastal interventions that enhance biodiversity while building resilience to coastal climate hazards and finally mitigating the climate through carbon sequestration. All while being economically beneficial due to the long-term benefits of redundancy, modularity, and flexibility, simultaneously contributing to the social aspects of human health, livability, and interactions between humans. The NBA catalog cards are constructed as the ‘first step of the Nature-based Thinking’ since the first step constitutes the investigation of nature-based solutions which can act as CCA interventions. The 18 different typologies are applicable by themselves or combined and constitute 18 diverse landscape solutions. Each includes the synergies between urban human-oriented values of climate resilience and values for the natural environment of the coastal zone. The catalog is a form of a basic assessment tool for readers to easily distinguish between the typologies while assessing and supporting decisions on suitability and feasibility between alternative typologies, including key performance indicators of synergy capacities and technical, economic, environmental, and social potentials. The catalog further implies a step toward NBT in which nature is no longer reduced to the final aesthetic layer or the so-called ‘icing on the cake’ in the urban development, but rather the synergy of nature and adaptation constitute the means to develop a more resilient and holistic interventions.

Main findings: The state-of-the-art NBA catalog consists of 18 different typologies, representing a noticeable difference from the conventional CCA interventions in demonstrating applicability for all the strategic CCA approaches in a more distributed manner. The difference from traditional dominant protection measures is especially relevant as this proves the character of NBA as a versatile approach to the long-term, uncertain coastal climate changes. Moreover, this thesis argues that NBA interventions in the urban coastal zone should be a cherished ‘first step’ approach to reconnecting citizens and nature, encouraging holistic and resilient interventions, and ensuring a transformative synergy of enhancing biodiversity, climate mitigation, and climate change adaptation.

To assess the potential of building resilience in connection with Nature-based Thinking in the four selected case projects in Denmark, interviews have been conducted with five municipal employees working with the case project and therefore contributing with context-relevant information, just as four other professionals within the field were interviewed which contributed with general knowledge on the scope of the thesis and selection of the case projects in the first place. The assessment of the conducted interviews was built on the chosen

theoretical and analytical background and the associated interview guideline based on theoretical principles for resilience. It is crucial to understand that the theoretical and analytical principles selected as the framework in this thesis are just one way to assess resilience. Other approaches could have contributed to different results of the analysis. This thesis has evaluated the following from the study of the four case projects: the transformability of the case projects in terms of NBT was assessed as being built in Vejle and Assens and to a degree in Aabenraa. However, Aabenraa admitted that the acceptance and implementation of the NBA scenarios were perceived unrealistic, which Svendborg additionally experienced as a conflict between the cultural and industrial use of the harbor and the adaptation interventions of nature-based character. The persistency of climate stresses and shocks concerning NBT are assessed as being built in Vejle and Assens, although this is not the case in Svendborg nor Aabenraa. The overall persistency is being built for all four case projects in terms of general acknowledgment of the need for long-term and adaptive pathways; however, it is solely Vejle and Assens who relate their building of persistent capacity directly to NBA. In the case areas, the adaptive capacity connected to NBT was assessed as being built in Vejle and Assens. Aabenraa and Svendborg are building adaptive capacity in general, as the process of the case projects is leading to citizens' involvement and learning-by-doing initiatives; however, these two cases are not succeeding with the building of adaptability concerning the focus of NBT.

When looking back to Section 6.3 on how the case projects were initially selected, the selection was based on the understanding that the four cases were working with nature-based CCA and long-term strategic planning and, therefore, additionally are the 'most likely' case projects to address Nature-based Adaptation in a manner in which contributed to climate resilience. However, according to the results of the analysis just described, only two of four case projects are establishing resilience due to the integration of NBA.

Main findings: The case projects are the 'most likely' projects to build resilience due to the integration of NBT in their contemporary work; however, the cases are divided in this regard. Vejle and Assens are perceived to overall build the three principles of resilience due to NBT. In contrast, Svendborg and Aabenraa doubt the feasibility of NBA in the urban coastal environment and, therefore, not building the resilience principles concerning NBT.

The assessment of the perceived barriers and opportunities regarding Nature-based Adaptation as a means to climate resilience in the four selected case projects highlighted the following aspects:

The opportunity and relevance of the link between NBA and adaptive planning. Adaptive planning, in the case projects especially prevalent through the use of the DAPP method, is perceived as a method contributing to long-term and strategic perspectives, which are reflected as being especially beneficial in legitimizing decisions behind paths for NBA, as nature-based interventions often are superior in the long run in terms of modularity and flexibility. The long-term and adaptive planning for NBA are components that enhance climate resilience.

The potential of multifunctional and transformative values that the NBA constitutes and the ability of NBA to increase awareness. NBA is perceived as being a constructive approach to step away from path-dependencies and ensure sustainable transformation of the urban development in the name of multifunctionality, enhanced nature qualities for the sake of nature itself, and new possibilities to encourage the discussion of differences in CO₂ footprints between conventional CCA measures and NBA. The components of awareness, transformability, and enhanced nature qualities could contribute to building climate resilience.

The case projects are deeply planted in a path-dependency approach, especially concerning the use of the strategic CCA approaches of 'protect, accommodate, and retreat.' The integration of all strategic CCA approach is perceived as challenging in the cases, especially concerning 'retreat' and associated NBA, as concerns are

being raised about whether politicians and citizens are ready to face the consequences. The perceived barriers regarding 'accommodation and retreat' could undermine the building of climate resilience.

The uncertainty for the future climate is perceived as a barrier to NBA interventions. The challenge lies in dissimilar advisory and use of climate history and projections in the cases, and the uncertainty in the long-term decision-making creates a barrier towards the acceptance of the NBA as a tool in the toolbox. NBA is often chosen due to the benefits of modularity and flexibility regarding uncertainty; however, as the case projects struggle to decide on the uncertain 'predict' element in their 'predict-and-prevent' tactics, then NBA will not be acknowledged for its benefits, which again will undermine the building of resilience.

The barrier to financing the NBA interventions. The cost of implementation and maintenance of coastal NBA is uncertain as the approach is perceived as relatively new, as well as the current general financial issues of CCA, nature-based or not, concerning distributions of financial contributions amongst the citizens and conflicts between politicians, citizens, and planners not seeing eye to eye on the necessity of finding finance for long-term horizons. This could undermine resilience as finances always will be a significant part of decision-making. If long-term financed projects are ruled out, the concepts of NBA and resilience are challenged.

Contemporary challenges due to inexperience, clashes of perceptions, and lock-in thinking concerning urban coastal nature. These barriers could further undermine the building of resilience, as experiences of the NBA approach in the urban coastal landscape are perceived as limited, which creates challenges such as lack of guarantees and trustworthiness of the interventions, lack of references of realized urban interventions, lack of willingness and perceived necessity to transform traditional urban or industrial areas, and clashes of acceptance and prioritization of urban natural wilderness from politicians, municipal administrations, and citizens.

Main findings: Within the case projects, NBA is perceived as an opportunity to challenge path-dependent decision-making, increase awareness, and legitimize long-term and adaptive decisions to which NBA is often superior. However, within the case projects, several barriers to the NBA approach are perceived, such as the accommodation to flood and managed realignment, the struggle of long-term uncertainty in the decision-making and agreement on long-term finances of NBA, and general inexperience and lack of references for NBA, and lock-in thinking in the development of urban coastal environment.

The final analysis consists of the 'second step' of the theoretical concept of NBT, which constitutes the step toward urban nature being acknowledged as a stakeholder in the urban and coastal environment to force a transformational change in the mindsets of citizens. It has been necessary to develop a 'reflection-tool' contributing to open the discussion of the perceived barriers and opportunities, the principles of building urban climate resilience in coastal cities, and how to integrate the two steps of NBT in the decision-making process of future resilient urban coastal development. The tool is developed with a point of departure in Metcalfe's (2015) argumentation that "there is no wrong way to use the cards." Therefore, the tool constitutes open 'reflective discussion-cards' to open the discussion on how to enhance the synergies between urban nature-for-natures-sake, climate resilience, and climate mitigation. The tool consists of two sections of discussion cards, each with two belonging principles, which constitute the first and second steps of NBT, and therefore ensure that both steps of the framework of NBT are present and contribute to potentially open the discussion of how NBT could enhance resilience. The 'reflective discussion-cards' of the first section build on the two main principles of *researching nature in a design context for climate resilience* and *designing interactions between human- nature-climate resilience*. The 'reflective discussion-cards' of the second section build on the main principles of *treating nature as a client of design in building climate resilience* and *designing climate resilience like an ecosystem*. Each section further constitutes associated subjects with belonging reflections and questions for each discussion-

card, which stems from a combination of the translations of Metcalfe's (2015) "Multispecies Design" to involve NBA and NBT, together with synergies to the main findings of NBA typologies and perceptions and potentials of building resilience from the previous analyzes conducted within this thesis.

Main findings: The development of a planning tool with the ability to open the discussion on NBT and climate resilience have contributed to the two-step 'reflective discussion-tool.' The tool constitutes the two steps of NBT and integrates the main findings of the three previous analyzes to establish a set of discussion-cards expectantly suitable to use in a decision-making process when aiming to integrate Nature-based Adaptation and – Thinking in the urban coastal development projects.

11.2 Limitations

In this section, the significant limitations of the research design for the thesis will be discussed regarding the reliability and validity of the results and theoretical, analytical, and methodological decisions taken.

Validity

Internal and external validity refers to the integrity and accuracy of results. Internal validity refers to the extent to which results within the context of the study represent reality, and external validity refers to the generalizability of these results. (Bryman, 2016).

The internal validity of the thesis could be compromised due to the chosen theoretical and analytical framework of assessment of climate resilience, as the approach consisted of taking a model for resilience, in this case, the three principles of building resilience, and checking it off, however, one could also directly have asked the municipal employees working on the case project whether or not they were working with resilience related to NBT and what this could constitute. The decision to follow the 'checking off' method stems from a wish not to influence the subject on reflection from the interviewee with specific annotations to *resilience* and *nature-based*. However, this resulted in findings that depend on specific theoretical and analytical assumptions. While the theoretical and analytical approaches have influenced the validity of results, the approach can still bring valuable insight into how the projects are developed in reality and the perceived barriers and opportunities in connection with ongoing experimentation and reflections on the use of urban nature in the CCA projects.

The external validity could have been compromised due to the decisions behind selecting the case projects, as the specific focus on critical and extreme cases could compromise the generalizability of the results. Nevertheless, the case projects can, due to their characterized unusual nature, act as an inspiration for other projects, just as the decision to identify the four cases as the 'most likely' to build resilience, due to integration of NBT, could create generalizability of the results for other case projects in Denmark. In my case, I argued that the case of Svendborg, just like Assens, Aabenraa, and Vejle, was a good example of a case with a focus on NBS. However, I realized eventually that this logic was flawed, as my research showed that the case project of Svendborg cannot be classified as 'most likely' to gain resilience through NBT, as especially local political influences are not proving this hypothesis true, and this was not clear in the initial research. Instead of Svendborg being a critical case, it might rather, according to Flyvbjerg (2006), constitute a maximum variation case as it is very different from the other cases in the dimension of perception of possibilities for urban NBA. This brings forward whether the cases are, in fact, the 'most likely' to build resilience through Nature-based Thinking. However, the cases all have experienced an interest in the development with nature, which cannot be said for many coastal urban projects in Denmark.

Furthermore, the generalizability of the review of NBA typologies could be compromised, as the state-of-the-art study builds on other sources which comprise its own internal and external validity.

Reliability

The reliability of results refers to the associated replicability of findings (Bryman, 2016). In this thesis, the results of the case projects' potential for building resilience might not be entirely generalizable; however, the approach to which the case projects are assessed could be replicated. Furthermore, the used quotations from the interviews of municipal employees in the case projects, although checked and re-written by the interviewees themselves before being used in this thesis, could be subjective results which could compromise the likeliness of receiving similar results if the study were to be reproduced. This is especially the case concerning the perceptions of the concepts of NBT and climate resilience, as the principles for the concepts constitute a picture of the present situation and current view on the topic and relevance of the concepts. Additionally, the interpretation and translation of the interviews from Danish to English could be a subject of researcher bias on my side, as my background in sustainable planning potentially could have influenced the reliability of the translations. Finally, the 'NBA catalog cards' results in Chapter 7 were primarily developed to create a basic catalog of typologies of easily-read and comparable cards. The focus was never to estimate the complete technical, economic, environmental, or social performance, which could compromise the reliability of the results. However, this has resulted in a catalog of suitable typologies within the urban coastal zone, although all the typologies may not be feasible in every technical or geological context.

11.3 Points of attention and recommendations

This section discusses points of attention and recommendations associated with the results of the thesis.

Consider Nature-based Thinking as an opportunity to discuss future needs.

Nature-based Thinking is not the solution to all the issues; however, it is a concept that could bring awareness and push for a transition from path-dependency of 'protection' toward multifunctional and combined solutions for the crises of biodiversity and climate change. In general, the use of the 'NBA catalog' and the 'reflective discussion-cards' could encourage ethical reflections upon how to balance anthropogenic and ecological values and could activate a discussion of nature views/understanding in which stakeholders' perceptions are challenged, and mindsets are changed, as well as interdisciplinary opportunities created. Questioning environmental ethics and urban planning decisions favoring anthropocentrism is likewise to take a step in the direction of socio-ecological resilience (Faragò et al., 2018). To take the crisis of biodiversity, as well as climate mitigation, seriously, a new perception of nature could be influential, and to ensure such a transformative change, Randrup et al. (2020) argue that the urban population must be reconnected *"with nature directly, physically as well as spiritual, emotional, etc."* (Randrup et al., 2020, p. 922). This thesis argues that NBT can open the discussion on future needs for humans and nature below and above the sea. However, I also agree with Metcalfe when he argues that: *"this is not to say that every feature in built environments should be enhanced for an ecological value, or made into a habitat for nonhuman species"* (Metcalfe, 2015, p. 115). Of course, cultural, industrial, etc., values in the urban coastal areas should be maintained, just as the case of Svendborg reflects upon regarding NBA. Historical and cultural values are essential to preserving; however, to take the crises of climate and biodiversity seriously, the status-quo might not be enough anymore. Randrup et al. are aware of this issue and argue that the concept is bound to experience resistance *"from existing institutions (and associated experts, planners, managers, and governments),"* and they say that the NBT approach, therefore, has to be long-sighted (Randrup et al., 2020, p. 924). For the existing resistance, such as Svendborg and Aabenraa, to take their guards down, Randrup et al. (2020) argue that a discussion of future needs instead of a discussion of the final layout of the cityscape could benefit both humans and nature.

Consider nature-based climate resilience as a resource rather than a threat.

Nature-based climate resilience could be utilized as a resource in the planning rather than being pictured solely as an approach to dealing with the threat of climate change. I argue that resilience could catalyze change, such as the development of synergies for several Sustainable Development Goals, when mindsets shift from climate change to a future negative impact instead of being an option of change for the better.

Both resilience thinking and Nature-based Thinking aim for the development projects to comprise a discussion of the process rather than an outcome in which the process allows for uncertainty and encourages CCA as adaptive, ongoing, and to a degree never ‘finalized’ (Faragò et al., 2018; Randrup et al., 2020; Tyler & Moench, 2012). Compared to the current practice of ‘predict and prevent’ in CCA projects, the focus is on developing a finalized outcome. However, as reflected upon in the case of Assens, the nature-based ‘outcome’ focus of the project resulted in disagreement amongst stakeholders. Could the focus on resilient processes rather than technical ‘preventive’ outcomes benefit the local discussions on utilizing climate change as a resource? This thesis argues that instead of predicting future impacts, the project should consider suitable adaptive strategies to cope over time, so we do not end up constructing one “Atlantis” after the other.

Furthermore, resilience is a holistic planning approach and could constitute a resource in the decision-making, as discussions of how to build the principles of transformability, persistency, and adaptive capacity in case projects benefit all stakeholders. This has been the case in Vejle, where the holistic project values social resilience just as much as the parts of persistence and transformability. When taking a step away from ‘predict and prevent’ with the associated goal of constructions having a certain height, which again gives people the association of protection, then the projects should instead, according to this thesis, encourage transformative change to an adaptive nature-based system, focus on making certain assets persistent, all while acknowledging the adaptive capacity of the social system as the social agents are the ones to respond.

Consider more interdisciplinary opportunities.

All of the case projects assessed in this study reveal that long-term financing of NBA, and CCA projects in general, are perceived as a barrier and that conflicts are experienced due to the tool of “distribution of contributions of finances.” Similarly, Faragò et al. (2018) argue that CCA is costly and that this makes it all the more relevant that the development are long term and capable in terms of multifunctional aspects for ecology, society, and economy. Good solutions are developed in a close and interdisciplinary dialogue between experts such as engineers, architects, citizens, ecologists, and other relevant professions (Faragò et al., 2018). However, as Dehlbæk (2022, p.c.) elaborated, the Danish multifunctional CCA project is still a rarity. I would argue that the opportunities of more interdisciplinary, and therefore multifunctional, projects could create synergies that several fields could finance. Furthermore, climate resilience, as well as Nature-based Thinking, are agendas across different professions; therefore, the projects should be equally interdisciplinary, and innovative networks, professional knowledge exchange, and even training and collective learning across sectors and disciplines with the purpose of climate resilient, long-term, and holistic planning, should be encouraged.

Acknowledge path-dependency of ‘protection’ and encourage the approaches of ‘retreat and accommodation,’ and consider the CCA language used in the projects.

Wiberg (2019) argues that if projects in Denmark continue to solely use the strategic CCA approach of ‘protection’ and dominant typologies of dikes and sluices, then we are just building ourselves into a new set of urban and architectural problems. The analysis results of the case projects reveal that the ‘protection’ strategy is the priority in Svendborg, Assens, and Aabenraa, whereas Vejle is working with mixed approaches. Especially the strategic CCA approach of ‘retreat’ is perceived as a barrier for all the cases: *“Retreat’ - it’s going to take a*

few years to talk about it. But there will come a time when we'll have to talk about that. But the political landscape is not ripe for it yet - not local politics at least. I think that is general in Denmark." (Katrine Juul Larsen, 2022, p.c.). This quotation indicates that the prioritization of 'protection' stems from local politicians not being willing, or able, to discuss the option. This is additionally the case in Aabenraa: *"The trend of 'retreat' there are many expensive agendas that speak against - because you must have secured the city one way or the other, and if you give up these areas to the sea where you actually have the space to build the security on - then you have a big minus in the economic side of it. (...) Here in Aabenraa, you cannot give up areas and just 'let them go'"* (Niels-Peter Mohr, 2022, p.c.). This indicates that the 'retreat' option is perceived as the opposite of 'securing' the city and the same as 'giving up areas.' The fact that 'retreat' is perceived as so difficult to grasp for the case areas is, I would argue, interesting when aware of how the exact opposite approach of land reclamation has been historically accepted; for instance, approximately 1/3 of Copenhagen is built on reclaimed land from the sea. (Faragò et al., 2018). The issue of acceptance of 'retreat' is not technical at all; it is, however, mental and cultural. To accept 'retreat' is a social and psychological challenge where humans have to humbly accept nature as having a prominent role. Therefore, the approach of 'retreat' is not just a matter of technical or financial matters; it has potentially more anthropocentric roots in which 'retreat' is contradictory to how humans have always endured and optimized their chances. (Ibid.). The non-acceptance of 'retreat' therefore stems from world-views, and an open discussion, for instance, when exploiting the 'NBA catalog' or 'reflective discussion-cards' of this thesis, could encourage reflections upon such world-views, lock-in perceptions, anthropogenic values, and the present path-dependency of static technical 'protection' measures in the urban environment.

A final aspect that should be considered in the planning when encouraging the approaches of 'accommodation and retreat' is how the actual terms and language are being used. Especially in the Danish language, this is relevant, as the common terminology used to describe the term 'climate change adaptation' often instead results in the use of the words 'climate-protection' or 'climate-securement.' In the case of Vejle, they are starting to become aware of this potential misuse of words: *"When we use the word protection, it also creates an expectation. (...) because we just use the word protection as a general word for adaptation. (...) However, I often say 'protection to a certain level.'"* (Ulla Pia Geertsen, 2022, p.c.). Geertsen is therefore aware that 'protection' is used as a general word for 'adaptation,' however aims to use 'to a certain level' as a solution to ensure awareness of the climate uncertainty in the CCA projects. The Danish language used within these CCA projects are especially relevant to consider, for instance concerning examples such as 'retreat' often being referred to as 'abandon' which could bring negative annotations (Wiberg, 2019), or 'retreat' being referred to as 'lassies-faire' which was the case in the Svendborg workshop (see Appendix A). Lassies-faire as a word, I would argue, has nothing to do with 'retreat' or 'accommodate'; it is merely an approach of being indifferent and not actively choosing a strategy to follow. The last aspect of language misuse, which I consider highly conflictful, is the one of 'accommodation' almost only being referred to as 'adaptation' in the Danish language. This causes a significant misunderstanding of the approach of 'accommodation' and potentially affects decision-making. A different word for coastal 'accommodation' in the Danish language is highly relevant to look for, as this could equally affect the public and political acceptance of NBA.

12. Conclusion

To answer the leading research question: *how can Nature-based Thinking in the field of coastal climate change adaptation contribute to the climate resilience of Danish coastal cities?* it has been necessary to investigate the two steps of Nature-based Thinking adapted in this thesis: (1) identify and analyze the contemporary typologies for Nature-based Adaptation through a state-of-the-art review, and (2) propose a planning tool for reflection on how to take a step further regarding Nature-based Thinking and urban coastal climate resilience. Furthermore, it has been necessary to (3) assess contemporary case projects initially defined as working with coastal NBA and consider whether these projects, according to the theoretical notions adopted in this thesis, are capable of building resilience, and (4) which perceived barriers and opportunities are present regarding the concepts of Nature-based Thinking and climate resilience in the selected contemporary projects. Thus, the following conclusions of the thesis can be emphasized:

According to this thesis, the analysis, which constitutes the first step of Nature-based Thinking, revealed 18 state-of-the-art Nature-based Adaptation typologies. Several typologies are well-known historical interventions, such as dikes. However, several newer innovative NBA typologies were identified, such as the Dutch sand motor, urban salt marshes, floating constructions, nature-based seawalls, aquaculture, and the identification of existing or pipeline resilience-based NBA projects such as 'Living Breakwater' and 'Resilient Boston Harbor.' Furthermore, the development of the 'NBA catalog' for the 18 typologies revealed varied abilities of persistence to the climate challenges of sea level rise and storm surges, as well as transformative characters in terms of modular, combinable, and flexible technical features, climate mitigating and biodiversity increasing environmental values, innovative economic activities such as aquaculture and tourism, and finally social values such as recreation and human health. These values reveal the feasibility of safe failure/no-regret adaptation to uncertain climate hazards while simultaneously providing suitable options of multifunctionality in the urban environment. Finally, the 18 typologies revealed different opportunities of the strategic CCA approaches, as in total, four options represent the approach of 'retreat', eight of 'accommodation', and ten of 'protection'. The distribution of the strategic CCA approaches is relevant, as the majority represent 'protection' which is directly comparable to the past and present Danish prioritization of protection measures. It is further relevant that almost as many qualifying typologies constitute 'accommodation' which could push for this strategy by choosing an initial focus on the NBA approach. Lastly, the strategy of 'retreat' is present, although often in combination with other NBA typologies. The increased focus on 'accommodation and retreat' when reviewing NBA interventions could contribute to shifts in awareness of urban nature and acceptance of urban dwellings in and with the water.

Based on the analysis of the potential resilience building in connection with Nature-based Thinking of the four contemporary CCA projects in Assens, Aabenraa, Vejle, and Svendborg, the cases differ in their prioritization and ability to build transformation, persistency, and social adaptability, due to varied prioritization and perceptions of the potentials of Nature-based Adaptation. The case project of Vejle and Assens are innovative and experimental and able to create a fundamentally different system with the ability to build resilience in terms of both transformative, innovative nature-based ideas, persistency due to natural no-regret interventions, as well as awareness and knowledge building values of the nature-based projects able to increase the adaptive social capacity of social agents. The case of Aabenraa, to a degree, build resilience through the investigation of transformative NBA narratives for future urban development. However, the case locally is perceived to build limited adaptive capacity, and together with a municipal lack of confidence in the persistency of the NBA narratives, the case of Aabenraa is considered unable to build resilience due to Nature-based

Thinking. Lastly, the case of Svendborg is, to a degree, building persistency in the project through the application of adaptive pathways (DAPP method). However, the persistency is not linked to the use of NBA, nor is the general building of adaptive capacity or transformability within the case, meaning the case of Svendborg is considered unable to build resilience through the use of Nature-based Thinking. As the four case projects initially were considered the most likely to establish climate resilience in connection with NBT, this hypothesis is true for Assens and Vejle; however, false for the cases of Aabenraa and Svendborg.

Based on the analysis of perceived barriers and opportunities in the case projects of Assens, Aabenraa, Vejle, and Svendborg regarding the implementation of resilient Nature-based Adaptation, the key perceptions regarding this matter have been identified. Based on the analysis, the perceived opportunities of NBA are the potential to challenge lock-in tendencies and path-dependent decision-making, as well as NBA project's ability to increase awareness of both climate change and biodiversity and legitimize long-term adaptive planning. Based on the analysis, the perceived barriers to implementation of NBA projects are, in fact, very general and not solely connected to perceptions of urban nature as several barriers imply struggle of decision-making within a field of long-term, uncertain climate changes, issues of long-term financing, and difficulties to integrate other strategic CCA approaches than 'protection' causing continued lock-in tendencies with no use of 'accommodation and retreat'. However, barriers are explicitly associated with the nature-based approach as references and experiences of urban nature as a transformative or persistent element in the CCA projects are perceived as lacking, and the perceptions of the use of urban coastal environments constitute a lock-in thinking of preservation of industrial and urban looks. These key perceptions of opportunities and barriers should be considered in further development of the case projects, as well as in any other urban coastal NBA or CCA projects in Denmark, as these aspects should be either taken advantage of or considered how to overcome, as these aspects could influence the local ability to build climate resilience.

Based on the analysis of the development of the planning tool of 'reflective discussion-cards', the purpose of the creation of the tool was to lift the discussion of Nature-based Thinking, as well as integrate the reflection upon the concluded perceptions of barriers and opportunities and the principles of climate resilience used to assess the four case projects. The planning tool constitutes the two steps of NBT, and each step identifies two main principles and associated discussion-cards. The first step of NBT, adopted in this thesis, is to investigate NBA. Therefore the two principles of 'step 1' in the tool are about *researching nature in a design context for climate resilience* and how to *design interactions between human-nature-climate resilience*. The second step of NBT is, according to this thesis, about establishing a new perspective of nature-for-natures sake. Therefore the two principles of 'step 2' in the tool are about how to *treat nature as clients of design in building of climate resilience* and further about how to *design climate resilience like an ecosystem*. The last two principles and belonging discussion-cards are developed to push for a transformational change in mindsets and enhance the adaptive capacity of the stakeholders, potentially using the 'reflective discussion-cards' in the decision-making processes of NBA projects.

According to this thesis, resilience is about using a crisis to transform, in this case, using the combined crises of climate change and biodiversity to ensure and explore a new agenda, which according to this thesis, constitutes the concept of Nature-based Thinking integrated into the field of climate change adaptation in Denmark. Based on the analysis of the NBA catalog cards, the assessment of resilience, perceived barriers and opportunities for NBT in the selected case projects, and the study of 'reflective discussion-cards', several aspects of the NBT concept could influence the building of climate resilience of Danish coastal cities. The central element is acknowledging and integrating the two steps of NBT and the three principles of climate resilience. The

acknowledgment of the combined concepts can push the perception of urban nature and preferences for 'protection' strategies and establish learning through new knowledge, and therefore, complement the building of adaptive capacity of the social actors. The concept of NBT is a means to develop the transformative aspect of resilience, as Nature-based Adaptation and the notion of nature-for-natures-sake can build awareness and innovation of the possibilities for combined biodiversity and climate change mitigation and -adaptation. Finally, the combined concept of NBT and resilience can build nature-based persistency to climate risks, as the nature-based approaches encourage a step away from the traditional CCA approach of 'predict and prevent' and as the NBA is especially beneficial for long-term uncertainty of climate changes due to adaptive planning, flexibility, and modularity. The climate and biodiversity crises are a picture of the future unless transformations are established, adaptive capacity is built, and persistency to the changes is enhanced. Resilience is a system-thinking approach to climate change issues, as is NBT a new tool in the toolbox, and together these two concepts could create holistic adaptation and enhance biodiversity and climate mitigating efforts.

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Minutes

DAPP workshop (2022). Workshop by Teknologirådet for Svendborg Municipality's project "Den Blå Kant". Conducted March 22nd, 2022, in Fremtidsfabrikken, Svendborg. See Appendix B for minutes.

P.C. (personal communication)

Andersen, K. J. (2022) Interview with Kaija J. Andersen, the Danish Coastal Agency. Interviewed by the author. Conducted March 10th, 2022, over phone. See appendix C.1 for résumé of the conversation.

Dehlbæk, C. B. (2022) Interview with Christian Billund Dehlbæk, Region Midtjylland. Interview by the author. Conducted February 18th, 2022, over Teams. See Appendix C.2 for résumé of the conversation.

Geertsen, U. P. (2022) Interview with Ulla Pia Geertsen, Vejle Municipality. Interviewed by the author. Conducted March 30th, 2022, over Teams. See Appendix C.3 for résumé of the conversation.

Korsgaard, T. (2022) Interview with Trine Korsgaard, Svendborg Municipality. Interviewed by the author. Conducted March 2nd, 2022, meeting at Svendborg Municipality. See Appendix C.4 for résumé of the conversation.

Larsen, K. J. (2022) Interview with Katrine Juul Larsen, Assens Municipality. Interviewed by the author. Conducted March 28th, 2022, over Teams. See Appendix C.5 for résumé of the conversation.

Mohr, N. (2022) Interview with Niels-Peter Mohr, consultant for Aabenraa Municipality. Interviewed by the author. Conducted March 23rd, 2022, over Teams. See Appendix C.6 for résumé of the conversation.

Nielsen, A. A. (2022) Interview with Anna Als Nielsen, Svendborg Municipality. Interviewed by the author. Conducted March 2nd, 2022, meeting at Svendborg Municipality. See Appendix C.4 for résumé of the conversation.

Sørensen, C. (2022) Interview with Carlo Sørensen, the Danish Coastal Agency. Interview by the author. Conducted March 10th, 2022, over phone. See Appendix C.7 for résumé of the conversation.

Wiberg, K. (2022) Interview with Katrina Wiberg, Associate Professor Cand. arch. MDL, PhD. Interviewed by the author. Conducted February 8th, 2022, over phone. See Appendix C.8 for résumé of the conversation.

Appendices

Appendix A: Interview guide for municipal employees

Interview guide with semi-structured questions for municipal employees contributing to the development of CCA in the case areas of Svendborg, Assens, Vejle, and Aabenraa

Status and problem:

- What phase is the pilot project in. When did it start - where are they now?
- What are their CCA goals, and what is the main problems?

In connection with the 'Realdania program' and the method of DAPP:

- Where are you in the process?
- In connection with DAPP step 2a, have you prepared your own catalog of ideas for measures for climate adaptation? Which catalogs of ideas or cases have you used as inspiration in connection with the preparation of initiatives for climate adaptation?

The assessment of potential for climate resilience

Persistence to climate change

- Are you looking at different scenarios (RCPs or SSPs) for the future?
- What are the time horizons of the CCA project?
- Have you worked with different CCA strategies for 'retreat, protection or accommodation'?
 - How do you use them?
 - Is NBA a part of the strategies?
 - What are the opportunities and barriers in terms of these strategies, and nature-based options, in the contemporary projects?
- What is the project's ability to absorb climate shocks and stresses?
 - How do you plan for the 'shocks' from climate change - such as higher storm surges?
 - How do you plan for the 'stresses' from climate change - such as the average sea level rise?
 - Is NBA/NBS a part of these decisions?
- Which conflicts or opportunities can you imagine are associated with building persistence to climate change in urban coastal areas?

Transformative capacity related to nature-based options

- What do the project associate with NBS/NBA? How is NBA perceived?
- Have you previously or currently focused on NBS or nature-based CCA in the projects for coastal CCA?
 - Are there a focus of the benefits/rights of nature itself? Do they consider biodiversity enhancement?
- Which conflicts or opportunities can you imagine are associated with NBS, and CCA in general, of coastal cities?

Adaptive capacity

- Do you identify and involve stakeholders (citizens, politicians, governance) in the planning, identification of problems, and decision-making of CCA/NBA initiatives and discussions of future climate change strategies?
 - If so – how?
 - Have NBA been on the official agenda? If so – how and what did it contribute to for the stakeholders?
- Which conflicts or opportunities can you imagine are associated with the adaptive capacity of the stakeholders?

Appendix B: Minutes from DAPP workshop

B.1 Resume of question related to relevant case projects in Denmark

Answers from representatives of the Technology Council present at the workshop, when asked:

- Question: Which coastal towns work with DAPP and possibly NBS?
 - Svendborg (This city already has an action plan; NBS for a certain area (Havnepladsen) has been a part of the discussion in the previous phases of the DAPP workshop)
 - Aabenraa (This city has focused on NBS)

- Lyngby-Taarbæk
- Dragør
- Assens (This city discusses when decisions should be made, it is not an implementation plan but an action plan. They work with NBS)
- Vejle (This city it was clear which strategy met the most criteria. They work with NBS)
- Randers (This city had 5 strategies and 3 that scored best)
- Otterup beach on Funen, and the North Coast of Zealand.

B.2 Minutes from DAPP-workshop for Svendborg “Den Blå Kant”

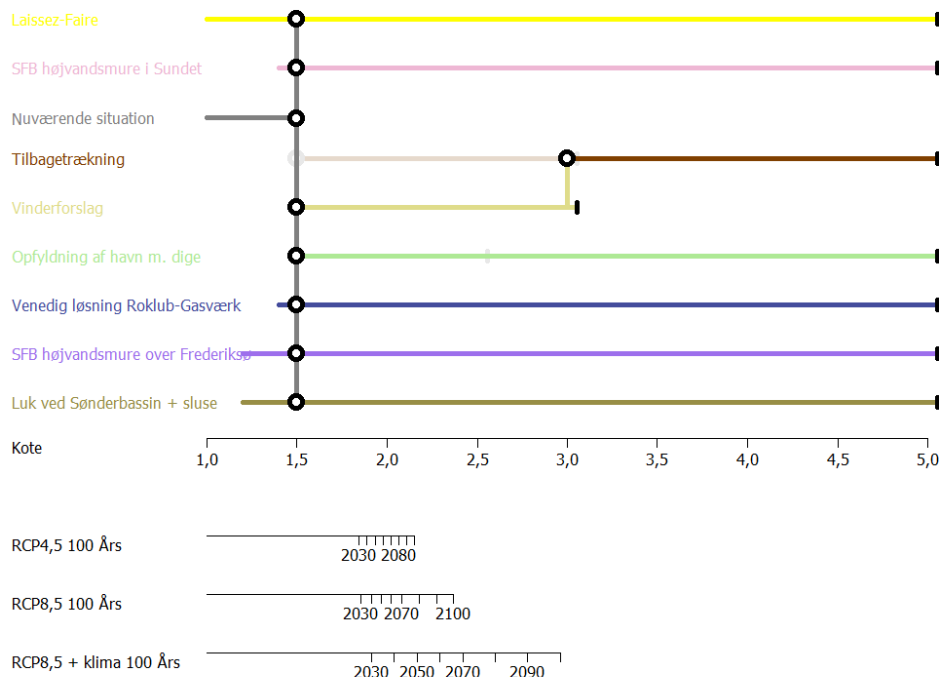
Nine participants at the workshop.

The first thing on the agenda is the review of the sub-areas' paths and approaches. Sub-areas can be seen in the illustration below (sent to the author by Anna Als Nielsen during the workshop).



The action plan is what we do now. It's very open - not a roadmap more a strategy.

Participants raise thoughts on the need for numbering of measures and explanation and reading guidance. There are confusion about the different paths. The winning proposal is integrated in the overall DAPP map for all the area. The overall DAPP map can be seen below. (sent to the author by Anna Als Nielsen during the workshop).



Map generated with Pathways Generator, ©2015, Deltares, Carthago Consultancy

Additional comments on the previous DAPP workshops and the minutes from last workshop:

- Uses Climate Atlas as background
- Participant: *"The DAPP method is a reality check for the municipality"*
- unrealistic to build for elevations +4 and +5 today. It's a reality check with the DAPP cards. If the bottom of a measure is dimensioned for elevation +3, you cannot raise to larger - so the bottom of interventions must be built so that they can rebuilt with larger elevation later on.
- When the flood wall in 100 years is not enough you have to change path. These are large time perspectives we are discussing. Trying to be aware of opportunities in the long run. One should revisit and update the paths.

Discussion of sub-areas and overall area and the DAPP maps made for each.

Sub-area 1

- Two areas in this. The old warehouse protected with a wall.
- "the mud hole" – either close or object protect, ensure new rules (accommodation) for new construction.

Sub-area 2

- Retreat does not protect the whole area therefore cannot stand alone.
- Two lines of protection are discussed - one by the water and one retreated line. First solution is possibly a pop-up wall, that can be raised in the long run. Other solution is move to the retreated line and create object protection = the area in front must then be able to handle it.
- one can also make lassies-faire.

Sub-area 3 Frederiksø

- Several tipping points - there are more than 3 paths in which you have to change paths due to low elevations.
- elevate ground floor to +2.5 m - why? maybe +3 instead?
- more relevant to discuss the solution of lassies-faire. A possibility never to protect Frederiksø from storm surge.
- Two options: keep water out - or invite water in (object protection and elevate ground floors/make them ok to flood).
- Long perspective = object protection + changed land use. More seasonal use. Otherwise in the long run raise terrain.
- The paths does not align with the overall case area? If the climate goes crazy then we can raise the walls of the winning proposal from elevation +3 to +5.

Sub-area 4

- Two safety lines relevant. The current and the railway line which is further inland.
- Protect or invite the water into the front area: short-term hold the water out – or invite the water in and thereby rules for new buildings in terms of ground floors.
- one can say elevation +3 m is the maximum for management of flood and then the path is lassies-faire like retreat to the hinterland. Very relevant to work with the two lines here.

Overall case area

- The primary storm surge barriers only make sense when looking at the overall case area, not for the sub-areas by themselves.
- Not many solutions to choose from when it is overall case area - as it is the whole area – it is not possible to change path in the same way as in the sub-areas. Lassies-faire is an option - one can choose not to do anything at all.
- Barges that can be lowered - technical solution to a high water gate - it is not a path.
- Maybe the inner line should be on here as a path.
- Carlo's proposal with the new landscape created from steel sheet walls – thereby closing off the entire Sound/harbor (from thurø to the tåsinge bridge) the entire boat harbor and ferry etc. must be moved out on the outside of the sheet wall and build landscape out to this.
- Dragør are working with a landscape solution - the landscape on the inside or the outside.
- These are external (outside the harbor) solutions.

Discussion on strategies for Svendborg in terms of long-term planning

Strategies

New discussion of which strategies to choose in the further work. Preference if the project group could choose 3-5 different to make it easier.

- It is strategies for the whole city - it is not strategies for the sub-areas one by one - it is strategies for the whole area.
- Comprehensive solution - it does not have to be divided into sub-areas strategically. Intermediate solution could be to secure buildings inside (object protection).

The method for this discussion:

- Brainstorm over possible strategies - after we have reviewed the sub-areas' opportunities for CCA approaches and paths.

Strategy 1 = "Outer line as fast as possible"

- Strategy when we switch from 'inner' solutions to 'outer' solution for CCA. When is it realistic to have built an outer solution?
- Do not start with thoughts on 'inner' safety solutions. Start with Venice-like solution and outer solutions - if you know that after a period you have to switch to the external line anyway (if this is the final path) then it is a waste of money to make inner security.
- Approaches:
 - Combination of outer line (wall) and solutions until this line is finished. Invite the water in on the inside of the wall. If a wall - how should the environment be on the inside?
 - This strategy is the winning proposal (more or less).
 - Patch the "holes" in the inner city before the outer is finished.

Strategy 2 = "invite the water in"

- From water to land - object protection.
- Requires an analysis of the average sea level rise - of permanent floods and robust harbor edge.
- It must be able to withstand the water. The city's identity is already by the water.
- Reflections such as the landscape they are working on in Assens.

Strategy 3 = "Inner line"

- Can be different lines inside the city. We do not shut the city off from the water.
- The owners of buildings must protect themselves.
- No external measures.

Strategy 3 = "inner line - give up frederiksø"

- It was a sandbank once and that's how it ends again one day
- Fewer measures possible. Invite the water into Frederiksø.
- Less ambitious inner line than strategy 3.

Strategy 4 = Most feasible / geographical stages for risk.

- It costs DKK 5.1 million / year if done nothing (risk-assessment).
- The most advantageous is to make an effort.
- It must be constantly thought in stages.

Strategy 5 = Inner line in sub-area 1

- If no solution in this area, there are water/floods in the rest of the harbor
- Protect objects or let the water come. Pushes for a shift to 'outer'.

Strategy 6 = Cheapest solution

- Socio-economic. Cheapest for everyone.
- Rain is calculated socio-economically. Storm surge is calculated per landowner contribution (everyone who benefits from the initiative)

There is afterwards a general discussion if cultural heritage must be a strategy. There may be other things than the lines in the DAPP maps that may constitute strategies.

Discussion of the tool “distribution of financial contributions”.

- Contributors depend on sub-areas or whether you take it all at once.
- Participant says the following out loud: *“Contributors depend on sub-areas or whether you take it all at once. It is difficult to have an overview of which strategy is easiest to distribute contributions with - the politicians probably also want that understanding. One great project is perhaps the hardest to get through [accepted] because it is the most expensive one.”*
- If you are first required to build a new building – and can’t “use” the ground floor because of flood protection measures - then the table catches for the municipality. If you [the owners of the buildings] are insured for +2.5 m, then the municipality must insure further.
- Politicians ask where the insurance companies are in these matters?

Final decisions on selected city strategies to proceed with:

- "Outer line as fast as possible"
- Invite the water in
- Inner line (Frederiksø can be cut off).
- Most achievable in stages / effective protection
- Inner to outer “as late as possible”

The method in the workshop to discuss the selected strategies in connection with the paths for the case areas:

Brainstorm over initiatives for the individual sub-areas in relation to the strategy. Talks about CCA measures - and what needs to be done or what measures used. They talk about which initiatives (paths) have been chosen for each sub-area - and which are relevant or not at all in terms of strategy. Talk about short- and long-term initiatives. It is difficult for people in the working group not to blend and confuse the selected city strategies and stay "on track". People want to talk holistically and like to mix the strategies for the different sub-areas. People find it difficult to talk about accommodation/ retreat – it is mainly the ‘lines’ of protection in the DAPP maps that are their focus - either ‘outer’ or ‘inner’ protection lines or ‘pop-up’ measures such as walls that can be built in the case of storm surges.

Strategy 1: “outer line as fast as possible”

(there is a lot of focus on this solution in the project group)

- When it is realistic? 2050? it takes many years to build this. Think 18 years ahead? Then it is approx. year 2040. designed to rebuild in the height later on.

In the long-term:

- External/outer solution - can be located in several different places on the ‘outer’ side.

In the short-term:

- Requirements for new construction and generally build up to a certain elevation level.
- Laissez-faire until year 2040 for everything within the planned ‘outer’ line.
- Object protection of certain low elevation buildings such as the heritage ones.
- Does not talk about how often it should be closed.
- The winning proposal is built on closing as often as necessary. It will have to be closed more often - also testing and maintenance once a year. We cannot count on any solutions until they are there - the reality is that some things must be protected for themselves in their own elevation.

Strategy 2: invite the water in

Method: we look at maps of the city. Talk about Hamburg-like dikes / raised roads. Reference is made to the city of Assens’ initiatives on dune landscape or a form of beach meadow area.

Short term:

- Object protection
- Requirements for new construction
- Pop-up wall “invites the water in”. (in the long run what then?).
- Free the ground floors (accommodation)
- Some sub-areas need to be protected and some not.
- The construction that is there must last as long as it can (until retreat)

- Possibility of dune landscape / meadow area by the yellow houses - move the wooden ship harbor – retreated flood safety line.
- Freeing up areas (save the places for no construction)
- Terrain elevation of new construction

long term:

- Wall on Toldbodvej (double wall) retreated flood wall
- Possibly future technologies can help

Strategy 3: Inner line (Frederiksø can be cut off).

Short-medium-term:

- Inner line on existing quay
- Raise quay edges / high water wall
- Inner building line as flood security line
- Object protection instead of flood wall
- Frederiksø (The present ship wharf say they can live with high water). It is at elevation 2 the buildings begin to be affected. The industry must organize own flood security.
- Inner wall / follow the buildings (a bit like strategy 2)
- Frederiksbroen?

Long term:

- Raise wall / quay edge

Strategy 4: Inner → outer ‘as late as possible’ in 2070.

Short-term:

- There are 50 years where the risk must be managed before the ‘outer’ protection is built.
- Must ensure the flood level of short-term storm surge levels in the city – approx. up to elevation + 2.5 m
- Quay edges are raised (will happen no matter what due to average sea level rise)
- Flood wall
- A lot of protection strategy → arguments that it makes sense to raise rather than ‘retreat’ when the goal is ‘outer’ security in 50 years, which is before the largest sea level rises). Cheaper to raise quay edges than object protection.
- No object protection
- Terrain elevation
- Elevated fixed pier at ‘the Mudhole area’
- Requirements for new buildings (+1.3 m), e.g. The new theater next to the museum for yachting

Long term:

- External solution is the final solution here

Strategy 5: “most feasible”

- Political decision what this means
- Not a strategy that can be discussed now - it is for all strategies.

Next steps for the following and last DAPP workshop:

- They give way to score the strategies today due to lack of time. But they can reach the time to do a presentation of the local politicians' brainstorm for criteria.
- Method of the criteria brainstorm: the politicians had to decide on criteria (max 5 each) they were 8 politicians from the technology, environment, plan, and local committee.
- Interesting criteria that were discussed (shown in presentation) but not selected - that relate to this thesis:
 - Biodiversity
 - The water as plus
 - Several purposes for climate adaptation
 - OK to “give up” areas - everything does not have to be prioritized equally
 - Something that works (tested, tried, seen before)

- The politicians' chosen criteria:
 - Clear 'distribution of financial contributions'
 - Secure cultural heritage
 - Recreational
 - Modulable
 - Aesthetic
 - Something that works
 - Continued opportunity for port business
 - Continued ferry operations
 - Secure port environment
- Political weighting of criteria:
 - They were two groups – and they are very different in weighting. We'll talk about that next time
 - multicriteria analysis next time.
- Reactions from the workshop project group regarding the politicians' choice of criteria:
 - Strange they have not chosen economics as a criterion. What do they envision financially? (surprise internally politically that economics is not a point - politicians must reckon that the distribution of contributions succeeded well).
 - Contribution benefits (politicians have thought that the distribution of finances is absolutely decisive in relation to contributions)
 - Not everything must be protected equally is not included.
 - Realdania has made a report on financial contribution issues (operation, etc., transparency) that could be beneficial in the further process and the further citizen involvement in connection with a citizens' meeting later in the spring.

Other talking points after the work on strategies and paths:

- Citizens' meeting coming up the 19th May 2022.
- Concerns: What climate risk - today and long-term statistics. Damage calculation - values and how this is calculated. Possibly, introduction of the four DAPP strategies - the overall result. Clarify that there will be some form of financial contribution distribution. This citizens' meeting could be the first step in starting a dialogue on the distribution of contributions and hearing expectations and concerns.
- Question: Have there been processes with the involvement of citizens in relation to the DAPP process? or in general in terms of choice of measures and criteria
 - Answer: No - only in 2017 concerning the catalog of ideas which is being used still. No further participation processes have been made during /concerning the DAPP process with citizens or companies, however politicians are much involved, and there are political and civic involvement in all major decisions that is taken.

General observations of the workshop:

- The workshop group have a hard time picturing 'retreat' and 'inviting the water in' (accommodation) - they themselves mention it as a fun notion that this is the case - that it is the 'protection strategies' about external and internal security of the city that are the focus.
- The Laissez-faire initiative was not mentioned once as an option under the discussions for long-or short-term approaches in the strategies. Although it was considered an option for all sub-areas.

Appendix C: Resumes of interviews

C.1: Andersen, K. J. (2022)

The conversation between Andersen and the author was over the phone. Andersen has worked on the Danish version of the DAPP material on behalf of the Danish Coastal Agency. Rewrite it from a Dutch to a Danish context. Her initial thought on the thesis: *"The subject is rather conflict-filled for cities with harbors as there is a conflict of interest in port/harbor cities. When there is an existing city, there are not so many opportunities for nature."*

She suggests, when asked for suggestions on Danish cases or cities that have contemporary work on CCA, that the following cities are or have been working on the DAPP process or are working on NBS: Vejle, Randers, Aabenraa, Assens (mentioned that they work with NBS), Lyngby-Taarbæk, Svendborg. After allowance from a GDPR co-worker, the contact information on Assens and Aabenraa is shared with the author. Reflections about Vejle's actual work on NBS, as this case has worked a lot with citizens' involvement and several processes, however, have not, from her knowledge, made a brainstorm on NBS ideas though they discuss the storm surge barrier should be green. She suggests getting inspiration from Realdania's *"The cities and the rising sea."* She suggests talking to C. Sørensen from the Danish Coastal Agency and the facilitator from Teknologirådet at the DAPP workshop in Svendborg.

C.2: Dehlbæk, C. B. (2022)

An employee in Team Climate and Water, Region Midtjylland. February 18th, 2022, Teams meeting, and email correspondence. Dehlbæk has contributed to the C2CCC work in the Region of Mid Jutland and is working on a collaborative strategy for the entire region related to CCA. Gave access and permission to the author to use data from the national questionnaire: "National examination of climate adaptation in a citizen and corporate perspective" from Region Nordjylland, Region Midtjylland, Region Syddanmark, Region Hovedstaden, Region Sjælland, DNNK, and Danske Regioner.

His thought on the subject of the thesis: *"The projects of the future must be multifunctional. However, the reality is not like that; the projects rarely manage to be multifunctional, and in reality that multifunctional projects are not often built."* His suggestions of urban coastal development projects: Dragør, Juelsminde, Kalvebod, Vejle, Svendborg, Randers.

C.3: Geertsen, U. P. (2022)

The interview was conducted with Geertsen over Teams. The interview was recorded on the phone, later transcribed, and translated to English. The quotations used from the interview were sent to the interviewee to check and comment before being used in the analysis. The complete transcription will not be made accessible; however, a resume of the conversation is written as the following.

Resume: The interview referred to the current work on the case project and the primary efforts of citizens and politicians in creating awareness of climate change challenges. Social resilience is essential for the project. The DAPP method was helpful in strategic adaptive planning and the creation of phases in the short to long run. DAPP was helpful with the politicians and legitimization of the decisions. The EU risk plans from 2015 initiated the work, and initially, the project was about protection, although the agenda is now moved toward more acceptance of floods and invitation of water into the city. The long-run retreat is also on the agenda. The current work is a membrane NBA solution with accommodation as an approach. Experiments of urban coastal nature are developed, and resilience is mentioned as essential also to building social consciousness. The CO2 footprint is relevant to look at in terms of development, as NBA could be superior here compared to building a concrete wall. The project is mentioned as complicated, mainly due to changing advice on future climate scenarios and differences in projections and past storm surge events. The word 'protection' is perceived as bringing expectations, which is incorrect as CCA is never failproof and only can protect to a certain level. NBA is considered significant; however, challenges such as cost and inexperience are creating obstacles to the approach, and also citizens need to change their perceptions of the differences between wild and polished urban nature.

C.4: Korsgaard, T. (2022) & Nielsen, A. A. (2022)

The interview was conducted with Nielsen and Korsgaard at Svendborg Municipality. The interview was recorded over the phone, later transcribed, and translated to English. The quotations used from the interview were sent to the interviewees to check and comment before being used in the analysis. The complete transcription will not be made accessible; however, a resume of the conversation is written as the following.

Resume: Presentation of us and discussion of the case project, re-evaluating whether the winning proposal is the right approach or whether other strategic CCA approaches should be used. A discussion on who should pay for this project and whether NBA and NBS could be a part as the project is "really far." An idea-catalog of NBA would be interesting to present to citizens, it would constitute a help and a tool; however, there are already so many tools, so it is probably a categorization of one of the existing tools. Discussion of Assens decisions of NBA and the small islands near Svendborg where the Natura2000 area makes NBA interesting. It is interesting to criticize the current case project and look at it through nature-based glasses. Some things would have to be pushed locally for NBA to win due to industrial and cultural values. The DAPP process is ongoing and possible to join and observe. A dune landscape was discussed, and alternatives to the case project design in the DAPP process.

The observation in the DAPP workshop could bring knowledge on competencies and topics and why different decisions are made. The politicians have just given them their criteria for the area, and biodiversity and nature were not chosen. The question is what one believes the harbor should be used for, and this is maybe not nature. They experience a lack of knowledge in the field of NBA and would like to use nature, especially concerning the opening of Kobbervækken. It could be interesting to have some design cards about nature, added values, and NBA, which could start a valuable discussion for citizen participation projects. The case project is about robustness and dealing with the climate challenges from the sea. Quintias NBA research was a part of the Realdanias' project; however, challenging to use in urban areas. Suggestion to contact Carlo Sørensen in the Danish Coastal Authority to ask about the Climate-game they are developing.

C.5: Larsen, K. J. (2022)

The interview was conducted with Geertsen over Teams. The interview was recorded on the phone, later transcribed, and translated to English. The quotations used from the interview was sent to the interviewee to check and comment before being used in the analysis. The full transcription will not be made accessible; however a resume of the conversation is written as the following.

Resume: The interview referred to the general agreement of the project being NBA, however, they realize the architectural look is not what will be realized due to exceptionally many hearing responses and local disagreement from especially housing where the views are threatened. The other coastline of Assens are also started with Nature-based Solutions using experience from the case project. The project is about flexibility and modularity and ability to build it higher over time. The DAPP method was considered useful and helpful as it was clear with the strategies and adaptive pathways where to start, however the projections of climate in the long run is tricky with changing advises and differences in calculations for CCA. Retreat is experienced as a difficult word to use right now, much of the area at risk is valuable and supposed to be built on as people want to live near the water. Retreat is however perceived as a necessity to talk about in the future when the political landscape is ripe for it. The project is a part of a much larger CCA project of the entire coastal zone in which a harbor gate, higher terrain, and natural processes is planned. A minimum of hard constructions and focus on recreation and biodiversity. NBA is assessed as something not many are familiar with yet, just like they are not even familiar with CCA except dikes or groynes, the NBA focus was chosen to investigate new options and there will be no compromise on the nature-based even though the project might be optimized. The project is mentioned being very complex compared to other NBA project on cloud burst issues etc. The major clash with NBA is perceived to be finances in the long-term and distributions of financial contributions being complex. Another major clash is the perceptions of NBA from the citizens as they are skeptical of the feasibility and skeptical about long-term solutions as they themselves plan more short-term.

C.6: Mohr, N. (2022)

The interview was conducted with Geertsen over Teams. The interview was recorded on the phone, later transcribed, and translated to English. The quotations used from the interview were sent to the interviewee to check and comment before being used in the analysis. The complete transcription will not be made accessible; however, a resume of the conversation is written as the following.

Resume: The interview referred to the status of the project on the table of the politicians, and as the project not being finished and the scenarios and narratives of development not 'as noble' as one could be chosen over another at this state. The project's goals, being the creation of a holistic description of challenges and possible solutions, are achieved and helps legitimize the thought process. No citizen or political involvement is connected with the scenario development; the technical details especially are a municipal concern. Not many politicians are expected to actually read the report as it just constitute an appendix. The politicians also might be indifferent as the time horizon is so long. CCA is mentioned as an influential agenda for the city which the city council should establish. The work on CCA has been ongoing since the 2015 EU Directive Risk Management Plan; however, there are now different levels of sea level rise to prepare for, and this is an ongoing discussion on what to plan for and when to build in the projected heights of storm surges. The project constitutes an adaptive strategic plan from the DAPP method. There are raised concerns about finances, CCA clashes with architecture, natural processes in the urban environment, local cultural challenges, pollution of areas, and ownership of the areas at risk. NBA is being investigated in two narratives; however, expected to be challenging to establish in urban areas, as ports are expensive, the land is valuable, and areas are polluted and should not be 'left to themselves.' However, NBA is seen as an approach to help fertilize the debate but is not as feasible in a place like Aabenraa. The work is considered complex. The 'retreat' is believed to be an agenda not applicable in the area due to the economy, as it is the economy of the sold building plots in the risk areas that must lift the entire economy of the CCA projects. Protection is often mentioned as the solution.

C.7: Sørensen, C. (2022)

March 10th, 2022, Telephone call and email correspondence. Manager, Danish Coastal Authority. Sørensen is the contact person in the Danish Coastal Authority for Realdania's "The cities and the rising sea" program.

Talk about the development of The Coastal Authority's Climate game: The game is underway – should create a room where one can play. It is a dynamic planning game about hazards + timelines + options for CCA etc. Talk about relevant Danish urban coastal cases that involve NBS. His suggestions to coastal cities working with CCA and NBS: Vejle, Dragør, Svendborg, Faaborg, and maybe Skive. Vejle is the furthest to draw basic ideas and focus on inviting the water into the city; it combines beaches, eelgrass, and a proposal of a membrane city. Dragør is also a good site. In Skive, they are redeveloping the BIG plan of BIGBlue, which is a plan with blue infrastructure. Faaborg is also working on something, as is Svendborg; however, they have very different issues, as Svendborg is still industrial. Suggests the author look at (Dansk Kyst- & Naturturisme, 2020) for inspiration from Danish and international cases. Suggests the author to look at IPCC's latest climate report, as this works with systematic thoughts on NBS on how to think about nature first. His opinion on the thesis: *"Nature-based solutions - it is not about 're-inventing the wheel' - but it must be long-term thinking, and one must deal with aspects of culture and the environment and static dilemmas."*

C.8: Wiberg, K. (2022)

February 8th, 2022, Telephone call and email correspondence. Title: Associate Professor, Cand. arch. MDL, Ph.D.

Wiberg and the author talked primarily about Danish and international urban coastal sites. Wiberg suggests looking at:

- Realdanias webpage with the webinars and cases of examples
 - Quintana has a note there about nature-based solutions, and KU has more about planning.
 - Cases such as Vejle, Dragør
- Kristina Hill from Berkeley Univ.
- Susannah Drake from DLAND
- Resilient by design with projects in the NY Bay Area and the US East Coast.

Wiberg additionally talked about her latest published research: "Vandets Byatlas" and "Postkort til Fremtiden," as possible sources to look for inspiration. Wiberg's thoughts on the thesis: *"NBS is important for the future CCA solutions. NBS, however, takes time to build, and the experiences with the approach is lacking. There is still a discussion to be had – about nature – whether it is the processes of and for nature or humans."*

Appendix D: The principles and associated elements of Metcalfe's (2015) "Multispecies Design"

Principle	Elements
Treating animals as clients of design	
	Extending responsibilities
	Identifying needs
	Participatory animal design
	Representing animals in the design process
Researching animals in a design context	
	Learning the science
	Multispecies design ethnography
	Proxy interviews
	Identify animal spokespeople
	Somatic design research
Designing human-animal interactions	
	Representing animals in society
	Focusing on mutually beneficial interaction
	Soft reservation
	Addressing existing cultural baggage
	Avoiding domestication
	Opening communication channels
	Seeking synergies
Designing like an ecosystem	
	Open-ended design
	Ecology of reference
	Connectivity
	Embrace complexity