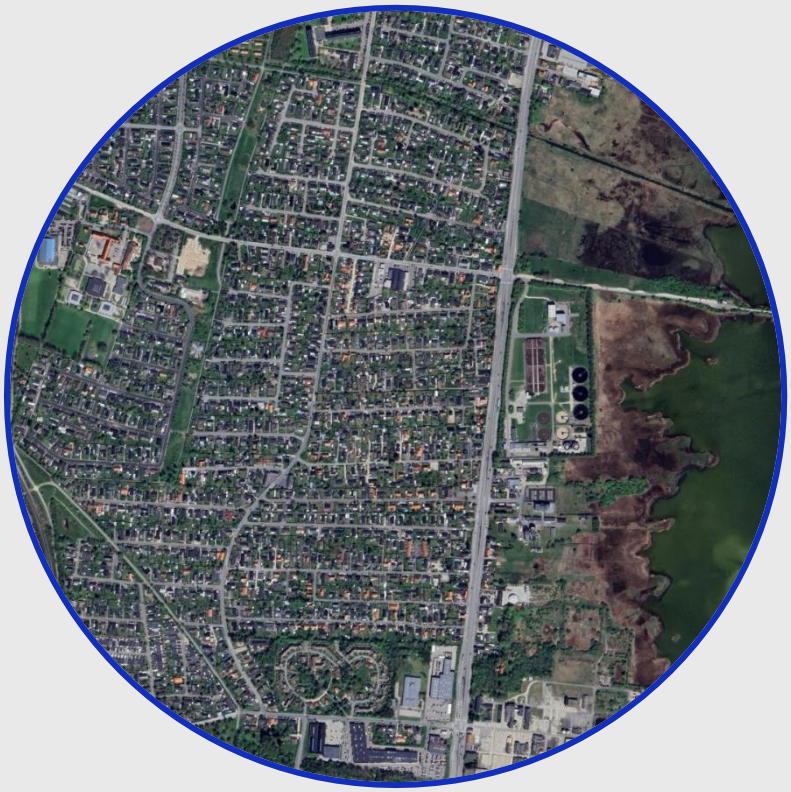
A redesign of Ølby Lyng and Ølsemagle

Focusing on sustainability and climate change adaptation.



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STUDENT REPORT

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- Ole Fryd, Associate Professor in Landscape Architecture, Planning and Design at Copenhagen University
- Jacob Skjødt Nielsen, Green Ambassador at Grøn Omstilling, Køge Municipality
- Signe Weinrech Rasmussen, Project Consultant at Grøn Omstilling, Køge Municipality
- Tore Bro, Civil Engineer at department Natur, Vand & Jord, Køge Municipality

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Abbreviations

SDG	**Sustainable Development Goals**
IPCC	**The Intergovernmental Panel on Climate Change**
RCP	**Representative Concentration Pathways**
UN	**United Nation**

Abstract

Climate change impacts on a global scale, the emissions caused by consumption contributes to these climate changes. Detached housing areas emit more CO2 than other forms of housing, and these areas are often highly fortified, which makes it difficult for water to seep down the terrain.

This thesis aims to answer the following research question:

How is it possible to redesign an existing detached house area when focusing on sustainability and climate change adaptation?

The two main focuses for the thesis are climate change adaptation and sustainability. To investigate how climate change has an impact on the project area Ølby Lyng and Ølsemagle, Scalgo Live has been used to simulate different events like sea level rises, cloudburst events, and elevated groundwater. Before redesigning the project area, an analysis has been developed to investigate the area and how it is affected by climate change in terms of different water events. In this thesis four interviews have been conducted, these interviewees contribute to the future vision and solutions in the redesign of the existing detached housing area. Furthermore, they contribute to understanding the actors' position in terms of solutions for climate change.

To ensure sustainability in the redesign of the area, the framework Doughnut for Urban Development has been used. Collaboration and changes in the practices of the human-actors are needed when redesigning an area with a focus on sustainability and preventing further emission to contribute to climate change. On the other hand, to withstand climate change in an existing detached housing area it is important to incorporate nature-based solutions within the living area and to planned for managed retreat for the area that are highly exposed to climate change. The redesign is presented in a plan, which includes different transformations of the area, sustainable and nature-based solutions, and how life in the area will be.

Finally, a discussion, surrounding the use of Doughnut for Urban Development as a sustainability framework for the existing detached housing area, the collaboration between actors and what to be aware of when redesigning an existing urban area, is made.

Contents

Introduction

This thesis is a collaboration with Køge Municipality. The subject surrounding this collaboration is to explore how to redesign an existing detached housing area in the local area Ølby Lyng and Ølsemagle. The focus points of the redesign are climate change adaptation and sustainability. In connection to climate change adaptation, we are investigating how to establish nature-based solutions as the main solution in an existing detached housing area. The sustainability aspect takes point in the framework Doughnut for Urban Development, to ensure that sustainability is a part of the redesign.

Detached housing areas increased in the 1960s and 1970s in Denmark which is due to the growth in society's prosperity (Møller and Lind 2014,140; Museum Sydøstdanmark, n.d. B). Around 450.000 detached houses were built in this period, which meant an annual construction of 22.500 new detached houses on average (Møller and Lind 2014,140; Museum Sydøstdanmark, n.d. B). Three trends that followed society's prosperity where 1) detached houses become a dwelling form that many of the citizens lives in, 2) the car outperformed the railway, 3) the average detached house size was exponentially increasing (Møller and Lind 2014, 24-140). In 1960, the average detached house was 123 m^2, and in 2024 the average size had increased to 154.5 m^2 (Møller and Lind 2014, 140; Danmarks Statistik 2024).

This increase in detached houses comes at an environmental price. According to an analysis produced by Andras Schjørring Wied and Kristian Madsen from Viegand Maagøe A/S (2023), newly built detached housing areas emit twice as much CO2 emissions as other housing forms (Wied and Madsen 2023). CO2 emissions are not the only concern when studying detached housing areas: such areas also increase fortification, resource consumptions, Greenhouse Gas emissions and thus contribute to Climate Change.

Thus, Køge Muncapility's challenges in ensuring a sustainable detached housing area in Ølby Lyng and Ølsemagle is similar to the challenges faced in many other places in Denmark. To understand the dynamics of change to nature-based solutions, we will now outline the initiatives that influence the planning strategies in Denmark both at a national, regional, municipal, and local level. A key framework is the 17 Sustainable Development Goals (SDGs), which represent sustainability initiatives on a global level. The Intergovernmental

Panel on Climate Change (IPCC) assesses climate change and has presented four different Representative Concentration Pathways (RCP), which will be used going forward in this project.

Interlinked climate change planning approaches

Nations worldwide are affected by Climate Change, which causes catastrophic events such as coastal and inland flooding, heat waves, fires, and cloudburst events. International organisations such as the United Nations (UN) use climate governance to address Climate Change. The Intergovernmental Panel on Climate Change (IPCC) is a UN body, which purpose is to provide scientific evidence about destabilising factors such as climate change, consumption, and Greenhouse Gas emissions to nations, and its research underscores the need for change in global practices (IPCC n.d.). IPCC develops artefacts such as scientific reports, frameworks, and scenarios, which are available to all nations and populations worldwide (IPCC n.d.). These artefacts also serve to frame particular issues related to Climate Change, and thus the IPCC plays an important role in shaping the discourse on global climate change.

Representative Concentration Pathways

The IPCC has developed the artefact Representative Concentration Pathways (RCP) (IPCC 2014). The RCPs are four different climate scenarios that show varying levels of Greenhouse Gas emissions and air pollutants, as well as their impact on atmospheric concentration and land use globally (IPCC 2014). The four RCPs are the so-called 'stringent mitigation scenario' (RCP2.6), two intermediate scenarios (RCP4.5 and RCP6.0), and finally what is termed a 'very high Greenhouse Gas emission scenario' (RCP8.5) (IPCC 2014). Anja Wejs (2021) estimates that the current observed Climate Change follows scenario RCP8.5, which represents the Business-as-usual approach. In this scenario, Business-as-usual will influence the global mean surface temperature to rise to 4.6°C by the end of the 21st century (2081-2100) (Wejs 2021, 15). The global mean surface temperature in RCP8.5 is predicted to cause sea levels to rise between 0.45 to 0.85 m (Wejs 2021, 15).

However, the IPCC Report does not only focus on the global risk of sea level rise, but also global risks such as climate-related drivers of impacts such as *"warming trend, extreme temperature, drying trend, extreme precipitation, damaging cyclone, flooding, storm surge,*

ocean acidification, carbon dioxide fertilisation" (IPCC 2014, 70). According to the IPCC report, these climate-related drivers will impact urban systems such as water supply systems, energy supply system, local housing, and marine biodiversity loss (IPCC 2014). Denmark is a country surrounded by seawater, and many of the cities are coastal cities. As introduced previously, there is a relationship between increasing temperatures and increasing sea levels. This means that Danish cities are exposed to rising mean sea levels and coastal flooding. The approach for working with coastal protection is that the Danish government encourages the municipalities to use RCP4.5 and RCP8.5 when planning for climate change adaptation (Bolig- og Planstyrelsen 2022). This demonstrates that the discourse from IPCC helps visualise how climate change will affect Denmark. In this thesis, we will study the effects of RCP8.5 in a local context.

Sustainable Development Goals

Another artefact, that is aimed at addressing some of the same tendencies is the framework of "the 17 Sustainable Development Goals" (SDGs), see Figure 1.

Figure 1: The 17 Sustainable Development Goals (United Nations, https://www.un.org/sustainabledevelopment)

The SDGs are developed by the UN and the plan for the UN Member States is to reach the 17 goals by the year 2030 (United Nations n.d). The 17 SDGs are a heterogeneous framework, and the framework does not prescribe an order for how actors should work with the goals and

associated targets. It can be challenging to work with the goals and associated targets, since it is a comprehensive framework with many interlinked goals and associated targets, and also because the framework is designed for developed and developing countries.

The question then becomes: how are the SDGs approach in Denmark? This is a question that the book "A sustainable Denmark with the Sustainable Goals towards 2023" [*Det bæredygtige Danmark Med Verdensmålene mod 2023*] in the chapter about Sustainable Cities and Communities [11 Bæredygtige byer og lokalsamfund] by Henrik Vejre, Ole Fryd, Marina Bergen Jensen and Gertrud Jørgensen (2023) addresses. According to Henrik Vejre, Ole Fryd, Marina Bergen Jensen and Gertrud Jørgensen (2023), '70% of the world's CO_2 emissions are connected to cities', making it important to build sustainable cities and communities to combat Climate Change (Vejre et al. 2023, 291). Henrik Vejre, Ole Fryd, Marina Bergen Jensen and Gertrud Jørgensen explain that to combat this issue, it is necessary to develop sustainable planning strategies that support a sustainable lifestyle. This must be done by creating better living condition both in the public and private environments. In this context, it is mentioned that developing sustainable forms of housing where people live close to nature-based solutions and sustainable infrastructure that includes walking, biking and public transport are important to support better living conditions (Vejre et al. 2023, 291-292).

The question then becomes who is responsible for developing a sustainable city and preventing climate change, and what are the current approaches? It is mainly the public sector actors, such as municipalities and municipally controlled utility companies, that are responsible for developing sustainable cities and preventing Climate Change in the cities (Bulkeley and Broto 2013). According to Bulkeley and Broto (2013), the approaches primarily include technical innovations in the urban infrastructure sector, including the water, energy, and waste sector. Whereas approaches dedicated to sustainable lifestyle for the citizens is least common (Bulkeley and Broto 2013). Henrik Vejre, Ole Fyd, Marina Bergen Jensen and Gertrud Jørgensen explain that current planning tendencies lack a holistic approach for working with climate change adaptation and sustainability (Vejre et al. 2023, 301). Additionally, this holistic approach must include collaboration between authorities, citizens, organisation, and companies. As well as innovative projects that experiment with climate change adaptation and sustainable urban strategies (Bulkeley and Broto 2013; Vejre et al. 2023, 301)

In summary, cities and communities impact Climate Change by emitting high concentrations of Greenhouse Gas into the atmosphere, which then leads to more extreme weather at a global level. In this thesis, we want to explore how we can contribute to solving this problem at a local level in Denmark in collaboration with the department Grøn Omstilling within Køge Municipality. We will investigate which actors there are relevant when focusing on climate change adaptation and sustainability as well as their relations. The point of departure for investigating the actors, is the detached housing area.

In this thesis, we will examine the following problem statement and research questions:

How is it possible to redesign an existing detached house area when focusing on sustainability and climate change adaptation?

1. What are the climate threats that the project area is challenged by?

2. What are the future visions of the human actors, and how are they positioned in terms of climate change adaptation?

3. How can the project area be redesigned so that it is sustainable?

Research design

The figure below illustrates that thesis structure consist of seven different phases. The main planning theory in this thesis is Relational Planning, which will be used frequently in our thesis to highlight the non-human and human actors.

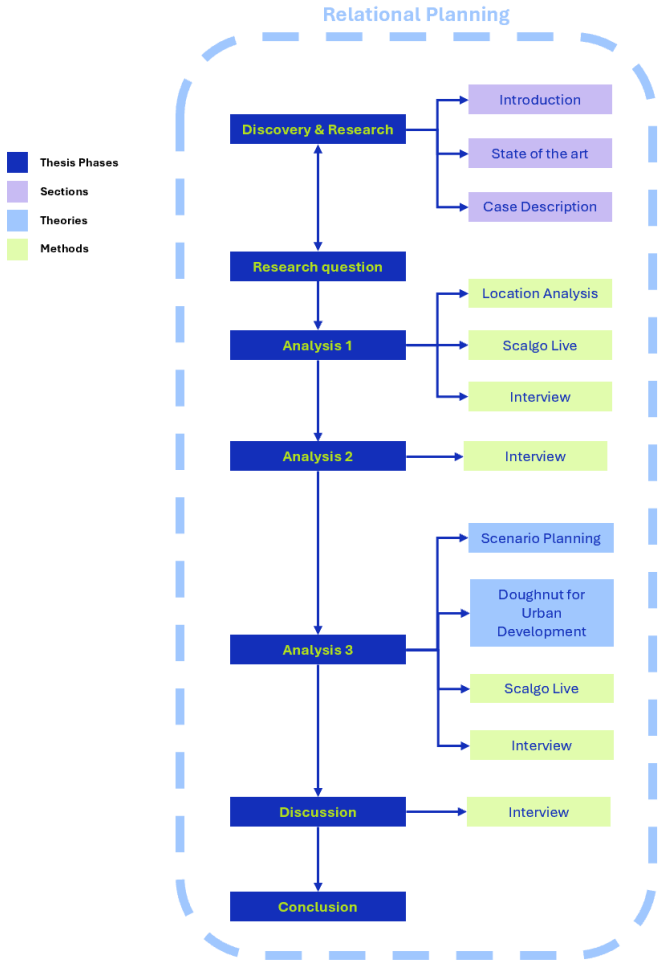


Figure 2: Research Design. (Own design)

The theories that are used in this project are Relational planning and Doughnut for Urban Development. Relational planning is used as an empirical approach, to explore the discourse that exists around detached house areas and climate change adaptation. In addition, Relational Planning is used to point out actors in the network and to discovers some relations. Furthermore, it is used to investigate where different actors are positioned in terms of technical and nature-based solutions. Doughnut for Urban Development is used as a framework to incorporate sustainability in the redesign of the area of Ølby Lyng and Ølsemagle.

The different methods are used to gain knowledge about the area of Ølby Lyng and Ølsemagle, as well as different solutions to prevent or adapt to climate change. The semi-structures interviews are used in this thesis to investigate different future perspective, vision and ideas from actors within the field of urban planning, and gain knowledge about technical and nature-based solutions. The location analysis and Scalgo Live is used to explore and understand the existing detaching housing area, what it looks like, what are the physical elements in area and what climate change issues that the detached housing area will be facing in the future. The scenario method is used to create the redesign of the area and a radical future of Ølby Lyng and Ølsemagle.

Introduction

The introduction outlines how detached housing areas contribute to emitting CO2, climate change, and fortification. The IPCC and RCP's scenarios are presented to give an overview of how CO2 emission is related to climate change and how it will affect Denmark. The SDG's are presented as a global sustainability framework, which also is used within the municipalities in Denmark.

Case description

In the section Case Description, we will first describe organisational structure of Køge Municipality and KLAR Forsyning A/S. Hereafter, we will describe the historical weather events that has affected Ølby Lyng and Ølsemagle, and which trends that have had an influence on the development of the area. Furthermore, we will provide an overview of Køge Municipality strategies and plans for climate change adaptation and sustainability. This will be presented to gain a greater knowledge about what have been part of designing the existing area and to discover Køge Municipality plan for the future Ølby Lyng and Ølsemagle.

State of the art

In the section state of the art, we will present key findings from our desk research that includes providing a historical view on how water is managed in cities and how it can be sustainable managed. We will investigate sustainable water management system such as nature-based solutions as solutions in different aspects.

Research questions

The research questions will be answered throughout the three analyses, and they are used for framing this thesis study.

Analysis 1

For the first analysis, we will use the software tool Scalgo Live to analyse how cloudburst events, storm surges and increasing groundwater levels are likely to affect the project area. The results from the Scalgo Live analysis will be connected to a location analysis. This fieldwork is inspired by Jan Gehl's methods for investigating social behaviour in a location. The analysis aims to investigate where the threat of flooding is located and to provide an overview of the actors in this area. This analysis will investigate research question one.

Analysis 2

In Analysis 2, the future perspectives and visions of the interviewee's are introduced. These elements are used as preparatory work for Analysis 3, to get an understanding of the solutions the actors are presenting. Finally, the network of where the actors are positioned in relation to the technical and nature-based solutions, is presented.

Analysis 3

The third analysis will present our proposed redesign of Ølby Lyng and Ølsemagle. The redesign will draw on future radical scenarios which aim to destabilise the current network. To do so, we will use scenario planning and Doughnut for Urban Development. Doughnut for Urban Development will provide sustainable aspects, and scenario planning will be used to develop a future radical scenario. It is also important to mention that the empirical work from the other sections will be used to create the future radical scenario.

Discussion

In this section, the use of Doughnut for Urban Development and how the redesign can be expanded to other areas will be discussed. Furthermore, a discussion of the elements and practices changes that must be implemented in the redesigning of the area will be included.

Conclusion

In the conclusion aspects from the case description and the key findings from the analyses and discussion will be presented.

Theory

In this section, the theories used in this project are presented. The two theories are Relational Planning and Doughnut for Urban Development. Relational planning is used as the planning approach throughout the project. The Doughnut for Urban Development will be used in the redesigning process of the project area to ensure that the sustainable targets are met.

Relational planning

Our understanding of 'relational planning' is heavily influenced by Yvonne Rydin's presentation of the theory in *Theory in Planning Research* (Rydin 2021).

The reason for choosing this theory is that it is useful as a planning approach when one wishes to consider both the physical and social world (Rydin 2021, 171). It is a planning approach that considers both human actors and non-human actors, and Yvonne Rydin's framework thus integrates many different perspectives that are used in other publications. For instance, her framework builds on the Actor-Network Theory by Bruno Latour (Rydin 2021, 181).

Relational Planning has several salient features, including 1) Assemblage Thinking, 2) Reconsidering Power, and 3) Self-organisation Experimentation.

Assemblage thinking is also a network, which consists of key element, such as human and non-human actors that come together. As Rydin describes it, "These networks are defined by the fluid set of elements they bring together" (Rydin 2021, 172). An important concept in Assemblage thinking is the idea of 'artefacts'. An artefact could be a plan, a map, reports, models, data and much more. Artefacts are a crucial part that makes a connection between objects and practices, this enables, among other things, that planners have the opportunity to work in the office, where the artefacts are representations of reality (Marskamp et. al. 2018, 11). This is expressed in the following quote:

> "*One of the ubiquitous artefacts in the planning office is the map […]. They allow planners to act on places from different locations and times*" (Marskamp et. al. 2018, 11)

Artefacts can therefore be key elements for decisions-making, which give the power within the assemblage. A case example where the artefact gains a lot of power in the decisions process is the "The environmental Big Data", an artefact presented by Francisco Ascui, Marcus Harward, and Heather Lovell in "Salmon, Sensor, and Translation: The Agency of Big Data in Environmental Governance"] (Ascui, Haward and Lovell 2018). The environmental Big Data became an unpredictable mediator. As Ascui, Harward and Lowell explain: "its outputs (interpretations) are not straightforwardly determined by its inputs (measurements), but depend on the perspective of the interpreter" (Ascui, Haward and Lovell 2018, 920).

This case example also relates to how Rydin defines power, as power can be given to both the human and non-human actors, through their relations to other actors. This is an important aspect to consider when redesigning an area, as to how the actors will be given or gain power through their relation to non-human actors like artefacts or to human-actors .It is also important to mention that there exists no fixed hierarchy inside the assemblage, because it is constantly shifted to new or other actors, who for example are disturbing or creating stability in the current assemblage.

Assemblages and artefacts can both act as a black box. In assemblages, the black box may consist in how the elements come together. In artefacts, the black box may consist in the work process that went into creating the artefact. (Rydin 2021, 189). As a planner in the relational planning approach, it becomes difficult to predict the effect of specific actions and planned implementations within the assemblages. This means that a plan can create chaos, but it is expected that the assemblages at some point will self-organise and reach stability again. Exactly what this stability will look like is impossible to predict, as the way the assemblages will be self-organised is uncertain. This happens because the world that we live in is affected by many factors both human and non-human, and the planner's role is to act as an intermediator. This means that planners can predict to some extent how their plans will be affecting the assemblages, but the total outcome of the effect will be revealed over time.

Our approach in this report is to destabilise the current assemblages, where the aim is that the system will adopt our solutions proposal for redesigning project area. The plan is that the solutions proposal, which will be designed throughout the study, will become an artefact within the assemblage, which hopefully will create reactions by the actors.

It is not only planning that can create instability within assemblages. An example of what else can create instability or shocks is an extreme weather event, which will test if the current assemblage is resilient (Rydin 2021, 175). Rydin describes how shocks can be both as "slow burn change over time as well as short-life catastrophic events", which are the elements that the current assemblage must self-organise around. In the view of Rydin, a system's resilience can become important to the planner, and Rydin defines a resilient system as follows: "A resilient system is also seen as one that is able to self-organise and respond to these various shocks and pressures by continuous adjustment; planning then becomes just part of such adjustments" (Rydin 2021, 175).

The aim of this project is to destabilise the current assemblage, since the current assemblage is not robust enough to manage extreme weather events, such as flooding from groundwater, ocean, cloudburst, and long periods of rain events. It is important for this project to redesign a detached housing area that both incorporates sustainable social habits that the residents must adopt and investigates how the material world must be redesigned.

Rydin points out that one limitation in using the concept of assemblages is that it is difficult to draw the line as a planner to determine what is relevant to investigate and what is outside the scope of the investigation:

> "*Researching assemblages is quite elusive and involves choices about where to draw boundaries. How far to go in tracing connections and linkages*" (Rydin 2021, 184).

We will use the theory as a planning approach throughout the report, but we will all also draw boundaries of how far we will be tracing connections and investigating the actors' dynamics. In this thesis, we use relational planning as an empirical approach to understand the discourse around climate adaptation and detached house areas. In addition, the theory is used to understand the actors and how they position themselves in relation to climate change adaptation.

Doughnut for Urban Development

To understand the Doughnut Economy, it is important to have knowledge about the planetary boundaries. The planetary boundaries are a framework of nine planet boundaries; climate change, novel entities, stratospheric ozone depletion, atmospheric aerosol loading, ocean acidification, biogeochemical flows, freshwater change, land-system change and biosphere integrity (Stockholm Resilience Centre, n.d.).

In 2023 six of the boundaries have exceeded the limit values, and in general, the pressure on the boundaries is increasing (Stockholm Resilience Centre, n.d.). Therefore, there is a need for urgent action, as an overshoot on the boundaries of the planet is already occurring. In 2024 Denmark's overshoot day was the 16th of March (Global Footprint Network, 2024). Therefore, it makes sense to focus on delivering within the limits set by the planetary boundaries when projects are carried out in Denmark.

The Doughnut Economy model made, by Kate Raworth, aims at meeting all people's needs, without compromising the means of the planet. This model is a holistic approach that consists of two rings, social and ecological. The social ring is to ensure life's essential for all. The ecological ring takes point in the model for planetary boundaries and to ensure the planet is taken care of, and that there is no overshoot on the planet's resources. It is between these two rings the people's needs are met as well as meeting the means of the planet (Birgisdottir et. al. 2023, 25).

In the figure below from the manual *Doughnut for Urban Development,* it is illustrated that the ecological ceiling in doughnut economy is based on the planetary boundaries (Birgisdottir et. al. 2023, 25).

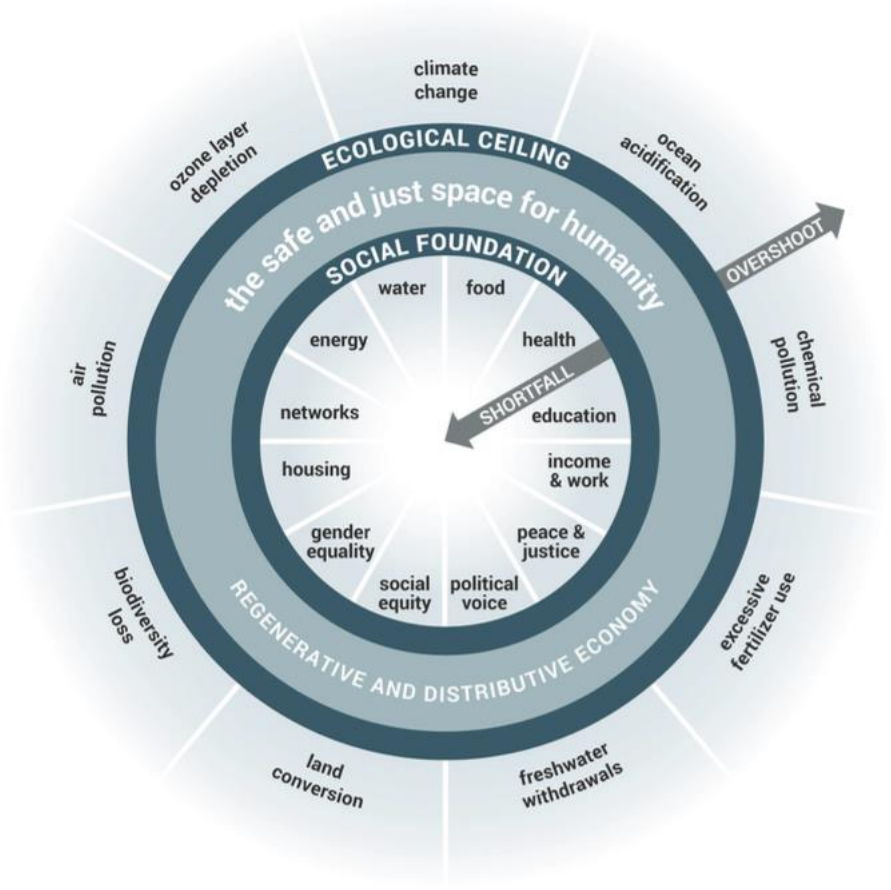


Figure 3: Illustration of the model of Dougnut Economy (Birgisdottir et. al. 2023, 24)

The focus on both the social and the ecological in the Doughnut Economy is due to the fact that in a global perspective, there are still problems with meeting the essential needs for a lot of people, but at the same time facing a challenge with overshooting on the planet resources.

Doughnut economics recognizes human behaviour, and that the world consists of systems, that can be understood through system thinking. Therefore, doughnut economics is a way of thinking that creates a focus on regenerative and distributive dynamics (Birgisdottir et. al. 2023, 27).

Figure 4 below shows the model The Doughnut for Urban Development, which is a framework that builds upon the Doughnut economy by Kate Raworth. The Doughnut for Urban Development was made as a guide to use Doughnut Economy in urban development. The illustration differs from the model of the Doughnut Economy by adding two rings. The

extra ring for the social foundation categorises the 12 social parameters into four categories; connected, inclusive, equitable and responsible urban development. In terms of the extra ecological ring, two categories have been added: climate stability and healthy ecosystems (Birgisdottir et. al. 2023, 30).

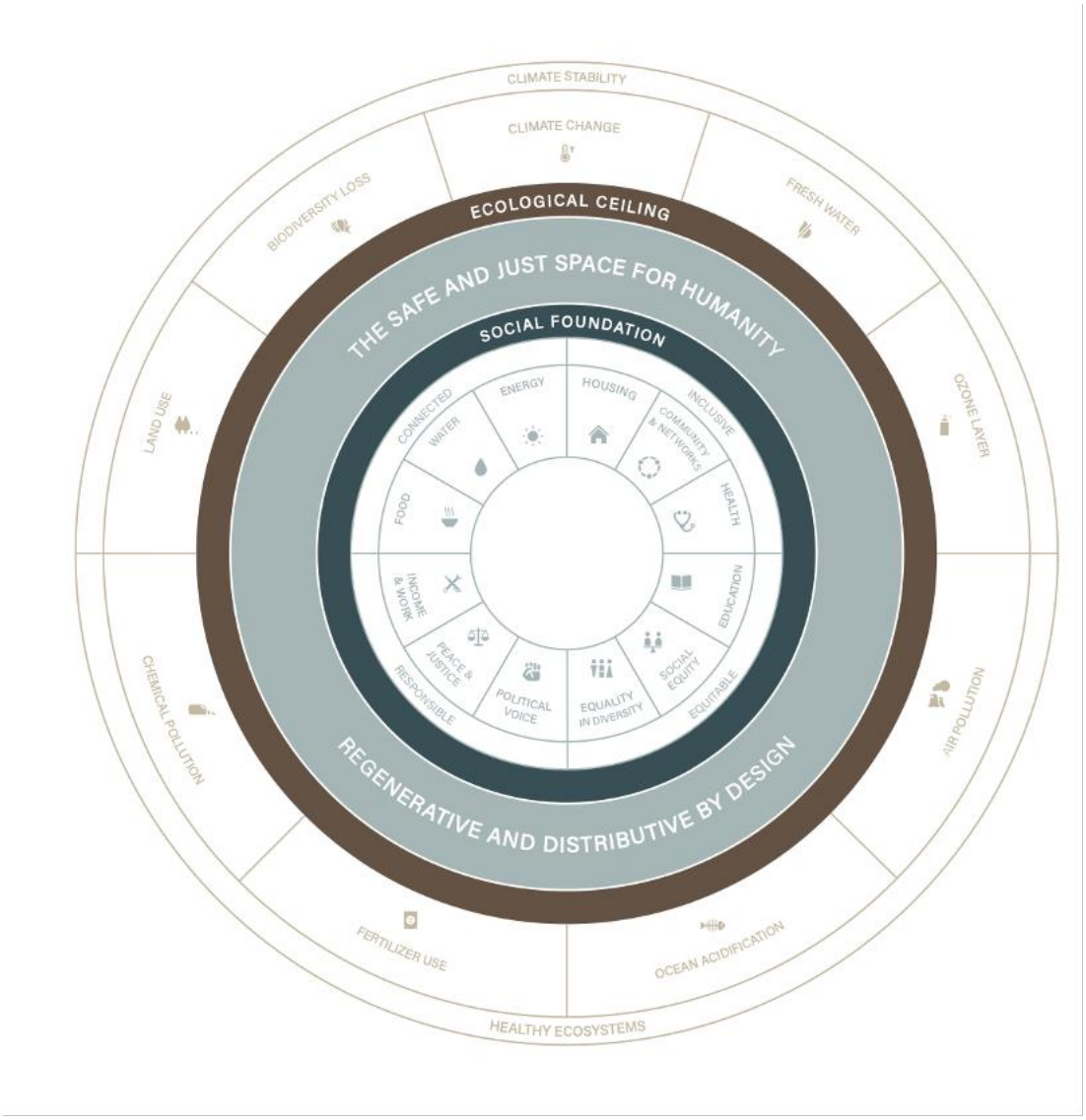


Figure 4: Illustration of the model of Dougnut economy for Urban Development (Birgisdottir et. al. 2023, 31)

The social foundation can help actors in urban development to overcome challenges and impacts. The social foundation should not be seen as complete but must be seen as a guide to develop and improve urban development (Birgisdottir et. al. 2023, 46).
The framework of the ecological ceiling focuses on that humans have to operate with a focus on the biophysical processes which are the basis for maintaining the Holocene-like state (Birgisdottir et. al. 2023, 81).

The trends seen with overshoot on the planetary boundaries must be reversed, and at the same time, there must be a focus on assessing the environmental impacts throughout the entire value chain (Birgisdottir et. al. 2023, 133).
The ecological ceiling is based on nine different planetary boundaries. Climate change and loss of biodiversity are core boundaries, if these are breached it can drive the earth system away from the Holocene and into a new state. The earth's ability to function deteriorates if the seven other planetary boundaries are exceeded. As ecosystems are part of what stabilises the climate, it is important to focus on the ecosystems and how they are functioning best (Birgisdottir et. al. 2023, 81).

Doughnut for Urban Development is used as a framework, that can contribute to ensuring the redesign of the project area will be sustainable. The Doughnut for Urban Development will help focus on the social aspects without overshooting the planetary boundaries when redesigning the area.
The Doughnut for Urban Development proposes some targets within the categories of the social foundation and ecological ceiling to ensure the framework in planning for urban areas. In this project, only the local targets are considered when redesigning the project area.
The local targets for the Social Foundation and the Ecological Ceiling can be found in Appendix 5.

Methodology

In the methodology section, the methods semi-structured interview, location analysis, the software Scalgo Live and scenario method are presented. The semi-structed interviews are used as the interview structure throughout the project, as it gives a structure to the interview, but at the same time an opportunity to deviate from the interview guide. The location analysis is used to understand the urban area of Ølby Lyng and Ølsemagle. The software Scalgo Live is used to investigate the effect of climate change and to illustrate how the urban area can be redesigned. Scenario method is used as a tool to create the future of Ølby Lyng and Ølsemagle in year 2050.

Semi-structured interviews

One of the methods used for this research is the qualitative method semi-structured interviews. Four in-depth, semi-structured interviews with relevant actors from Køge Municipality, with the utility company KLAR Forsyning A/S have been conducted in this research and a lecture in planning and design from Copenhagen University (see Table 1). We developed an interview guide for each interview. This approach gave us the opportunity to become visible as a knowledge-producing participant in the process itself, and we were not strictly required to follow the interview guide (Brinkmann 2023, 18). If, for example, we had chosen the method structured interviews, we could not depart from the interview guide (Brinkmann 2023, 17). Our goal was that the questions from the interview should elicit general information about the actors to allow us to gain insight into the life world of the interviewee, which helped us improve the data collection within the study (Brinkmann 2023, 19-20).

The interview guide's questions were based on both the literature "Rain and Sewage Plan 2021-2026", published by Køge Municipality, and the research statement and questions. The structure of the interview guide was divided into different themes as recommended by Galletta and Cross (2013): one section with questions focusing on the life world of the interviewee and another section with questions about Ølby Lyng and Ølsemagle (Galletta and Cross 2013, 45).

Furthermore, we also asked the following question in each interview:
What is your wildest vision, if you had a non-restricted opportunity to implement whatever you desired for climate change adaptation?

The reason for asking this question was that we wanted to investigate what the interviewee with his/her professional background would choose to do if anything was possible. The question was also asked to investigate if the interviewee had any ideas to add to our research statement and questions. In general, the interview guide was specifically framed for each interviewee to explore different perspectives within the problem field.

The interview guide also included images, figures, maps of the research area and KAMP-analysis to support the questions we asked at the interview. Common for each interview was also that they were recorded and transcribed.

During the project period the following interviewees have been interviewed (see Table 1).

Interviewee	Purpose	Format and data	Reference
Bettina Simonsen, Project Engineer at KLAR Forsyning A/S	To obtain knowledge about the planning processes for Ølby Lyng and Ølsemagle.	Physical interview	Appendix 1
Jacob Skjødt Nielsen, Green Ambassador at Grøn Omstilling, and **Signe Weinreich Rasmussen,** project consultant at Grøn Omstilling in Køge Municipality	To obtain knowledge about the planning processes for Ølby Lyng and Ølsemagle.	Virtual interview through Teams	Appendix 2
Tore Bro, Civil Engineer at department Natur, vand & jord in Køge Municipality	To obtain knowledge about the planning processes for Ølby Lyng and Ølsemagle.	Virtual interview through Teams	Appendix 3
Ole Fryd, Associate Professor in Landscape Architecture, Planning and Design at Copenhagen University	To obtain knowledge about non-traditional planning processes and to learn from his experience within the field of climate change adaptation.	Physical interview	Appendix 4

Table 1: An overview of the semi-structured interviewee, the purpose and format of the interview.

The semi-structured interviews also have limitations. A limitation of this method is how we interpret the composed stories by the interviewee since stories tend to be presented in a way that is full of gaps. This can sometimes act as a black box, which the planner can have a difficult time unfolding. As Brinkmann (2023) points out, one approach to unfolding these gaps is "[…] to be open to multiple interpretations of what is said and done in an interview" (Brinkmann 2023, 21.). In addition, the interviews were carried out in Danish, but when using the interview in the report they are translated to English. This means that some of the meaning can be lost in translation.

Location analysis

In this section, the method of location analysis will be presented. The location analysis will be used to obtain a greater understanding of the area Ølby Lyng and Ølsemagle, as it is important to have a deep knowledge of the area and how it is used if wanting to redesign the area. When performing the location analysis there will be a focus on how the urban spaces are and how the area is used, but there will also be a focus on climate adaptation in the area.

Three fieldworks have been carried out within the project area to research the area, based on the method of the location analysis. Fieldwork is defined as follows in the Cambridge Dictionary:

> *"study that consists of practical activities that are done away from your school, college, or place of work"* (Cambridge Dictionary n.d.)

In this project, the fieldwork is carried out as a study of the urban life in the detached house area of Ølby Lyng and Ølsemagle. The urban space is examined and the functions in the area are located. Observation is important when performing a location analysis. Here, the urban space must be observed as well as the people who use it, to determine how the urban space are used (Gehl and Svarre 2013, 32-33).

When studying an area, it is important to know what kind of area it is. In this project, the area is a detached house area or residential area. This information is relevant because the type of area has an impact on when it is relevant to register data for the area. Also, the weather and type of day, if it is a weekday or weekend, is relevant to the registrations in the area, as the area is likely to be used in different ways depending on the weather and type of day. Even when looking at an area where no people are using it at that specific time, maybe due to the weather, it is still possible to discover clues to how the area is being used. Clues can for example be paths where grass is worn down, due to people's moving patterns (Gehl and Svarre 2013, 32-33).

In order to map the urban space and what it is used for, some tools can be used when you are out in the area. The tools used in this project are the following 1) C*ounting,* 2) *Mapping,* 3) *Photos,* and 4) *Diary* (Gehl and Svarre 2013, 34). These mentioned tools will be used during the fieldwork We will in the following sections elaborate these mentioned tools.

Counting

Counting is used to register the number of different elements that exist or are experienced in the urban space. It can be anything from the number of trees to the number of people who smile (Gehl and Svarre 2013, 35).

The things we are counting can be categorised into two categories, fixed elements and movements. These are shown in table 2.

Fixed elements	Movements
Grates	People
Benches	Dogs
Nature-based solutions	Cars
Rainwater beds	Bikes
Bus stops	Busses
	Excavators
	Scooters

Table 2: Shows the movements and fixed elements that was counted.

The result of counting is quantitative data that can be used in the project. Fixed elements in the area such as sewer grates are counted individually. When people or similar are counted, random samples are carried out to form a picture of how the urban space is used (Gehl and Svarre 2013, 35). These counting's of fixed elements and random sampling was carried out during the fieldwork.

Mapping

Mapping is a tool used to mark different things or aspects on a map of the area. Mapping is to mark different spots on a map of the area to create awareness of what is happening in the area and where in the area these things take place. As an example, the mapping could be of certain activities such as where people are sitting in the area, to create an overview of where in the area people usually stay (Gehl and Svarre 2013, 36).

Photos and diary

Taking photos can be used to document different situations or the data the other tools produce. Photos help convey the things that are registered out in the area. By using photos as a tool, new details can be discovered when you get home from the data collection of the area, as the image captures the situations and allows you to better get a detailed overview (Gehl and Svarre 2013, 41).

Keeping a diary while exploring an area helps to remember details of the urban space. The diary provides qualitative data to complement quantitative data from the other tools used to investigate the area (Gehl and Svarre 2013, 42).

In this project, the location analysis is used to get an understanding of how the area is being used by people and for what. This way of observing an area only provides a snapshot of reality. A range of tools can be used to investigate the area, but choosing which parameters the location analysis should include is a subjective decision. Therefore, there is some subjectivity in this kind of analysis, as the planner chooses what to look at.

Scalgo Live

The section below will present the method of using the program Scalgo Live. Here the features such as analysis and workspace will be described as well as how these are used in this project and contribute to Analyses 1 and Analysis 3 respectively. Scalgo Live is a program (non-human actor) that contains tools to make it possible to investigate how the area will be affected by climate change in the future and to make changes to the area and see how these changes have an effect.

A workspace must be made to investigate and make changes to the project area in Scalgo Live. The area is marked when creating a workspace, and an analysis is chosen (Scalgo n.d. E), in this case the analysis is flash flood. Other analyses like sea level rise can be added when the workspace is created.

Scalgo Live in Analysis 1

In the program Scalgo Live, it is possible to make various analyses, including storm surge events, sea level rise and groundwater levels. In addition, the elevation of the project area and sewage catchments including combined sewer system and separated sewer systems are

shown. These analyses are used to show how the various water events have an impact on the area.

To make these analyses, the elevation map is activated in Scalgo Live. This map is based on data from the Danish Elevation model (Scalgo n.d. C). In addition, the sewer plans, which show what kind of sewer system there is in the area, are based on data from Plandata. The groundwater levels is based on data from Hydrologisk informations- og prognosesystem (Scalgo 2016).

Sea level rise is an analysis in Scalgo Live, where it is possible to simulate a sea level rise, where the value for the sea level rise is put into Scalgo Live. This will create a simulation where it is possible to see how much of the area there is affected by the sea level rise. The value is set in centimetres (Scalgo n.d. B). The flash flood analysis is an analysis where it is possible to put in a rain event at a specific amount in millimetres. This will show where the water will accumulate in the area during the specific event (Scalgo n.d. A). It is possible for the flash flood analysis to consider the sewer system within the simulation. This will help show where there are issues even though the sewer system has been implemented (Scalgo n.d. C).

Scalgo Live in Analysis 3

In Analysis 3, Scalgo Live has been used to change the terrain within the project area. The tools interpolate and lower and flatten have been used to make these changes.

The tool Interpolate interpolates the terrain, so the elevation in the area of the interpolation is the same (Scalgo n.d. D). In this project, the mode *Area* has been used to remove buildings (Scalgo n.d. D), so the terrain becomes the same elevation as the ground. It is used to show the managed retreat of the coast and to make green areas in the project area.

The tool Lower and flatten has two modes *Path* and *Area* (Scalgo n.d. D), these has both been used to create solutions in Scalgo Live in this project. The path mode has been used to create ditches along the side of some of the roads in the area, the depth of the ditches is 1 meter. The area mode has been used to create rainwater ponds in the area, these are 3 meters in depth, as the maximum depth in most lakes in Denmark is 3 meters (Miljøministeriet, n.d). In both the ponds and the ditches side slopes are created, which is a tool that creates slopes going from the bottom of the basin or ditch up to the terrain (Scalgo n.d. D).

In this thesis, these tools are used to show how the area can look in 2050 by making changes to the terrain. Then showing how this has an impact on the water accumulation during a rain event and sea level rise.

Scenario

Scenarios are used to give an idea of how the future could look, as scenarios tell a story about the future. The scenarios have to be creative to ensure the planned areas are prepared for what the future can bring. At the same time, it is important to acknowledge that there is an uncertainty in the future, that always will be there (Bishop, Hines and Collins 2007, 5).

There are different types of scenarios and different ways to approach them. In this thesis, the method baseline scenario is used. This is used because the method helps create a baseline, a plausible scenario, for the alternative scenarios. The baseline scenario is based on trends in society, and on how these are likely to evolve until the period of the future scenario (Bishop, Hines and Collins 2007, 11-12).

To do the baseline scenario the Manoa technique is used, which was developed by Wendy Schultz. The goal of this scenario technique is to create alternative futures that can be developed as well as create additional futures. This method explores the primary and long-term effects of change and its outcomes (Schultz, 2015).

The first thing to do when using this technique is to identify three issues or trends within the categories of social, technological, environmental, economic, or political sectors and then state how they will be in the time perspective of the scenario. Then it is important to brainstorm which primary and secondary impacts these changes have. Some impacts might overlap, therefore the cross impacts between the trends in the future scenarios have to be identified (Schultz, 2015).

As a part of this scenario technique a story about, *a day in the life* of a person living in this future has to be created (Schultz, 2015). This can also help to understand how the future will look like, and understanding the differences there are from the present.

The baseline scenario is used in this thesis as a base for creating a redesign plan for the project area in year 2050. In Analysis 3 emerging issues of change will be presented, which

originates from the Manoa technique. In addition, a section with *a day in the life* will be in the end of the redesign plan.

State of the art

In this section, state of the art, we will explore how cities can transition towards a sustainable urban water management system and how nature-based solutions can be an alternative to technical solutions in urban water management systems. This state of the art will give the necessary background knowledge for understanding the analyses that we will present later.

Transition of the urban water system

The point of planning for an urban area in terms of climate change adaptation is that the world's population is concentrated around the cities. It is important to recognise that cities are shaped by various interconnected processes and the relation between different locations within the city (Fratini and Jensen 2017, 86-88).

The point of the text *Urban water management in cities: historical, current, and future regimes* by Brown, Keath and Wong (2009) is to present a framework for the transition towards sustainable urban water management.

The model shown below (Figure 5), is the urban water management transition framework by Brown, Keath and Wong. This framework takes point in Australia but can be transferred to a European context because Australia's early water management originates from Europe and has been presented to water professionals in England and the Netherlands. It is important to acknowledge that the different phases are not linear, but cities can move across the six phases (Brown, Keath and Wong 2009, 850-51).

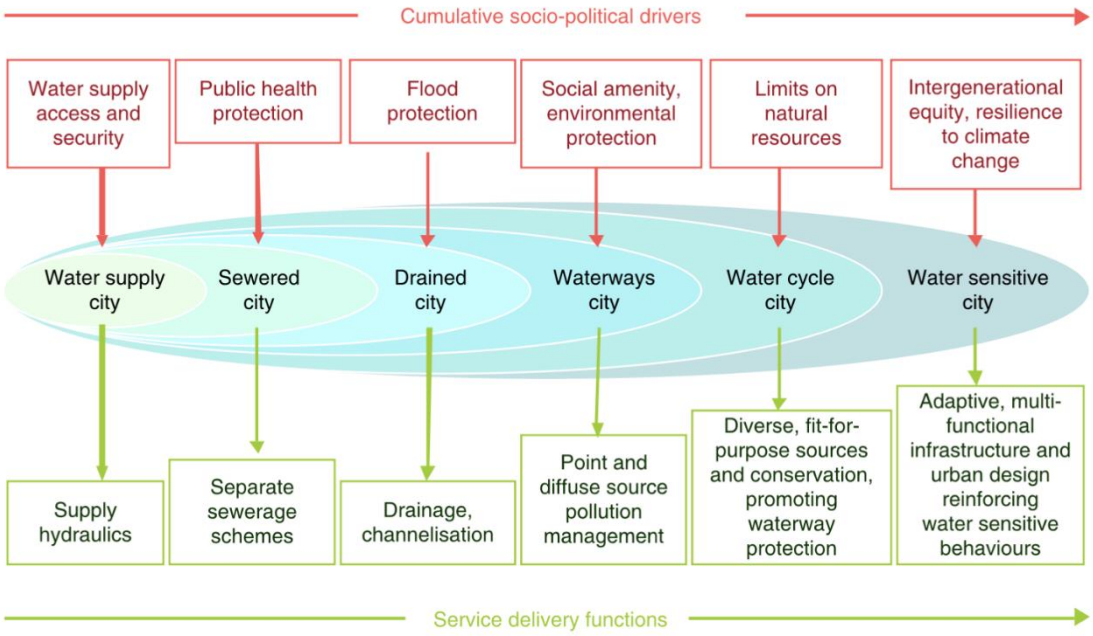


Figure 5: Model showing the different phases in the Urban water management transition framework (Brown Keath and Wong 2009, 850)

The six phases are 1) Water supply city 2) Sewered city 3) Drained city 4) Waterways city 5) Water cycle city 6) Water sensitive city (Brown, Keath and Wong 2009, 850). The different phases have had an impact on how water is managed today. Due to economic growth and a public interest in the environmental consequences from 1970 to the late 1980s, further development of the water infrastructure where the implementation of treatment plants was in focus, was on the agenda (Fratini and Jensen 2017, 91). This means the focus was on the environment and how water pollution could be minimised, which is the main concern in the Waterways city.

The basis for the Water supply city was to ensure the water supply of fresh water to the growing urban population, where it initially concerned water supply for the elite, but changed to the idea that it should be a public right. Therefore, the first hydro social contract was drawn up, which was to ensure the supply of water at a cheap price. This contract also secured taxation to pay for the water infrastructure. This system supplied water through the extraction of larger quantities of water by building dams and pipe systems (Brown, Keath and Wong 2009, 851).

The sewered city started due to health risk in the European cities which led to the invention of the combined sewer system, where the wastewater would be transported outside the cities. Due to the difference in the rainfall in Europe and Australian investment in a separate sewer system was done (Brown, Keath and Wong 2009, 851-52).

The drained city made its entrance in the period after the Second World War when people wanted to move into their own houses with a garden and where the car made it possible to live further away from the city centre. To reduce the consequences of flooding, local rainfall records and drainage design standards were established. To ensure efficient transport of stormwater away from the cities, as stormwater was seen as a nuisance, waterways were placed underground in pipes and river systems were canalised (Brown, Keath and Wong 2009, 852).

Waterways city challenges the hydro-social contract as environmental services and environmental protection are taken into account. There was also a change in the way water was viewed, and water was planned as a recreational function in urban development. This led to requirements for water quality and regulation of discharges with pollution from wastewater and industrial processes. With new approaches to water, the distribution of responsibilities also changes. Although this could be a point of tension between those who believe in the traditional values of water management and those who want change with a focus on environmental protection. When Melbourne transitioned to Waterway city, stormwater management was primarily driven by those who wanted change (Brown, Keath and Wong 2009, 852-53).

In Denmark, the change towards above-ground solutions for water was a part of a paradigm shift, where urban planning was inspired by Jan Gehl and his concept in *Life between buildings,* as these solutions should add value to the urban areas. In 2007, a project named 2BG, was financed in which green urban spaces were to be included in managing water rather than only optimising the pipelines for water, which is located underground. This led to further funded projects where the actors within water management had to be more actively involved in experimenting with water infrastructure on the surface which had to be integrative and multifunctional in the urban spaces (Fratini and Jensen 2017, 92).

The Water cycle city is based on recognising the limits of the traditional water sources as well as the ability of the waterways to absorb pollution. In addition, consideration towards sustainability in its three forms; social, economic, and environmental has been acknowledged. Water cycle city is a water cycle approach that includes water saving and water supply according to the purpose. Thus, the quality and the sources will vary according to the purpose for which the water is to be used. This approach, with the use of other sources of water or recycled water, helps the security of supply as well as protection of the water resource at a

time when the limits of sustainable use of the water resource have been reached. However, this approach challenged the promise of risk-free water supply in the hydro-social contracts (Brown, Keath and Wong 2009, 853-54).

The Water sensitive city is a concept that represents a potential sustainable future in relation to water and the management of water resources. The hydro-social contract will be different in this future as this contract for the Water sensitive city:

> *"[...] would integrate the normative values of environmental repair and protection, supply security, flood control, public health, amenity, liveability and economic sustainability, amongst others."* (Brown, Keath and Wong 2009, 854).

In this sense, the city, hydro contract etc. will be flexible and in constant development, also recognising the connection that exists between society and technology, and thus designed to support a sustainable lifestyle that is adaptive (Brown, Keath and Wong 2009, 854). This point of adaptiveness should be considered when redesigning the project area, as it will have to continue to adapt to the climate change that is in constant change.

Nature-based solutions

Nature-based solutions are an alternative to technical solutions like sewer systems for managing the effect of climate change. The European Commission defines a nature-based solution as:

> *"Solutions that are inspired and supported by nature, which are cost-effective, simultaneously provide environmental, social and economic benefits and help build resilience. [...]"* (European Commission n.d.)

This means that a nature-based solution is to get the natural environment and implement it in the urban atmosphere and is an actor there can help in withstanding climate change. These solutions are based on natural processes and should fit into the local area (Fryd, Jørgensen and Lund 2023, 37). These solutions can both help with water absorption and with heatwaves (Bush & Doyon 2019). The nature-based solutions are a part of the transformation towards a Water sensitive city, as this actor is based on the natural resources to resist climate change and bring some green areas to manage water in large fortified areas.

Scientists such as Bush and Doyon (2019) make it clear that nature-based solutions are a part of the solutions towards sustainable cities. This is because nature-based solutions aim to address societal challenges, including climate change, through ecosystem-based approaches. These solutions contribute to recreation and cohesion in urban spaces and local communities, as well as contribute to physical and mental health (Bush and Doyon 2019). This is a new form of climate change adaptation that the planners, the municipalities, and the utility companies must master in both new and existing urban areas.

In terms of nature-based solutions that help against sea level rise, storm surges, and coastal erosion, Ole Fryd and Anna Aslaug Lund provide some ways to address these challenges in the book *Tænk os om*. Here is mentioned the technique managed retreat of the coast where the point of retreat of the coast is to give the sea back some of the area that has often been filled in before, which enables the sea to spread further up on land and gives the area a wider coastal line. This can be categorised as a nature-based solution because;

> *"[…] as it is based on a reading of the landscape and the dynamics of nature."*(Fryd, Jørgensen and Lund 2023, 40 – own translation).

Retreat of the coast can be based on different reasons. The different managed coastal retreat is market driving managed coastal retreat, catastrophic managed coastal retreat or planned managed coastal retreat. The managed coastal retreat is based on supply and demand, if no one want to live near the coastline, will the buildings over time automatically be removed. The catastrophic manages coastal retreat is moving of the buildings do to catastrophises like flooding. At last, the planned managed coastal retreat is a planned retreat where areas there are exposed, over time will be retreated (Fryd, Jørgensen and Lund 2023, 40-42).

Alternatives to this management of water are following two planning concepts proposed 1) to live with the water when the weather events are happening 2) to stop building so close to the coastline or in areas that are at risk of flooding.

The intent of this section was to give an insight into the transformation of the water system and how the meaning of water has changed over time from being seen as trash to a recreative element in urban planning. This will be used to get an understanding of the transformation of climate change adaptation, which black-boxes the traditional water management system is containing and how this transformation can help in redesigning the project area to become sustainable and withstand climate change. At last, the element of nature-based solutions was

presented as this is a technique for managing water, and how this will contribute to a sustainable urban area.

Case description

The chosen project area is a detached housing area located in the city of Køge in Denmark (see Figure 6). This area has been chosen, since in this thesis we are collaborating with the department Grøn Omstilling (in English: Green Transition) within Køge Municipality. The project area is called Ølby Lyng and Ølsemagle. The ambition for Grøn Omstilling is to develop an experimental local plan for the project area. In particular, this experimental local plan will include climate change adaptation strategies and suggestions for new sustainable living conditions. Our contribution to the collaboration with Grøn Omstilling will be creating a future scenario of how the project area can be redesigned regarding climate change adaption and DE. We will work with the timeframe of the year 2050, due to Køge Municipality's ambitions to become climate-neutral by the year 2050 (Køge Kommune 2020). This is an ambition presented in Køge Municipality's DK2020 Climate Plan, and we will present key elements from this plan later in this section.

Figure 6: Shows the project area (Own design; Styrelsen for Dataforsyning og Infrastruktur and Køge Kommune, n.d.)

In Ølby Lyng and Ølsemagle, most of the project area is used for detached houses. Close to Køge Nord Station a park is located, which also functions as a nature-based solution that both absorbs water and as a place to storage run-off. Only one stream, Snogebæk, runs through the area out to the ocean (see Figure 6). In terms of transport and mobility, the residents have several opportunities to get to and from the area, including public transport such as busses, S-train, and railways, but also access to roads such as the highway E20, the main road Københavnsvej, suburban streets, and sidewalks. Figure 7 gives an overview of some of the key locations in Ølby Lyng and Ølsemagle mentioned here.

Figure 7: Shows pictures of different places of the project area, the pictures were taken in February (Own pictures)

In this paragraph, we will present the history of how Ølby Lyng and Ølsemagle developed into the area it is today. We will also introduce how Køge Municipality plans to manage water in the project area, and we will briefly present the future and current plans for the area Ølby Lyng and Ølsemagle. This is important to outline, since we want to redesign the area and explore which strategies human actors use to influence the area. First, we will introduce

the organisation structure of Køge Municipality and the utility company KLAR Forsyning A/S, then the history of Ølby Lyng and Ølsemagle and the plans will be introduced.

Organisation structure: Køge Municipality and KLAR Forsyning A/S

Køge Municipality is a traditional sector-oriented organisation, which is making holistic approaches difficult. Grøn Omstilling is a department that can move freely amongst the other departments, and they develop project with residents, local organisation, and companies that interested are in green transitioning (Appendix 2). Grøn Omstilling is a part of Køge Municipality's department the Technical and Environmental Administration (in Danish: Miljø- og Teknikforvaltningen) (see Figure 8). The Technical and Environmental Administration's organisational structure consists of different sub-departments, and the work processes include aspects from planning infrastructure and constructions, maintenance, premises rentals, environmental and nature projects as well as acquisition and sale of properties or land. In connection to the semi-structured interviews, the interviewee civil engineer Tore Bro is employed in the sub-department Natur, vand & jord.

Furthermore, the Technical and Environmental Administration collaborate with KLAR Forsyning A/S, which is owned by the municipalities Greve, Køge, Stevns and Solrød (see Figure 9) (KLAR Forsyning n.d.).

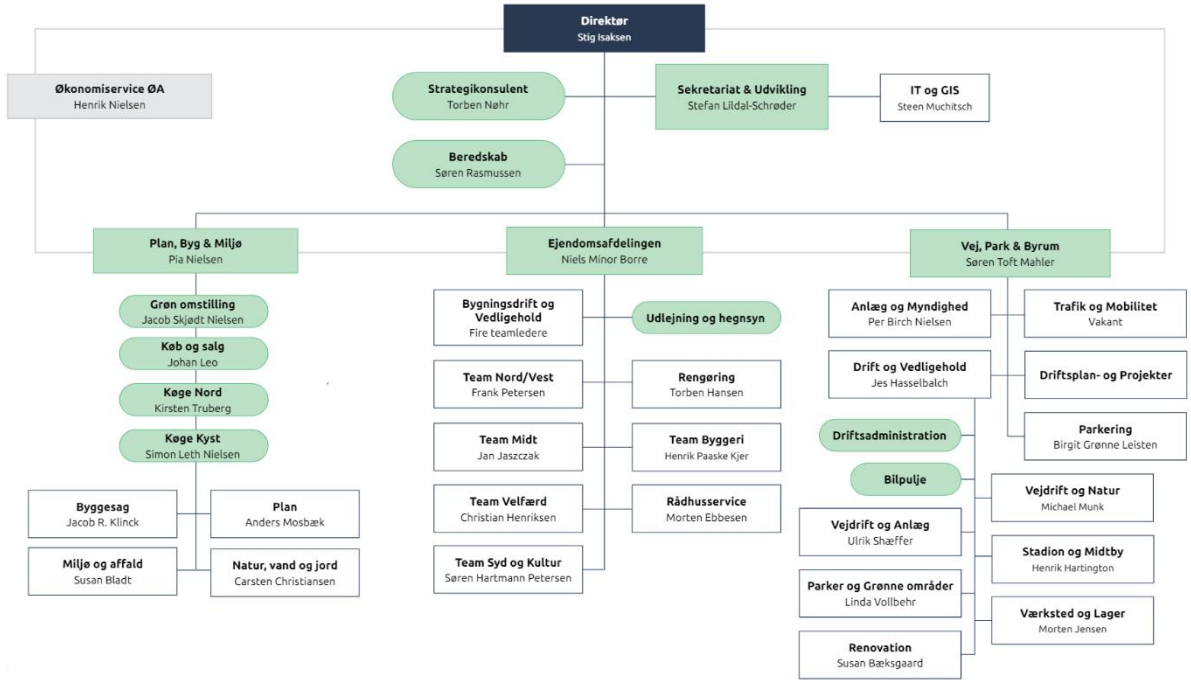


Figure 8: Organisational structure for the Technical and Environmental Administration (Køge Kommune 2023B)

KLAR Forsyning A/S's responsibility is to deliver services and solutions to residents in terms of water, electricity, and heat. They deliver services such as cleaning the wastewater from the detached houses, operate and maintain the sewer system, and plan and carry out climate change adaptation projects in the project area and the rest of Køge and neighbouring municipalities (KLAR Forsyning n.d.). KLAR Forsyning A/S's organisational structure is spread out on these mentioned municipalities, but also on different sub-companies (see Figure 9).

The sub-company Køge Afløb A/S is responsible for treating the wastewater and rainwater in the project area Ølby Lyng and Ølsemagle (see Figure 9) (KLAR Forsyning n.d.).

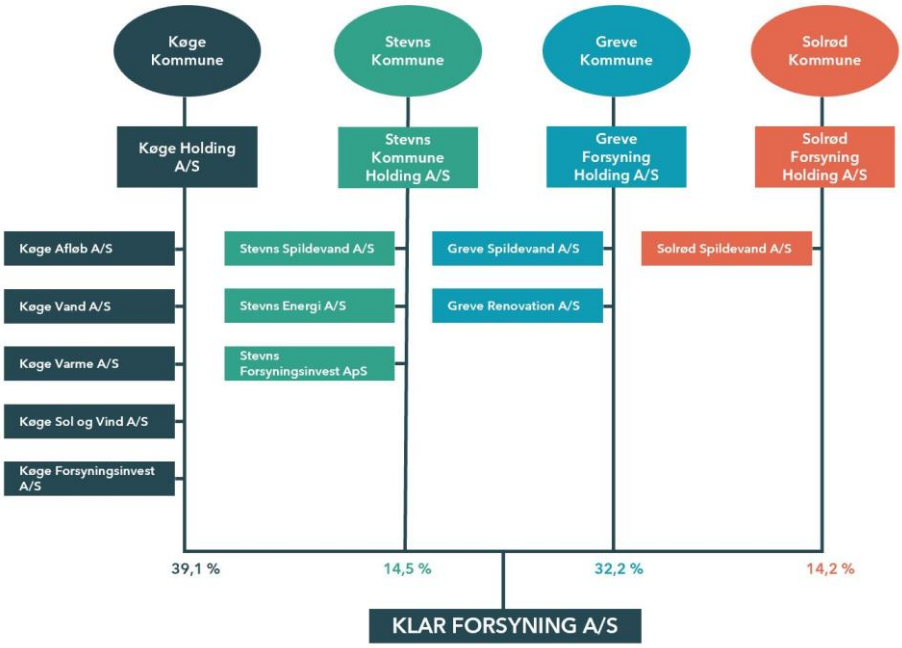


Figure 9: KLAR Forsyning organisational and supply structure (KLAR Forsyning n.d.)

The history of the project area and municipal plans

One key reason that we want to redesign the project area is that the detached housing area is located near the ocean, and the residents of the area have historically been affected by storm surge events (see Figure 10). The storm surge in the year 1872 affected the sea level so it increased by 3.5 meters, and to remember this event, a monument was placed in the project area to mark how far up the water went (Køge Arkiverne n.d. A; Køge Arkiverne 2013).

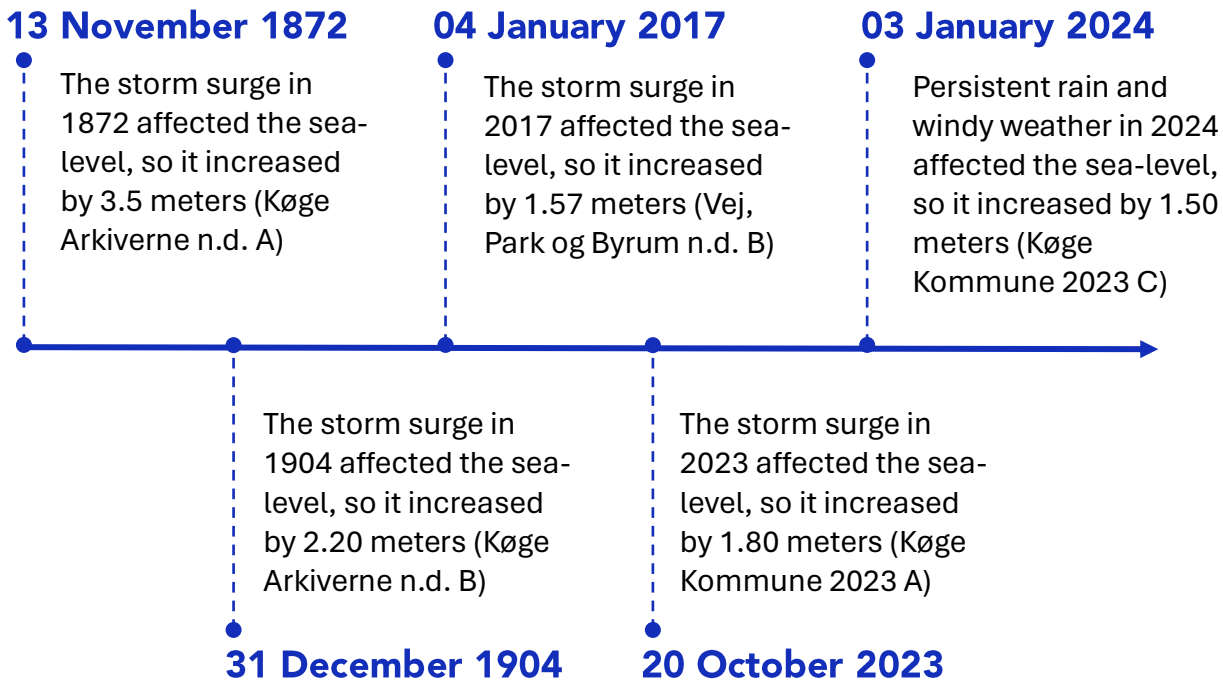


Figure 10: Shows a timeline for the historic storm surges and persistent rain in Ølby Lyng and Ølsemagle (Own design)

Not only has the project area been affected by storm surges, but the area has also become more fortified. The problem with fortification is it leaves less space for the planner to manage water in the area such as runoff from persistent rain and combined events, for example storm surge events combined with flash floods from above (Wejs 2021, 17). Fortification is an important challenge which will be discussed at greater length later in this section.

Køge Municipality's current approach for managing climate change events for the project area is to develop a dyke to prevent storm surges up to 2.8-3.0 meters over the normal sea level (Vej, Park og Byrum n.d. A). A factor that influenced the Køge Dige plan as the key approach for climate change adaptation is the storm surge event in the year 2023 (Vej, Park og Byrum n.d. A). The dyke project is managed by the sub-department Vej, Park & Byrum (see Figure 8) and the name of the project is Køge Dige. Vej, Park & Byrum expects that the dyke will be realised in 2025 or 2026 (Vej, Park og Byrum n.d. A).

The dyke will consist of large amounts of materials, such as sand, clay, and soil. The dyke is an example of a non-human actor in the network, which will play an important role in terms of protecting the area against floods from the ocean. Køge Municipality will establish a dyke corporation which will be the actor who is responsible for the maintenance and operation of

the dyke. Køge Municipality has received financial contributions towards paying for the establishment of the dyke from the Danish Government, which also helps the municipality navigate Danish laws such as the Danish Nature Protection Act (Vej, Park og Byrum n.d. A). Residents in the area will pay the remainder of the cost of establishing the dyke, and residents will also bear the maintenance and operating cost of the dyke. It is expected that the lifetime of the dyke will be 30 years, thereby the residents will be obligated to pay the maintenance cost for 30 years. According to Vej, Park & Byrum, the dyke will have to be enhanced after 30 years depending on how fast the sea level will rise (Vej, Park og Byrum, n.d. A).

As part of Køge Municipality's approach to managing climate change adaptation, the municipality has separated and expanded the current sewage system into managing rainwater in one sewer and wastewater in another (Vej, Park og Byrum n.d. A; Køge Kommune 2021) Køge Municipality expects that the lifetime for the separated sewage system will be 75-100 years (Køge Kommune 2021). It is important to mention that Danish municipalities are required by law to develop a rainwater and sewage plan. The current rainwater and sewage plan was developed by Køge Municipality in collaboration with the engineering company EnviDan A/S, and with close dialogue with KLAR Forsyning A/S. The plan was developed in March 2021, and the plan period runs from 2021 to 2026. This gives Køge Municipality, KLAR Forsyning, and Køge Afløb A/S five years to implement the goals presented in the plan (Køge Kommune 2021).

Køge Municipality's rainwater and sewage plan introduces three main reasons that the sewage system must be expanded: 1) the volumes coming through the sewage system are already too large, 2) urban densification in the area is increasing and may further increase in the future, putting the sewage system under even greater strain, and 3) of climate change in Køge Municipality makes greater amounts of rain much more likely, and may lead to higher water levels in both the streams and the oceans, which can cause more water on terrain.

According to the rainwater and sewage plan, it is not possible to design the sewage system so that it can manage all kinds of rain events (Køge Kommune 2021), perhaps because the dimensions of the system would have to be so large that it is not physically or economically viable to implement in a detached housing area. This means that residents still have a responsibility for managing flooding which may still occur. For instance, the plan mentions

that residents are themselves responsible for securing their basements by investing in anti-flood valves.

Køge Municipality is not only focusing on climate change adaptation but also mitigation strategies. Køge Municipality is part of the DK2020 partnership now called *Klimaalliancen.* This partnership consists of the philanthropic organisation Realdania, the think tank Concito, global collaboration network C40, and most Danish municipalities. The partnership's purpose is to reduce CO2 emissions and hinder global warming. Specifically, the cities participating in C40 commit to halving their share of emissions by 2030 following the SDG's and assist in limiting global warming to 1.5 degrees Celsius (C40 Cities Climate Leadership Group n.d.).

Køge Municipality has developed a plan called the DK2020 Climate Plan (Køge Kommune 2020). This plan includes a detailed description of how Køge Municipality will reduce CO2 emissions in the sectors of heat supply, electrical system, agriculture, transport and mobility, and consumption. In addition, the plan also includes a summary of climate change adaptation strategies for the municipality. Køge Municipality aims to reduce emissions by 47% in the year 2030 and to become climate neutral in the year 2050. To realise the plan, Køge Municipality will collaborate with different actors (see Table 3 below).

DK2020 Climate Plan topics	Actors who will be involved in meeting the targets
Heat supply	Internal departments in Køge Municipality, utility companies, citizens, local associations, non-governmental organisations, and private companies.
Electrical system	Internal departments in Køge Municipality, utility companies, plot owners, private companies, and directorate.
Agriculture	Ecological national league, local associations, the Danish government, universities, private companies, and internal departments in Køge Municipality.
Transport and mobility	Internal departments in Køge Municipality, public-owned companies, developers, other municipalities, regions, private companies, citizens, private companies, housing associations, private developers, other municipalities and the regions.
Consumption	Internal departments in Køge Municipality, private companies, citizens, non-governmental organisations, and other municipalities.

Table 3: Provides an overview of the actors that Køge Municipality have planned to collaborate with to reduce the overall consumption in Køge (Køge Kommune 2020)

Below, we will provide selected examples of how this plan will influence the residents in Ølby Lyng and Ølsemagle.

In terms of heat supply, the municipality has a target involving undertaking energy upgrading for private homes, residential homes and private companies in Køge (Køge Kommune 2020)

In connection to transport and mobility, the car is the most CO2-emitting form of transport in Køge, and it is the citizens' preferred form of transport. The citizens travel an average of 40 kilometres per day on average, and a majority of the households own one or more cars. It is Køge Municipality's desire to reduce negative impacts from the transportation sector and to provide alternatives to the cars, such as public transport, a super bike path at Københavnsvej, car-pooling, and shared cars. (Køge Kommune 2020)

Furthermore, Køge Municipality is focusing on reducing consumption, and the municipality has developed targets that include preventing food waste, changing dietary habits, reducing consumption of textiles, increasing the reusing and recycling of textiles and electronic products, including circular principles for the building industry, and utilising existing buildings. Køge Municipality expect that the citizens will adopt some changes to their way of living before the year 2050. Some of Køge Municipality's approaches to changing the habits of the citizens are to inform through campaigns, collaborating with companies in Køge, and adopting the desired development in Køge Municipality's departments (Køge Kommune 2020).

One of the climate change adaptation strategies from the DK2020 Climate Plan is to develop an afforestation plan. Another strategy is that KLAR Forsyning A/S will implement nature-based solutions in the new neighbourhood of Køge Nord. The central element in these nature-based solutions is a green area called *Det Grønne Strøg*, which includes different kinds of vegetation and depression in the terrain to create small lakes that can manage the rainwater. KLAR Forsyning A/S has designed the green area so that it can manage rain from the roofs of buildings, roads, and parking lots. A third strategy has been to work with permeable paving for a parking lot at Køge Campus. This material has been used because it delays the rainwater, which prevents overflow in the sewer system (Køge Kommune 2020). These climate change adaptation strategies show that both Køge Municipality and KLAR Forsyning A/S can take the initiative to establish nature-based solutions in Køge. However, the

approach for climate change adaptation in existing areas Køge Municipality is mainly focused on technical and traditional climate change solutions. In this project, we want to focus on how we can work with the current terrain and develop nature-based solutions instead of solving climate change adaptation with technical solutions (Appendix 2). To do so it is important to have an even greater understanding of the historical development of the project area. Figure 11 shows historical maps of the development of the project area from the year 1842 to the year 2024.

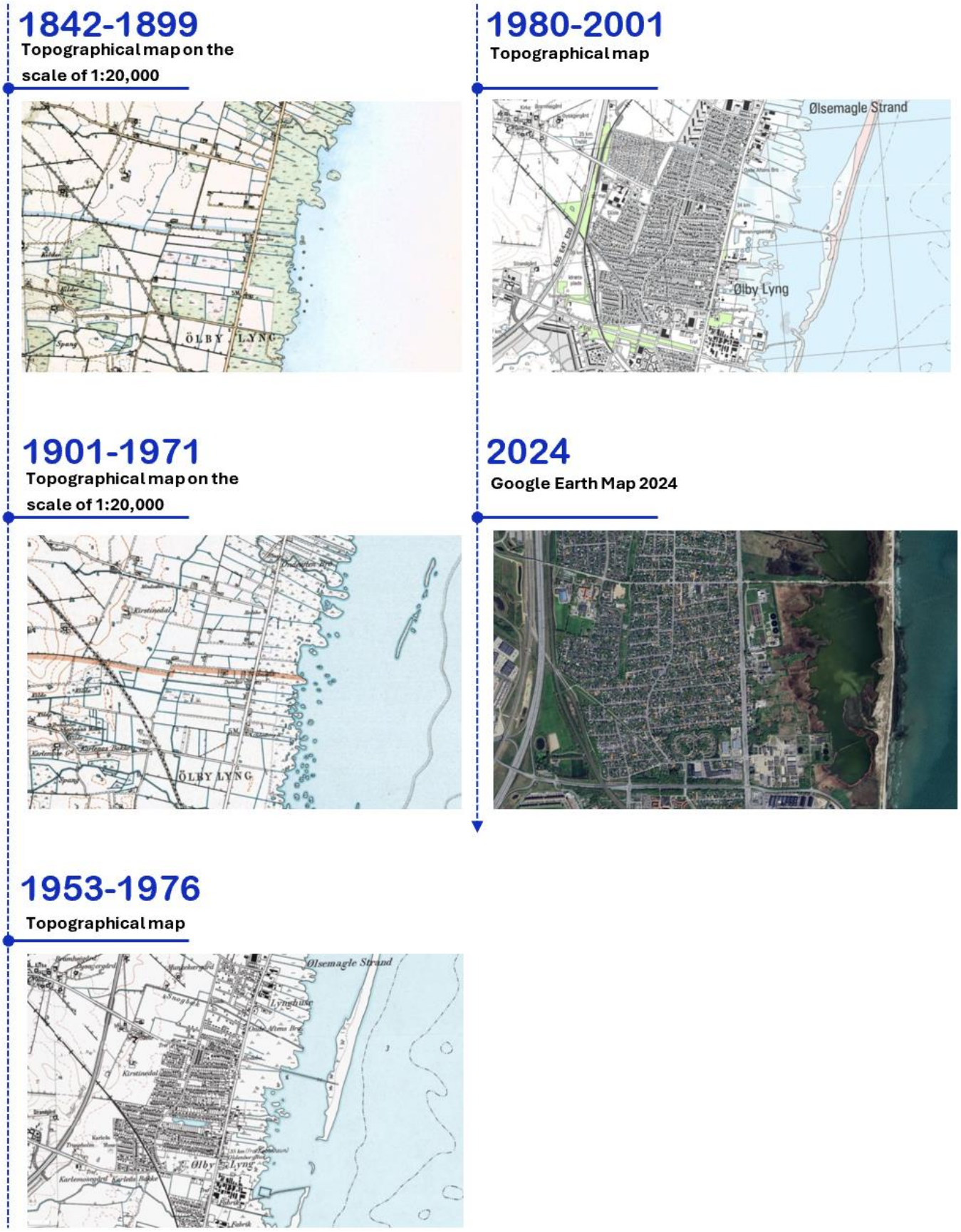


Figure 11: Shows the historical development of the project area Ølby Lyng and Ølsemagle. Figure (Own Design. Maps (Styrelsen for Dataforsyning og Infrastruktur n.d.; Google Maps n.d.A)

The map 1953-1976 from Figure 11 shows that there was a lake in the terrain of Ølby Lyng and Ølsemagle during that period. On the map from 1980-2001, there is no such lake. It is conceivable that the lake might have been drained so the detached houses could be built on the terrain, or the lake water could have evaporated. According to Brown, Keath and Wong, drainage design standards were incorporated into the engineering practices as part of a new urban water management transition which started in cities in the 1950s (Brown, Keath and Wong 2009, 852). Brown, Keath and Wong (2009) call this urban water management transition 'the drained city', which also means that it was the time in history when waterways were piped and located underground (Brown, Keath and Wong 2009, 852). According to Tore Bro climate- and wastewater employee from Køge Municipality specifically mentions that some of the streams had been piped (Appendix 3).

Figure 11 show that Ølby Lyng and Ølsesmagle have become more fortified, and as previously mentioned, increased fortification may cause significant drainage issues. We will now introduce the historical trends that have affected the area so that it has become more fortified. In the nineteenth century, it became more common for both the upper middle class and the working class to live in detached houses. The middle and working class achieved the same housing standard in this period by owning their own house and gardens. In Denmark, the detached housing boom happened in the period between 1960 and 1970. The following trends moved this societal change forward: 1) good lending conditions, 2) tax benefits, 3) increasing house prices, and 4) decreasing debt through the 1960s and 1970s made it possible for families to invest in detached houses, and the detached house became the most common housing unit in Denmark (Museum Sydøstdanmark n.d. B). Figure 11 shows that the area of Ølby Lyng and Ølsemagle has been highly influenced by these historical trends, and on the historical maps, it can be found that detached houses have now come to dominate the project area terrain.

Both the detached houses movement and transport and mobility infrastructure improvements made Ølby Lyng and Ølsemagle more fortified, which Figure 11 also illustrates. The average size of detached houses also changes over time. In the 1950s the average size of detached houses was 81 m^2, whereas in 2024 the average size is 154.5 m^2 (Museum Sydøstdanmark n.d. A; Danmarks Statistik 2024). Modern detached houses normally can include a garage, a covered veranda, or a conservatory. The project area has been influenced by different time periods, and the detached houses in the area are not all similar (see Figure 12).

Figure 12: Shows a small number of the different detached houses in the area (Google Maps n.d.B; Google Maps n.d.C; Google Maps n.d.D; Google Maps n.d.E; Google Maps n.d.F; Google Maps n.d.G)

Another element that influenced the movement of detached houses was the improvement of the transport and mobility infrastructure system. Historically, it was first the development of the railway roads, then afterwards roads were built for cars, which became the means of transportation in the detached houses areas in Denmark (Møller and Lind 2014, 150).

The detached house movement also had an impact on the societal culture, since the exponential increase of detached houses is correlated to an exponential increase in citizens being property owners. Furthermore, detached houses were marketed as a family style of living and became a symbol of freedom. According to Møller and Lind (2014), detached houses are associated with freedom and privacy (Møller and Lind 2014, 10), and these associations is part of the cultural norm of owning a detached house. Another association is also that detached houses emit more CO2 than other forms of living. According to Køge Municipality's DK2020 Climate Plan, the detached houses with more square meters consume more energy, and thereby, emit more CO2 than smaller housing units (Køge Kommune

2020). As previously mentioned, most citizens use the car as their primary form of transportation, which also a form of transportation source that emits more than public transportation or biking. All other things being equal, living in a detached house equals having a lifestyle that puts greater strain on the environment, due to both primary transportations being car and to expending more energy on heating.

Most of the properties in Ølby Lyng and Ølsemagle are privately owned, which means that homeowners play an important role in how the area is used. In some cases, Køge Municipality engage in dialogue and collaboration with the residents to explore how to solve the current challenges or involving residents in workshops and citizens' meetings about the current municipal plan strategies (Køge Kommune 2020)

Having now given an overview of the network and the primary actors involved in shaping the area both historically and in the present, we will move onto the analyses. Analysis 1 will contain two parts, first will the results of our fieldwork be presented followed by a Scalgo Live analysis of how climate change is affecting the area of Ølby Lyng and Ølsemagle.

Analysis 1 – Location and Scalgo Live analysis

In this analysis, we will investigate research question 1, what kind of climate threats that the existing detached housing area affected by. Furthermore, the existing detached housing area will be mapped out, and issues regarding water will be analysed. Water as an actor, in terms of rain, sea level rise, and groundwater is important to acknowledge when planning for an area, and this is why water have been chosen as a key focal point of this analysis.

Location analysis of Ølby Lyng and Ølsemagle

The project area that is researched is the area of Ølby Lyng and Ølsemagle, including the oceanside. This is to give a more complete overview of the risk of elevated groundwater level, the increased amount of rainwater, sea level rise and to help us understand how the water moves through the area through technical and more natural systems like Snogebæk to

the ocean. The Figure below shows the limited geographic area and the functions located within this area.

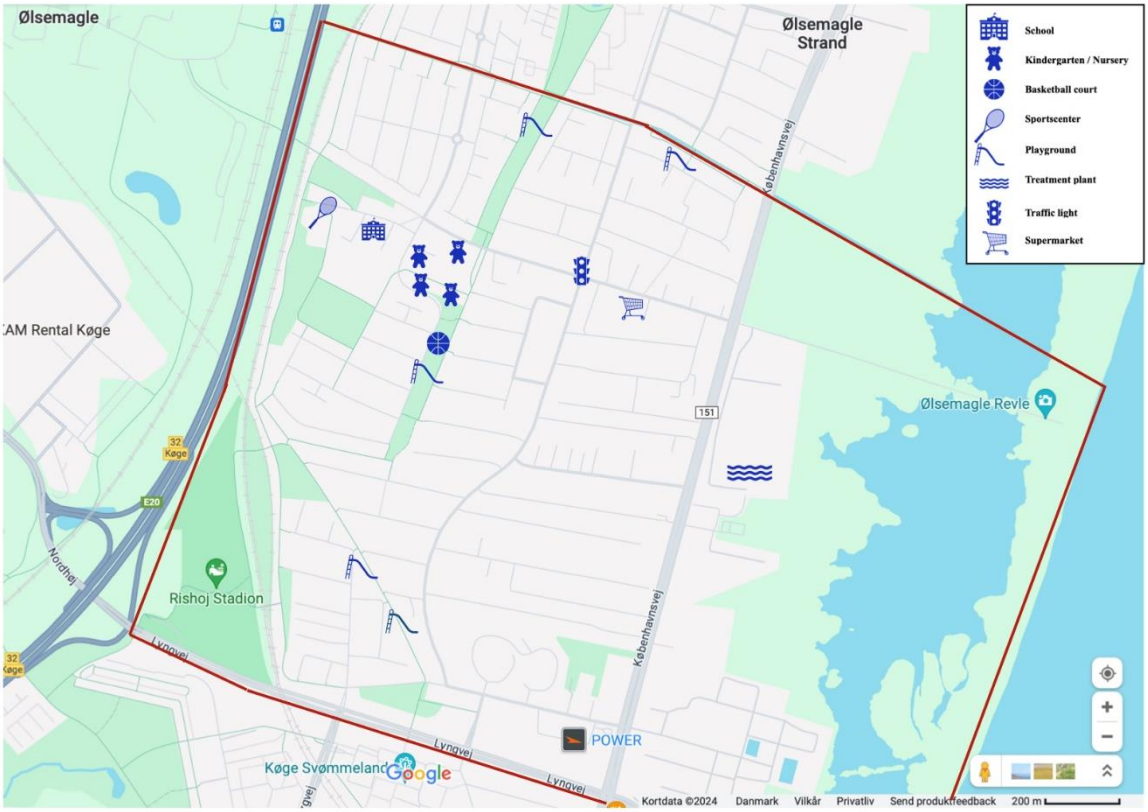


Figure 13: A map showing the project area in Køge (Own design; Google Maps. n.d. A)

Three fieldwork trips were carried out. The first fieldwork trip was a walk through the area, where a Kamp analysis was used to determine where the water might accumulate, and we investigated if this was the case when it rained in the area. During the second fieldwork trip, we walked through the area to get an overview and a sense of what the area looked and felt like when walking through it. The route went from Køge Nord Station to the bus stop Gammel Lyngvej, which can be seen in figure 14. The distance of the walking route was around 2,6 kilometres.

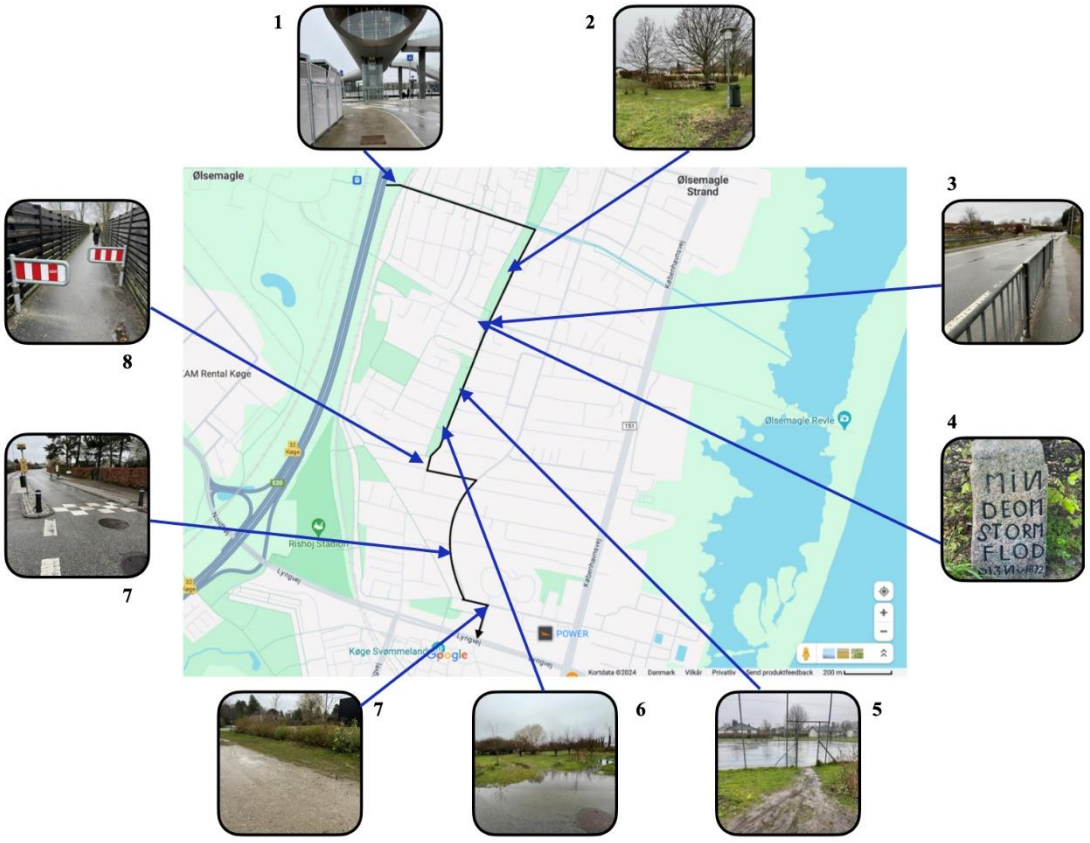


Figure 14: Map showing the location of different elements (Own design; Google map (Google Maps. n.d. B)

Along the route, there are some focus points in terms of traffic, infrastructure, and nature. The map above (Figure 14) shows where different elements are located along the stretch. There are two long and narrow green areas where playgrounds, benches and a basketball court are located, which indicates the opportunity to play and stay in the area. Picture 5 shows the entrance to the basketball courts which are very muddy due to the rain. This suggests that rainfall may already affect the area's usability in notable ways.

Figure 15: Three pictures of water accumulations in the project area, taken on the 4th of April (Own picture).

In the pictures above (Figure 15) some of the places where the water accumulates on the fortified areas in the project area can be seen. This shows how water can have difficulty seeping down when there are large, fortified areas. The first picture also shows water lying on top of the grate going into the sewer, which indicates that the sewer is either filled with water or blocked.

Random samplings of the people and their mobility took place at five different locations in the area: 1) Fuglebæk allé above the path to Køge Nord Station, 2) The green area by the playground, 3) By the basketball court 4) The intersection between Rønnevej and Hedebovej, and 5) The intersection between Nylandsvej and Ølsemaglevej. The random samplings were conducted on the 4th of April and the 13th of April 2024. Our observations suggest weather conditions can have a significant impact on the choice of movement (Gehl & Svarre 2013): on the 4th of April the weather was drizzle rain and 4 degrees Celsius, and on the 13th of April, the weather was windy and cloudy with a bit of sun and 15 degrees Celsius.

	4th of April 2024	13th of April 2024	13th of April 2024
1. Fuglebæk allé	Time: 10.02 – 10.12 Cars: 4 Excavator: 1 Bikes: 0 People 4 Dog: 0	Time: 12.49 – 12.59 Cars: 23 Excavator: 0 Bikes: 3 People: 8 Dog: 1	Time: 14.30 – 14.40 Cars: 20 Excavator: 0 Bikes: 3 People: 8 Dog: 0
2. Green area by the playground	Time: 10.19 – 10.29 Bikes: 1 People: 3 Dogs: 2	Time: 13.07 – 13.17 Bikes: 3 People: 8 Dogs: 0	Time: 14.46 – 14.56 Bikes: 0 People: 15 Dogs: 1 *The playground was in use*
3. The Basketball court	Time: 13.07 – 13.17 Cars: 7 Bikes: 1 People: 2 Dogs: 0	Time: 13.27 – 13.37 Cars: 5 Bikes: 4 People: 4 Dogs: 2	Time: 15.04 – 15.14 Cars: 4 Bikes: 1 People: 6 Dog: 2 *The Basketball court was in use*
4. The intersection between Rønnevej and Hedebovej	Time: 13.29 – 13.39 Cars: 2 Bikes: 1 People: 1	Time: 13.49 -13.59 Cars: 3 Bikes: 0 Scooter: 1 People: 3 Dogs: 0	Time: 15.25 - 15.35 Cars: 6 Bikes: 1 Scooter: 1 People: 1 Dogs: 0
5. The intersection between Nylandsvej and Ølsemaglevej	Time: 13.46 – 13.56 Bus: 1 Cars: 57 Scooter: 1 Excavator: 1 Bikes: 12 People: 8 Dogs: 2	Time: 14.06 - 14.16 Bus: 0 Cars: 75 Bikes: 8 People: 10 Dog: 2	Time: 15.41- 15.51 Bus: 1 Cars: 73 Bikes: 5 People: 3 Dog: 2

Table 4: Fieldwork observations.

When looking at the table 14, there are some clear differences in usage patterns. The playground and basketball court were both in use on the 13th of April after 14.00 o'clock, and this might have something to do with it being a Saturday and people having the day off, as there is a difference in how an area is used in the weekdays and the weekend (Gehl & Svarre 2013). It is also important to notice that detached housing units usually have private gardens

and often play areas. This may mean people in the area are living individual lives, with separate gardens and own playgrounds rather than using the public green spaces and playgrounds.

Scalgo analysis

To understand the climate change challenges that this detached house area is exposed to, an analysis of the area is developed with the software program Scalgo Live. The maps are created using data from DMI's Klimaatlas, which is a database that can be used to plan climate change adaptation, as it contains data for the expected changes in climate in the future for the whole of Denmark. The Klimaatlas uses the period 1981-2010 as a reference to the future values (DMI n.d. A).
In this report the data based on RCP8.5 is used, as this is the high emission scenario. The data period is 2041-2070, and this period is chosen because the planning in this report is set for 2050.

Sewer systems in the area

The rainwater and wastewater plan for Køge Municipality describes how separate sewer systems have been introduced in various properties over the course of several years. The separate sewer system has relieved the load on the old combined sewer system during rainfall, which has reduced overflow of wastewater to Ølsemagle Revle and Staunings Ø (Køge Kommune 2021).

The map below (see Figure 16) shows the sewer systems within the project area.

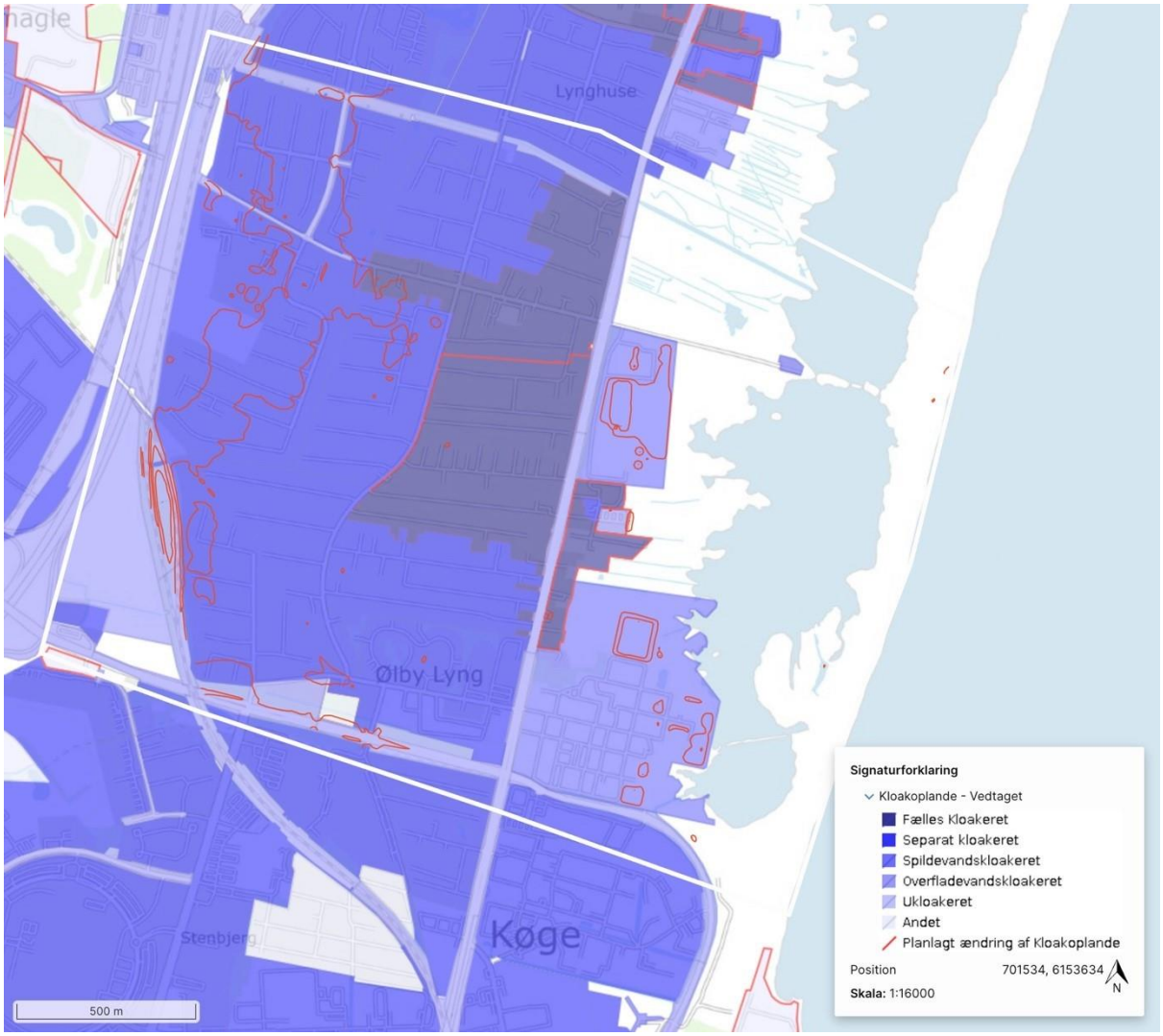


Figure 16: Sewer systems within the project area made (SCALGO 2016)

In a big part of the area the sewer has been separated so there is a pipe for wastewater and a pipe for rainwater, which could potentially relieve some of the pressure on the sewer system as the waters do not mix. However, a key problem in this area is that Københavnsvej has a combined sewer system, and this is the pipeline going to the treatment plant. This means that wastewater as well as rainwater even from the separate sewer systems end up at the treatment plant and put pressure on it. As Tore Bro from Køge Municipality points out, separating the sewer system in the area wasn't an optimal solution and it did not benefit the residents.

"[…] here, for example, there are some separate sewer system areas, […], but the water runs out into the pipe that runs in the road here. And the pipe that runs in the road, it's a combined sewer pipe. So, it may well be the owners here, they have had a rainwater pipe and a wastewater pipe installed for themselves. But the water runs out into a combined, in a single large pipe that runs into the treatment plant. So, in reality, they don't have any effect from the investment that they made […]." (Tore Bro. Pers. Comm. Own translation, Appendix 3, 33)

This means there is still more to do in the area with the technical solutions to manage rainwater, eventually combined with nature-based solutions.

Sea level and storm surge

The illustrations below (see Figure 17) show the elevation of the area. By making impact points on the map, large parts, including the living spaces of the area, are only 1.4 meters to 2 meters above sea level. On the coastal side of Københavnsvej, most of the area is around 0.5 meters above sea level.

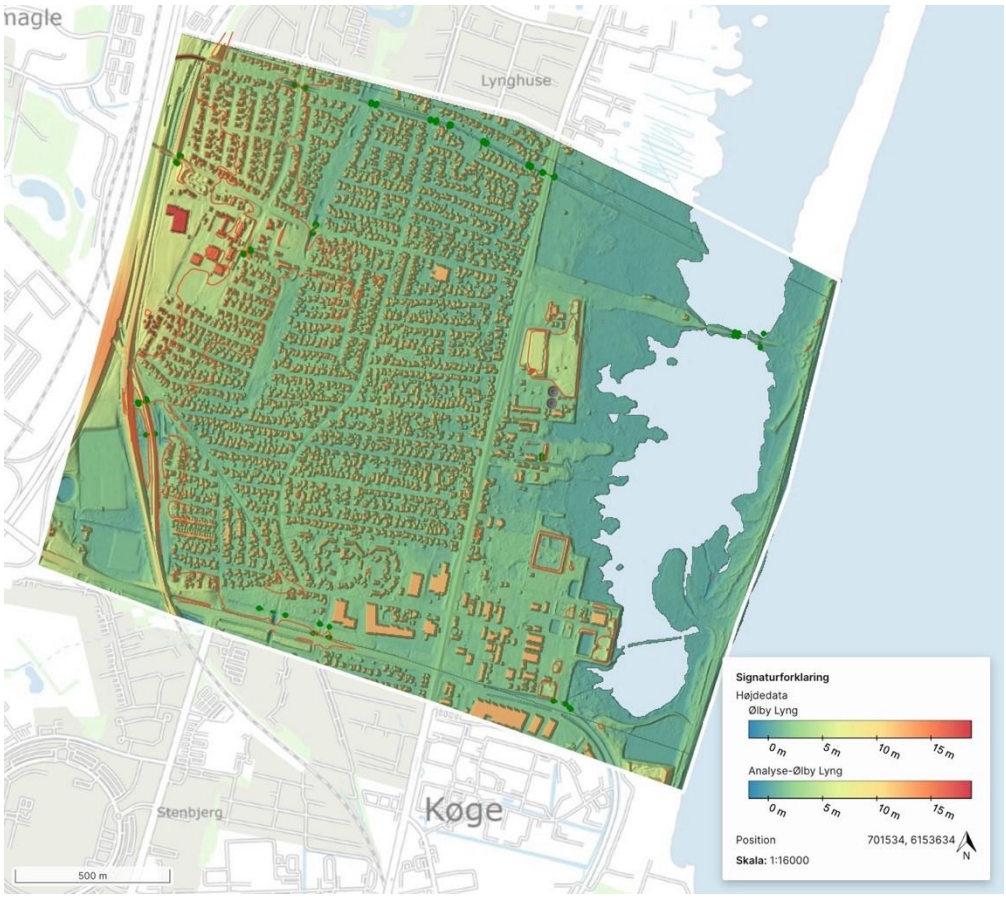


Figure 17: Elevation map of the project area (SCALGO 2016).

The low-elevation in the project area can be a significant problem since the sea level is expected to increase by 20-40 centimetres by 2050 due to global climate changes (Madsen & Schmidt 2017). During the interview with Ole Fryd, he points out that the reason why these issues occur is due to the fact that the expansion of cities results in building in low-elevation areas (Appendix 4).

The data in table 5 shows the mean sea level rise from 2041 to 2070 at the RCP8.5.

The mean sea level rise from year 2041-2070 following the RCP8.5	
Lower limit	8 cm
Median	28 cm
Upper limit	63 cm

Table 5: Shows the lower limit, median, and upper limit for mean sea level rise in year 2041-2070 with a high emission scenario RCP8.5 (DMI n.d. B)

The data in table 6 shows figures for a 100-year event of a storm surge in the period of 2041 to 2070 at the RCP8.5.

Storm surges at 100-year from year 2024-2070 following the RCP8.5	
Lower limit	160 cm
Median	187 cm
Upper limit	236 cm

Table 6: Shows the lower limit, median, and upper limit for storm surge events in year 2041-2070 with a high emission scenario RCP8.5 (DMI n.d. B)

For the storm surge simulation, we have created an event to show how much the sea level could rise for a storm surge event when the sea level has also risen. The event is based on the upper limit in table 6, which is 236, because it is important to create events for extreme weather, as it is likely there will be more of these extreme weather events in the future (DMI 2023). Moreover, the chosen data for the expected sea level rise in year 2041-2070 will be 28 cm. In Scalgo Live, the data for storm surge and the data for the mean sea level rise will be combined, so the sea level rise data that is put into Scalgo Live is 264 cm. The following map shows the effect of such an event in the project area.

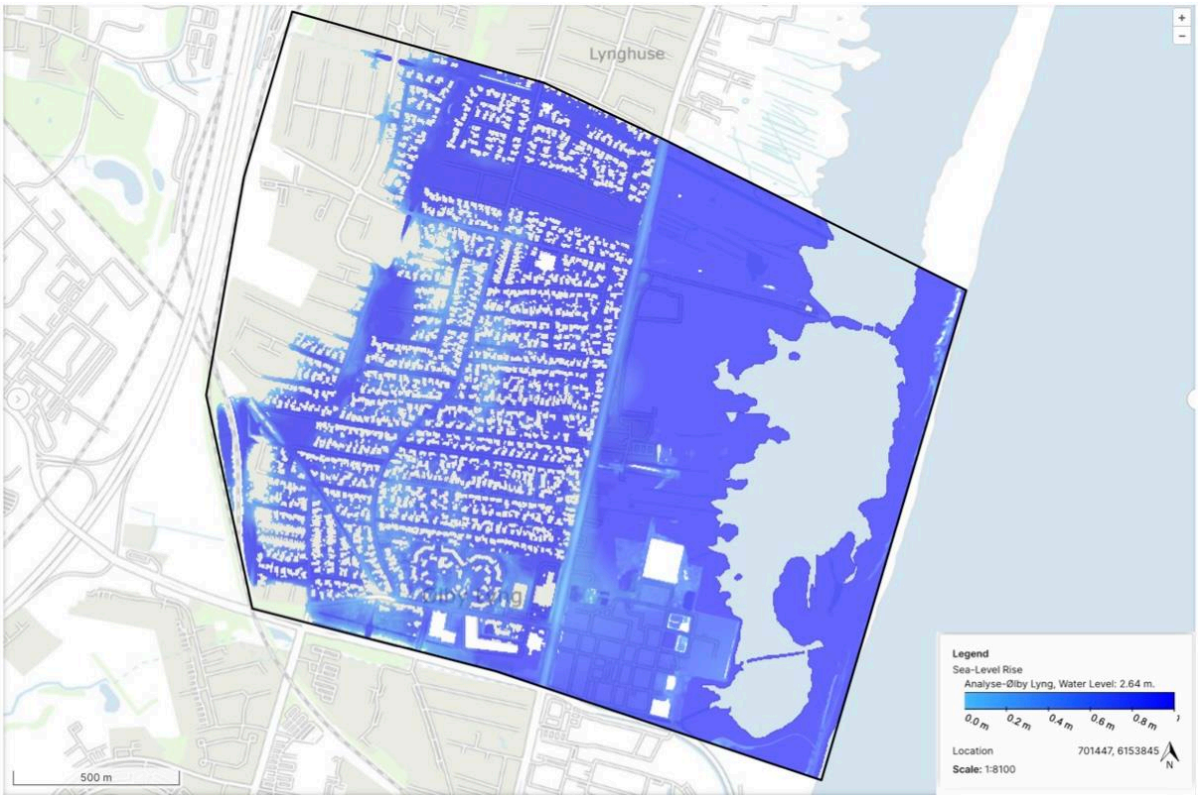


Figure 18: Simulation of a sea-level rise at 264 cm (SCALGO 2016).

As the map illustrates, the sea level rise is an actors that needs to be considered when doing climate change adaptation and planning for an urban area, as most of the area on this map is flooded. Storm surge is an event that has occurred in the area before, as it is detected all the way back to the year 1872 when large parts of the area were flooded due to a storm surge. Figure 18, picture 4 shows the storm surge stone's location, which is where the water went up to, during the storm surge in 1872.

As mentioned in the case description, Køge Municipality is in the process of building a dyke to ensure the area can withstand sea level rises to 2.8 - 3 meters (see Case description). Therefore, this map is an estimate, as the dyke will prevent the area from flooding as it is seen on the map. Ole Fryd, lecturer at Copenhagen University, gives an insight into the problems that can occur when municipalities are investing in a dyke,

> *" […] there is that you can say the big one, on the big track there is the dike paradox here is that when you build a dike, it is actually also an incentive to speed up the investments on the dry side of the dyke. But if the dyke then collapses or there is a storm surge that is greater than what has been dimensioned for, then the damage is even more extensive. So, in that way there is a dike paradox or dike effect, which is kind of challenging."* (Ole Fryd. Pers. Comm. Own translation. Appendix 4, 39)

It is therefore important to consider the risk of an event where the dyke cannot keep the water away from the area or a situation in which it breaks, as the area depends on this dyke to keep the flooding away. The dyke in Køge is supposed to keep around 22.000 people and values up to 3,7 billion DKr safe (Køge Kommune n.d.). This means that the dyke can become a powerful actors in the network of climate change adaptation.

Groundwater levels

Another issue this area is dealing with is high groundwater levels, the map below (see Figure 19) shows the groundwater level in the project area, where the depth is up to 1 meter underground and it is set at T2 in the program, which means it is a 2-year event (Scalgo 2016). It is based on the RCP8.5 in year 2041-2070.

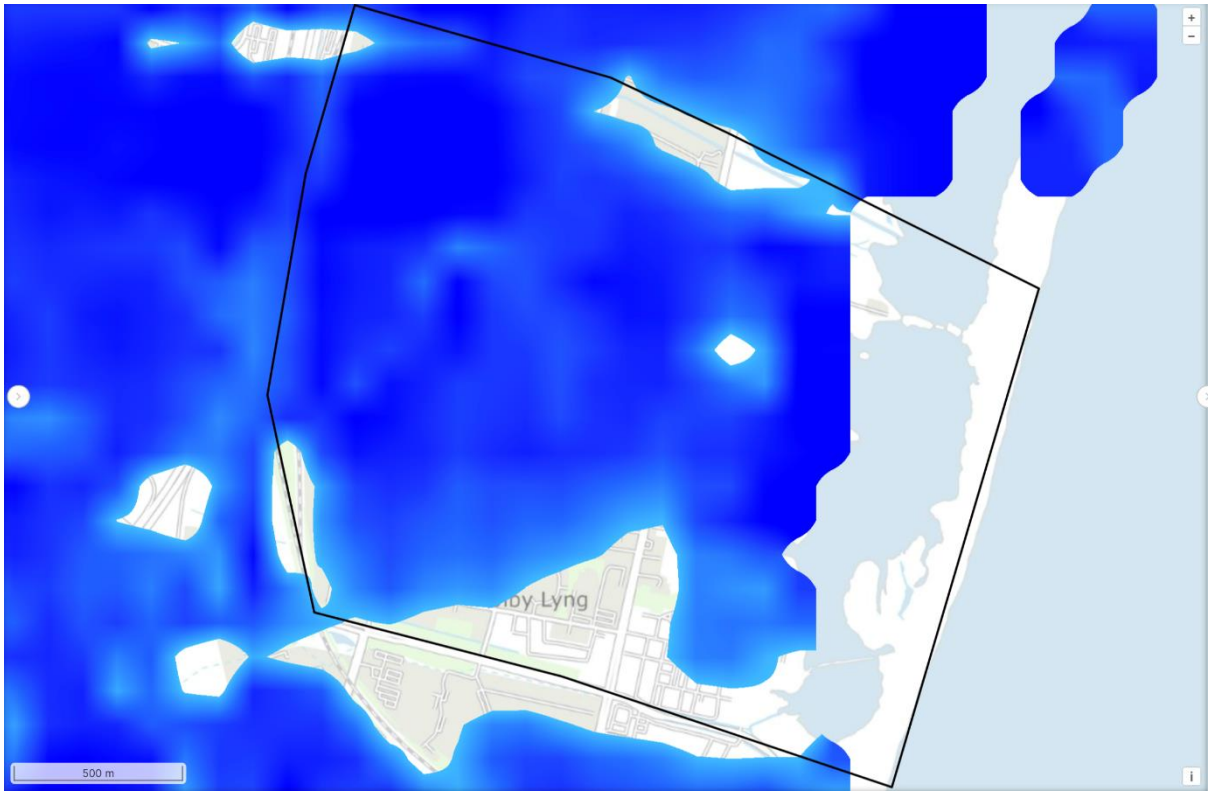


Figure 19: Groundwater levels up to 1 meter below ground in year 2041-2070 based on RCP8.5 (Scalgo 2016).

Problems with flooding can arise if there is elevated groundwater in an area, especially in low-elevation areas (Stiesen & Fonseca 2024). Therefore, this is yet another problem that the project area has to deal with as it is a low-elevation area. This means that the groundwater only is 1 meter below the resident's property. With elevated groundwater, the soil is saturated with water, which means that the soil cannot absorb the water during rainfalls or if snow is melting and therefore accumulates on top of the soil (Stiesen & Fonseca 2024).

Cloudburst events and prolonged periods of rain

Cloudbursts and prolonged rain are both weather situations that can put pressure on the sewers, and especially in areas with combined sewer systems, it can also cause problems for treatment plants, where overflows with wastewater can occur.

DMI defines a cloudburst event as 15 mm rainfall within 30 minutes (Damberg 2021). This definition of cloudburst events is used as a base. Table 7 shows three examples of cloudburst events. The cloudburst event with 15mm rainfall within 30 minutes is defined in the as a low-level cloudburst.

Cloudburst events type	Measurements
Low-level cloudburst	15 mm
Double cloudburst	30 mm <
Third double cloudburst	45 mm <

Table 7: Shows different types of cloudburst events that can affect the area.

DMI has data predicting periods of rain and the data is based on RCP8.5 (see Table 8). Periods with prolonged rain put pressure on the sewer system, and especially in areas that are highly fortified, as all the water that ends up on the roads, bike lanes etc. ends up in the sewer if there are no other measures (for instance nature-based solutions) for managing rainwater.

Season	Year	mm per day
Winter (Dec, Jan, Feb)	2011-40	1.70
Summer (Jun, Jul, Aug)	2011-40	2.25
Winter (Dec, Jan Feb)	2041-2070	1.82
Summer (Jun, Jul, Aug)	2041-70	2.17

Table 8: Data for prolonged periods of rain (DMI n.d. C)

Figure 20 shows a double cloudburst event with 30 mm rainfall where the sewer is taken into account. The map therefore shows where the water will accumulate when larger amounts of rain fall in the area. This accumulation can occur during cloudbursts and prolonged periods of rain when the sewer is under pressure. The darker the blue is, the more water is accumulated in that specific area.

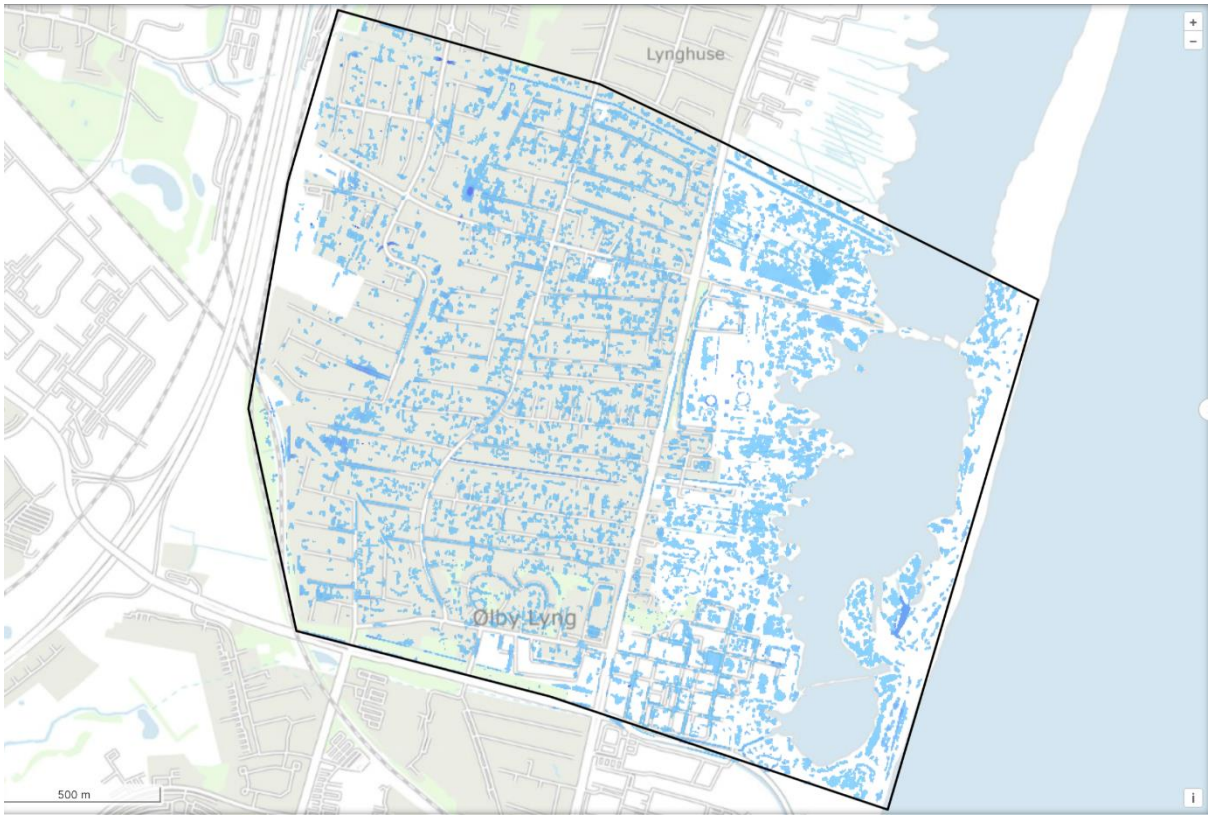


Figure 20: Map showing accumulations of water during a cloudburst event of 30 mm (SCALGO 2016).

Figure 20 shows that the water accumulates on the roads and by detached houses.
In addition, there can also be prolonged periods of rain, where cloudbursts can also occur, which would put even greater pressure on the sewer.

Sub-conclusion

The area may face various threats as a result of climate change. With a sea level rise of 264 cm as a result of storm surges and mean sea level rise, large parts of the area would be flooded with water. The residential neighbourhood has been constructed has been built on top of an area that was flooded in a storm surge event in 1872, which shows that this threat is not merely theoretical but very real. Additionally, there are challenges of managing rainwater in the area due to the area being largely fortified and the area having technical solutions that mix

separate and combined sewer systems. There are two large green areas where the water can be diverted, but there are not many existing nature-based solutions.
The area has a distinctive style that is typical for detached house areas. Apart from traffic, the public areas of the neighbourhood seem to be sparsely used, perhaps reflecting that people who live in detached housing have access to green spaces on their own properties Although it is difficult, addressing these issues when planning for cities is necessary to ensure proof for the future, not just for the next five years.

Analysis 2

This analysis will provide an overview of different approaches to climate change adaptation management and explore how different actors contribute to this agenda. Furthermore, we will present the future wildest vision, future perspective, and ideas that was proposed by the interviewees from the semi-structured interviews. This analysis will be providing valuable information that can be include in Analysis 3 where we want to gather key findings from each analysis to redesign the project area Ølby Lyng and Ølsemagle. In this analysis, we will answer research question 2, what are the future visions of the human actors, and how are they positioned in terms of climate change adaptation.

Different approaches to planning for climate change adaptation

In this section, we will present different approaches to planning for climate change adaptation, which includes strategies involving sustainability. The different approaches that will be presented will be based on the findings from the semi-structured interviews. We will draw on literature that support some of the arguments presented within the field of planning, climate change adaptation, sustainability, and social solutions.

Climate event can act as shock, which can influence the dynamic of the current relations in the assemblage. As mentioned in the case description, Køge has been affected by storm surge events. In the interview with Bettina Simonsen, project planner from KLAR Forsyning A/S, and Tore Bro, an engineer from the municipality, they mentioned that Køge has been affected by three recent flood events: one in October 2023, another in January 2024 and a third in

February 2024 (Appendix 1; Appendix 3). According to Bro, the Køge Dige project got more attention from politician and the resident after these events had occurred. This means that relation to building a dyke has been strengthened, because of the three recent flood events. As explained in the Case description, it is the sub-department Vej, Park & Byrum that responsible for the Køge Dige plan. The object for the dyke is to prevent flooding from the sea, but it does not prevent sewer flooding if Ølby Lyng and Ølsemagle are affected by a storm surge event, which can cause maladaptation. It is KLAR Forsyning A/S responsibility to ensure that the sewage system is not flooded. In the interview with Bettina Simonsen, she addresses that the solutions to this problem will be to install electrical pumps, which will pump the water from the sewer system over the dyke (Appendix 1). In connection to managing the flooding from the sewer system, Tore Bro explains that the residents can install an anti-flood valve in the sewer, which will prevent backflow of grey water through the drainage system in the detached houses (Appendix 3). This clarifies that KLAR Forsyning A/S and Køge Municipality current strategy for preventing maladaptation is mainly to address the situations with technical solution.

In connection to shock, Ole Fryd, is a Associate Professor in Urban Environmental Planning at Copenhagen University, explains it is common to develop a plan for hard coastal protection when a city has experienced a major storm surge. According to Ole Fryd, it is in this time that the actors must stop and consider how long-term transformation of the city can be planned (Appendix 4). The same ideas were proposed by Yvonne Rydin, she explains:

> "*Restoring a flooded city to exactly the pre-food situation would not make the city more resilient. It would be better for the city to be adapted to cope with flooding through a mix of hard and soft engineering works, altered ground management practices in the catchment area and better information for local residents and businesses on how to protect their premises.*" (Rydin 2021, 180).

As mentioned in the State of the art, Fryd also explains three types of managed coastal retreat (Appendix 4). In this analysis, we will elaborate the planned managed coastal retreat. This type of managed coastal retreat includes strategies such as phasing out and transformation. Fryd's example of this approach is that detached house has change owners over a period of years, so phasing out is about retreating over time, which will function as something that happens parallel with the residents living with the water. An opportunity for the detached

house is that it is transformed over a period from an all-year residence to a holiday house to a club house to phasing out. Fryd explains that the decisions made in such a process must be thoroughly evaluated to make sure they do not cause large CO2 emissions. This means to calculating how many people we are and considering whether the detached house can be used as resource bank. When the phasing out has happened then we can decide what kind of landscape that can be developed (Appendix 4). The planned managed coastal retreat is an example of a nature-based solutions to manage coastal flooding.

The interview with Signe Weinreich Rasmussen, a project consultant at Grøn Omstilling and Jacob Skjødt Nielsen green ambassador also at Grøn Omstilling, also contains ideas that harmonise with Ole Fryd's concepts of manage coastal retreat. Nielsen mentions an approach that also could have been a planned manage coastal retreat approach, and in this interview, it is called an economic model. One economic model that would change the future of the project area could be if Køge Municipality bought up detached houses over a long period of time with the intention to transform the existing project area (Appendix 2). We will explain Rasmussen's and Nielsen's visions for transforming the existing project area later.

Another planning approach for climate change adaptation can also be to put human actors in centre of planning. From the interview with Bettina Simonsen, we became aware that the residents play a great part in the planning processes. In the interview, Simonsen mentions that she has experienced that the residents believe that the utility company has a greater responsibility to manage water at their properties than they actually do, and these beliefs cause problems when residents find out that they actually have a greater responsibility themselves. The same observation has been made in the book Resilient Cities and Homeowners Action, chapter 2 Governing for Flood Resilience through Homeowner Contributions by (Barbara Tempels, 2022), which also suggests residents' may often misunderstand their own responsibility in the face of climate change:

> "*Homeowners often still assume that managing natural hazards is a governmental responsibility and governments and engineers are technically and financially capable of preventing flooding.*" (Tempels 2022, 18-19)

Barbara Tempels describes that, the management of rain events and flooding must be a collaboration between actors such as *water managers*, *disaster managers, spatial planners, local governments, individual citizens, civil society, and homeowners* (Tempels 2022, 18-19).

The activities that the residents can contribute with are *prevention, protection, preparing* and *recovery* (Tempels 2022, 18-19). Barbara Tempels explains the residents must take responsibility in these areas both individually and collectively by using their resources such as *money, time, physical labour, and knowledge*. The same ideas were proposed in the interview with Ole Fryd. Fryd comments on residents' responsibilities when it comes to protection, prevention, and recovery; responsibilities that may contain social as well technical aspects (Appendix 4):

1. Social recovery: Residents become more aware of each other when shock events have occurred. The social recovery consists of residents helping each other get through the difficult situation they are experiencing (Appendix 4).
2. Nature-based preparation: In terms of nature-based solutions, technical preparation has to do with how the residents design their garden. For example, residents can use an evaporation wall, instead of having a fence made of wood around the house. Evaporation walls are made of plants that can absorb a lot of water and thus prevent water for straining the sewage system. Another example of a nature-based solution is swamp vegetation (Appendix 4).

In connection to nature-based preparation, in the interview with Bettina Simonsen, she is particularly interested in creating a dialogue about how the residents and private companies could design their property for climate change adaptation. Simonsen also emphasises the need for residents to take a greater responsibility for their property (Appendix 1).

In the interview Simonsen also addresses that the current approach to planning must change to develop joint plans for how the future must be managed. According to Bettina Simonsen, the joint plans must be developed in collaboration with Køge Municipality, and the reason is that currently the plans are developed more in what she considers "silos". This description implies that currently, plans are not written in a collaborative way, which can cause maladaptation when the different plans are implemented in the society. Furthermore, Bettina Simonsen emphasis:

> "[...]*Plans must have the residents' supports*" (Bettina Simonsen. Pers. Comm. Own translation, Appendix 1, 10)

Simonsen also stresses that the plans must be long-term and include strategies for what will happen in 30, 50 and 100 years (Appendix 1). This is similar to what we discovered about

Ole Fryd's approach to planning. Ole Fryd's approach to climate change adaptation is to have a plan with different time perspective, and this plan must include different climate change adaptation strategies that make sense at specific future dates (Appendix 4).

The interviewees' wildest visions, future perspectives, and ideas

In this section we will present the future wildest visions from the four semi-structured interviews. In some sections we will also include future perspectives and ideas that are presented in the interviews, and which connect to the scope that we are working with. As mentioned in the method section, the following question is asked in every semi-structured interview: *What is your wildest vision, if you had a non-restricted opportunity to implement whatever you desired for climate change adaptation*?

Project engineer Bettina Simonsen from KLAR Forsyning A/S

We will firstly present Bettina Simonsen's answer to the question that was asked all the interviewees, and next we will present her explanations about the Køge Nord project, which is about implementing nature-based solutions.

The first vision Bettina Simonsen mentions, is another vision that she is inspired by. She describes this vision as the cheapest approach. This vision includes that in about 50 or 100 years it will not be allowed to build classical detached houses. Instead of building classical detached houses, this vision draws inspiration from the Netherlands. The proposed buildings could be apartment blocks built on stilts or apartment blocks that are elevated from the ground level in another way, so that water can run underneath the buildings. Instead of having a detached house with a large footprint that takes up the area, the area can instead be used for something else (Appendix 1).

Another vision of hers is that the detached houses could be removed and replaced by new buildings that take up less space. These buildings must be built so that they can be temporarily flooded without the buildings being damaged (Appendix 1).

A third vision that she mentions, and which she describes as expensive and unrealistic is to implement coastal protection such as a dyke further out in Køge bay than the dyke from the Køge Dige project. She explains that this vision is also inspired by the Netherlands, where

something similar has been implemented. This wild vision includes a buffer zone between the low-lying Ølby Lyng and Ølsemagle and the Køge Bay dyke, which would act as a zone that delays the water, so it does not impact the project area when a storm surge happens. Furthermore, Simonsen suggests that a road could be built on this dyke, so that noise problems and pollution from cars would be minimized in Ølby Lyng and Ølsemagle (Appendix 1).

The fourth vision Bettina Simonsen mentions is that it is not only the physical space that needs to change, but also the current construction laws. A key element of this fourth vision is that the new construction law must define where it is suitable and not suitable to build buildings in Denmark (Appendix 1).

Besides the visions, Bettina Simonsen did describe the project Køge Nord more in depth, we have mentioned this project briefly in the case description (see Case Description). We want to include this description, because Bettina Simonsen explains the nature-based solution approach in the new areas. Bettina Simonsen explains, that the climate change adaption strategy for the Køge Nord project is to construct a wetland area that looks like a natural environment. This constructed wetland area will be designed, so it can manage the rainwater in the area. The design includes a ditch, a lake, a stream, and a planted path which cleans and delays the rainwater. Furthermore, is the idea to develop a wildlife corridor, which means the constructed wetland will be connected to the existing natural areas (Appendix 1). This project is an example of a nature-based solutions, that both includes the design for the resident and nature, but as we want to explore how can this approach of planning be used when redesigning an existing detached housing area. We will explore this in Analysis 3.

From the interview with Bettina Simonsen, she explains that they are also in the start-up phase with conducting an LCA analysis for their climate change adaptation project. She adds that this is a new approach, which means that they have not yet collected any experience data for the climate change impact of their climate change adaptation strategies. Currently, the LCA analysis has mostly been used in connection with construction of a water utility and a wastewater treatment plant. This example illustrates that KLAR Forsyning A/S is interesting in investigating the environmental impact of their climate change adaptation strategies.

Green ambassador Jacob Skjødt Nielsen and project consultant Signe Weinreich Rasmussen from Grøn Omstilling

In this section, we will present the wildest vision presented by Jacob Skjødt Nielsen and Signe Weinreich Rasmussen. In the interview, Nielsen and Rasmussen suggested they would cooperate to tell their wildest vision on the given subject, so the vision that we will present from this interview will consist of different ideas that constitute a shared vision from the two participants.

The first idea connected to the vision is presented by Signe Weinreich Rasmussen:

> "*One thing that had been talked about with the students, in our process with them, was breaking up the detached housing properties. It was also something that Jacob mentioned, thus, to think more in the direction of joint ownership. This is also a keyword in the green transition, that there are more community properties and all in all community […].*" (Signe Weinreich Rasmussen. Pers.Comm. Own translation, Appendix 2, 25)

Rasmussen describes this idea as "radical" and explains that part of this idea is to remove fences, so that private gardens can be open spaces. She adds that the gardens could be developed into a common park area that would include more biodiversity and nature. Part of the idea is the open gardens can be used for climate change adaptation projects. The parking lot connected with the detached houses would be replaced by nature. Furthermore, Rasmussen suggests that it could be interesting to include the houses in the vision and build something more modular. She explains that this kind of suggestion would also change the current norms and planning approach, and that this could include a radical shift from private ownership to joint ownership. Another suggestion is to make a law about demolishing injunction, where the law supports transformation and renovations of properties (Appendix 2).

Jacob Skjødt Nielsen went even further:

> "*In continuation of what Signe just said, I would say that the most radical idea I could imagine is to declare a building stop […].*" (Jacob Skjødt Nielsen. Pers. Comm. Own translation, Appendix 2, 26)

Jacob Skjødt Nielsen explains that the reason for declaring a building stop is that there is a need to clean up or improve the existing areas instead of expanding the city in all directions.

Furthermore, this idea includes transforming what already exists. To do so, Nielsen explains that the transformation could be accomplished in collaboration with architects, engineers, sociologists, and other relevant professions (Appendix 2).

Rasmussen and Nielsen's vision includes a dream of a new city where people want to live and share stories about how all resources have value. Furthermore, Jacob Skjødt Nielsen emphasises that this vision is about respecting the planetary boundaries and that growth will be on new terms. Rasmussen and Nielsen's vision is about creating a life for residents that is more community-based, which ensures resources are being respected, and which ensures more resources can be recycled within the area, including more nature-based solutions, to densify the area at Køge Nord Station with buildings that do not take up as much space as the detached houses (Appendix 2). To elaborate on Rasmussen and Nielsen's vision must a relation or more relations be established between various actors like the residents, Køge Municipality, KLAR Forsyning A/S, since this will contribute to it will become possible for the residents to live within the planetary boundaries.

Civil Engineer with specialisation in water Tore Bro from Køge Municipality

In this section, we will present the future wildest vision, perspective, and ideas from the interview with Tore Bro, who is a civil engineer with a specialisation in water and is employed in a the sub-departmen Natur, vand & jord in Køge Municipality. In Køge Municipality, Tore Bro works with regulatory assignments and with urban development projects. In the interview, Tore Bro describes the process that happens when a property owner, for instance a private housing association, contacts the municipality to investigate to what extent a property can be fortified or how the property can be developed. The actor network in such a process may involve a local management planner, a water management planner, a traffic management planner, Grøn Omstilling and KLAR Forsyning A/S, who all may play a role in the further process.

In Tore Bro's vision, some of the detached houses should be replaced with multi-storey housing that takes up less space (Appendix 3). He adds to the vision:

> "*[...]Ølby Lyng must be redesigned so that water can run underneath the buildings*"
> (Tore Bro. Pers. Comm. Own translation, Appendix 3, 38)

Tore Bro explains that this vision will need an actor who has the capital to buy detached houses that can cost three million DKK or more. He adds to the vision that it is important to move away from the areas that are highly influenced by water, such as elevated groundwater. He also explains that it is possible to live with water and refers to the Netherlands. Another perspective from Tore Bro is that currently, only rather few people are living in the detached house area, and therefore only a small population is exposed to flooding. If the area became more densified, then it would be easier to plan for flooding (Appendix 3).

We will now introduce a perspective on how to work with a landscape presented in the interview with Tore Bro:

> "*[...] when you are developing a climate change adaption project regarding water, you must respect the contour lines of the landscape and the history of the landscape.*" (Tore Bro. Pers. Comm. Own translation, Appendix 3, 37)

Bro emphasises that this approach could entail that wetland areas or streams that have been built on can again become part of the urban landscape. On that note, it is important to look at the ways the water flows through the landscape to ensure that future planning respect the landscape's natural flows. An argument could be that planning the project area so the residents would live in greater harmony with the natural landscape could be part of the solution for preventing flooding.

Associate professor in Urban and Environmental Planning Ole Fryd from Copenhagen University

This section will explore Ole Fryd's perspective, wildest vision, and ideas. From the interview with Ole Fryd, it became clear that the main focus of attention is to discover a way that cities can live with water and managed coastal retreat sustainable. Furthermore, Ole Fryd also explains that we have become overly confident with how we are designing cities. In interview, he explains draining areas such as swamps to build houses on will impact the terrain, so that the area will be lower elevated than the sea-level. Ole Fryd's addresses that we must renegotiate our relationship with nature and become more humbler to nature (Appendix 4).

He adds to this perspective:

> "*Something that we are currently investigating is to experiment how far we can go. The groundwater is rising, there are coming more rain, the sea-level is rising, how far can we protect the city, instead of building dykes in the sea or drain or pump the water away, it becomes possible to respect natures dynamic and process*" (Ole Fryd, Pers. Comm. Own translation, Appendix 4, 44)

Considering Ole Fryd's perspective it can be concluded that it is time to re-evaluate the current approach of designing cities, such as building and designing infrastructure and detached houses.

In the interview with Ole Fryd, he shared different strategies for redesigning an existing detached housing area. As Ole Fryd points out in interview the detached houses area is known to be fortified, and public spaces is used to the fullest. He points out that there is a CO2 impact in the already existing built infrastructure, which includes roads, sewer system and properties. Ole Fryd explains that this is an argument against revitalise the existing detached housing area. Furthermore, Fryd describes that an opportunity to add nature-based solutions to an existing detached houses areas is to limit the size of a road or to remove the sidewalk at one side of the road to make space for nature-based solutions. Another idea that he mentions, and which he describes that if houses that are highly affected by flooding could be moved from one place to another in the area, to make space for nature-based solutions (Appendix 4). He adds to this idea, that moving houses is not a new phenomenon and that the museums industry using this approach. Fryd explains:

> "*So, we have the Frilandsmuseet in Lyngby and Den Gamle By in Aarhus. Common for these mentioned museums is that buildings have been moved stone by stone and reconstructed at the museums' property. Which means there are examples of buildings that have been moved to another place*" (Ole Fryd, Pers. Comm. Own translation, Appendix 4, 48)

A third idea of his, for redesigning is to investigate the demography of the existing detached housing area, which can be an approached to investigate how many people are living alone in the detached house area, and how much space does they occupy.

Ole Fryd's future wildest vision is in line with previously explored ideas and perspectives. For this reason, we will briefly explain some other ideas and perspectives that he presented in the interview.

Ole Fryd's future wildest vision includes practices like 1) Learn how to live with water, 2) Be humbler towards water, 3) Work with not against water, 4) Work with freshwater resources, 5) Protect the beach meadow that are disappearing, and 6) Work with the water balance, which is about working with evaporation and massive planting of trees (Appendix 4).

Furthermore, his wildest vision includes sustainable practices such as fucus on reducing the resource consumption when designing an area, focus on how it is possible to climate change adapt without impacted the climate, and focus on reducing fortification (Appendix 4).

In previous sections, we have explored the interviewees different wild visions, future perspective, and ideas to approaching planning for climate change adaptation. We discovered that each of the interviewees had both similar and different points of view about what should be developed in the future for climate change adaptation.

The relations between the actors

From this the previous sections, the Case description, the State-of-the-art, Analysis 1, and semi-structured interviews, we have discovered following relation between human and non-human actors (see Figure 21). We acknowledge that it is a simplification of the assemblages, and the actors is part of much larger assemblages.

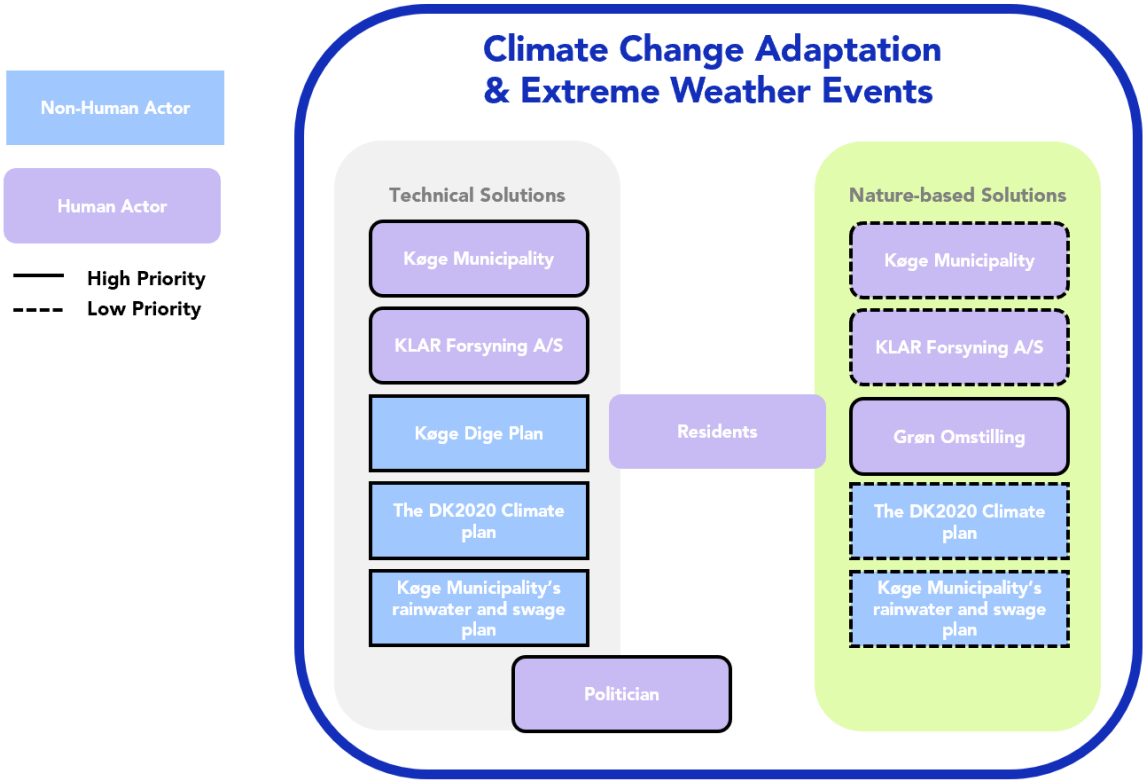


Figure 21: Shows the network of priorities for managing Climate change & Extreme weather events (Own Design)

In the figure 21, we have chosen to place the residents in between the technical solutions and nature-based solution, since most of the residents do not have expert knowledge about which solutions would be the best solution to implement in the area. In addition, the resident's objective in this network is that they do not want their property to be flooded. KLAR Forsyning A/S is positioned in both the technical solutions and nature-based solutions. The reason that we have positioned KLAR Forsyning A/S as highly prioritising technical solutions, is due to Bettina Simonsen explained the following in the interview:

> "*The reason that multifunctional solutions are highly mentioned in the Rainwater and Sewage Plan is that we want to create solutions in terrain. However, it requires more space, due to more safety, so that the system can contain more water in the future. […] we want to have the solutions in terrain integrated in the landscape, because*

> *these solutions are excellent and cheap. […] But there is a battle over the land*" (Bettina Simonsen, Pers. Comm. Own translation, Appendix 1, 1)

It is difficult for KLAR Forsyning A/S to find spaces for nature-based solutions in Ølby Lyng and Ølsemagle, due to the public owned land is fortified. In the interview with Bettina Simonsen we asked if KLAR Forsyning A/S had considered buying up some of the properties in Ølby Lyng and Ølsemagle, and she explained the following:

> "*We have considered to buy up houses in the area for climate change adaptation. The problem is that it is expensive and unpopular. Who should be affected by this? [...] There is not any support to this approach […] So, what we have been doing in the last 10 years, it is to solve the problem with underground basin"* (Bettina Simonsen, Pers. Comm. Own translation, Appendix 1, 3-4)

We have discovered that KLAR Forsyning A/S want to integrated nature-based solutions in terrain, but there are several actors preventing this accomplishment, such as there is a battle over the land. Furthermore, KLAR Forsyning A/S and Køge Municipality relation is very connected, which meant that Køge Municipality also is positioned both in the technical solutions and nature-based solution, and as highly prioritising technical solutions. Moreover, it became clear that Køge Municipality approach to protecting Ølby Lyng and Ølsemagle against flooding is with technical solutions like the dyke. The three flood events that Køge experienced is one actor that have influenced Køge Municipality approach to planning for climate change adaptation.

Another actor that influences this network is Grøn Omstilling. As mentioned in the Case Description, Grøn Omstilling is interested to develop an experimental local plan for climate change adaptation strategies in Ølby Lyng and Ølsemagle, that include nature-based solutions (Appendix 2). Jacob Skjødt Nielsen explained the following in the interview.

> "*Building dykes is a traditional approach. [...] Signe and I, and the student we have collaborated with, are more interested in nature-based solutions.*" Jacob Skjødt Nielsen, Pers. Comm. Own translation, Appendix 2, 18)

We have positioned Grøn Omstilling as highly prioritising nature-based solutions. Grøn Omstilling is an actor that is closely connected to Køge Municipality, since the department is consulting the Municipality with sustainable ideas. It is an actor in the network that is

experimenting with different ideas and new insight for sustainable urban development. The limitation of Grøn Omstilling is that they do not consult Køge Municipality with authorities processing (Appendix 2).

In the presented assemblages it is the technical solutions that is highly prioritised for managing water in Ølby Lyng and Ølsemagle. We found out that some of the human-actors are interesting in integrating nature-based solutions, but several actors are preventing this interest for happening.

Sub-conclusion

In previous section, we have explored the interviewees different wild visions, future perspective, and ideas to approaching planning for climate change adaptation. We discovered that each of the interviewees had both similar and different points of view about what should be included when redesigning for an existing detached housing area for the future. In Analysis 3, we will draw on the key findings from this analysis to investigate how these findings can become part of the redesign of Ølby and Ølsemagle. Table 9. shows the key findings from this analysis.

Bettina Simonsen	Jacob Skjødt Nielsen and Signe Weinreich Rasmussen	Tore Bro	Ole Fryd
The residents play a great part in the planning process.	Køge Municipality bought up detached houses over a long period of time with the intention to transform the existing project area.	Multi-storey housing that takes up less space.	Planned managed coastal retreat includes phasing out and transformation.
Current approach to planning must change to long term collaborative plans for how the future must be managed.	Modular buildings	It is important to move away from the areas that are highly influenced by water.	An opportunity for the detached house is that it is transformed over a period from an all-year residence to a holiday house to a club house to phasing out.
This constructed wetland area will be designed, so it can manage the rainwater in the area. The design includes a ditch, a lake, a stream, and a planted path which cleans and delays the rainwater.	Declare a building stop to clean up or improve the existing areas instead of expanding the city in all directions.	It is possible to live with water.	Nature-based solutions such as evaporations walls and swamp vegetation.
Design for the resident and nature.	A city where people want to live and share stories about how all resources have value.	Wetland areas or streams that have been built on can again become part of the urban landscape. On	Social recovery consists of helping each other get through the difficult

		that note, it is important to look at the ways the water flows through the landscape to ensure that future planning respect the landscape's natural flows.	situation they are experiencing.
Instead of having a detached house with a large footprint that takes up the area, the area can instead be used for something else.	Joint ownership.		Plan with different climate change adaptation strategies where the future is taking into account.
	Densify the area at Køge Nord Station with buildings that do not take up as much space as the detached houses.		Moving house and rebuild the house at another place that is less affected by water.
	Creating a life for residents that is more community-based which ensures resources are being respected, and which ensures more resources can be recycled within the exiting detaching housing area.		

Table 9: Shows the key findings from Analysis 2.

Analysis 3 – Doughnut Economy and scenario planning

In this analysis we will answer research questions 3, how can the project area be redesigned so that it is sustainable. In the beginning of this analysis, we will present three emerging issues for change, which both Analysis 1 and Analysis 2 have contributed to establish. Next, we will propose our redesign of the project area by using the key findings from Analysis 1 in Scalgo Live. Hereafter, we will present an investigation for how the key findings from the Case description, State of the art, Analysis 1 and Analysis 2 relate to the framework of Doughnut for Urban Development. In this section of the thesis, we will combine the mentioned key findings with the aim to create an overview of the most important sustainable practices of the redesign of the project area Ølby Lyng and Ølsemagle. The chosen key findings must be related to the social and planetary boundaries to make sure that the redesign will be sustainable. Finally, we will suggest how an existing detached house area can be redesigned with a focus on sustainability and climate change adaptation.

Emerging issue of change

As mentioned in the Case description and Analysis 2, the current network of change for the project area focusses on Køge Municipality's approach to preventing flooding, which consist of short-term technical solutions. These technical solutions are not multifunctional, which mean that they are effective measures against only one kind of flooding. An example of this is that the dyke's only function is to prevent flooding from the ocean. Our findings suggest Køge Municipality's approach lacks solutions that are multifunctional, including solutions that do not use huge amount of virgin materials. Køge Municipality should aim for more sustainable solutions, which could be either physical such as nature-based solutions or dependent on change in how the human actors behave. To manage the findings explored in previously sections, we will used the Manoa method. As mentioned in the methodology section, the Manoa method is a future planning strategy, and to manage change we have used the strategy *Emerging issue of change*. This strategy helps create awareness of emerging issue of change for the project area.

The three identified emerging issue of change are the following:

1. Climate change is pressuring the existing area for change by influencing the area through different types of flooding.
2. A need for sustainable urban practices that reduce climate change and integrate nature-based solutions in Ølby Lyng and Ølsemagle, which require active participation and engagement by the human actors.
3. It is important that the nature-based solutions that will be implemented supplement the existing technical solutions in the project area.

The first emerging issue of change emphasises that there is a need for new strategies to manage the pressure of flooding. This emerging issue of change relates to the second emerging issue of change which emphasises that sustainable urban practices will help reduce climate change and prevent flooding by integrating nature-based solutions. In addition, the second emerging issue of change conveys that there is need for collaborative approach, where human actors such as residents, Køge Municipality and KLAR Forsyning A/S all take on a greater responsibility. This greater responsibility relates to the third emerging issue of change, which cover that there a need for implementing nature-based solutions that will support the existing technical solutions and will help with flooding.

In the next analysis of the Doughnut for Urban Development, we will cover what kind of change that will be necessary to implement both in terms of the relations between the human actors and in relation to implementing physical solutions in the project area. This will contribute to framing the primary impact of change and to the redesign of Ølby Lyng and Ølsemagle.

Redesign of the project area with Scalgo Live

In this section, the project area's terrain is redesigned in Scalgo Live. This is to show what these changes will attain in terms of managing the water events.

The following ideas relate to terrain changes that are adapted to climate change. The ideas are created based on the maps from Analysis 1. As there are major issues in the existing area with water events, such as sea level rise, rainfall, and rising groundwater, various measures should be carried out within the project area to alleviate some of the pressure from climate change.

Climate change adaptation for storm surge and sea level rise

The figure below (see Figure 22) shows how the area would be affected during a sea level rise and storm surge at 264 cm, when the terrain has been changed.

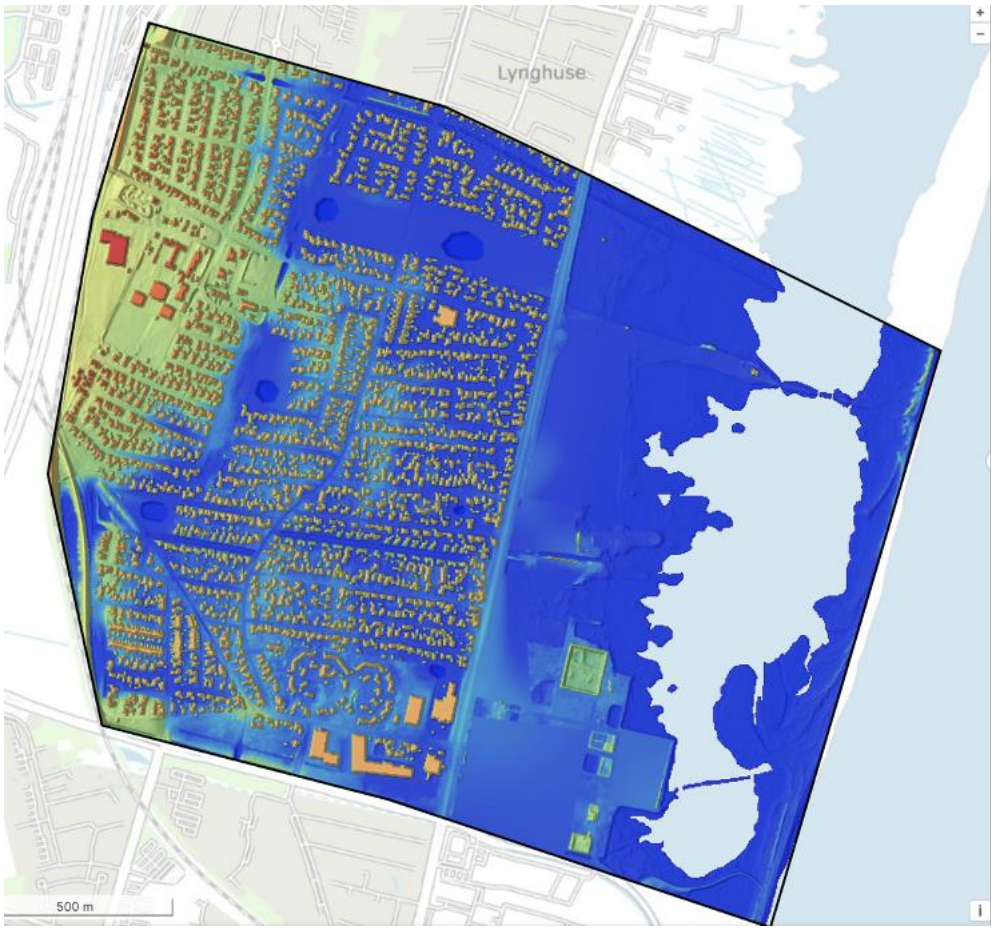


Figure 22: Terrain change and sea level rise (Scalgo 2016)

To withstand the rise in sea level predicted to occur by the year 2050 including the risk of storm surge, it is important to look at how close to the coastline infrastructure and housing are placed. Therefore, a solution is managed retreat of the coast (see State of the art). On the side of Københavnsvej that faces the sea, there must be no buildings, as the area will be exposed to large amounts of water during storm surges and the rising sea levels that will occur in the future. Therefore, this land must be given back to nature, so that the sea can move back and forth as it rises. This requires a major restructuring of the current infrastructure, as the wastewater treatment plant for Køge is located on this side of Københavnsvej. Therefore, a new location must be found for the treatment plant, and the pipes that lead the water to the treatment plant must be rerouted.

Withstanding rainwater events

In figure 23, the water accumulations that would occur during a 30 mm rain event are shown, as managing rainwater is also an issue the project area is facing.

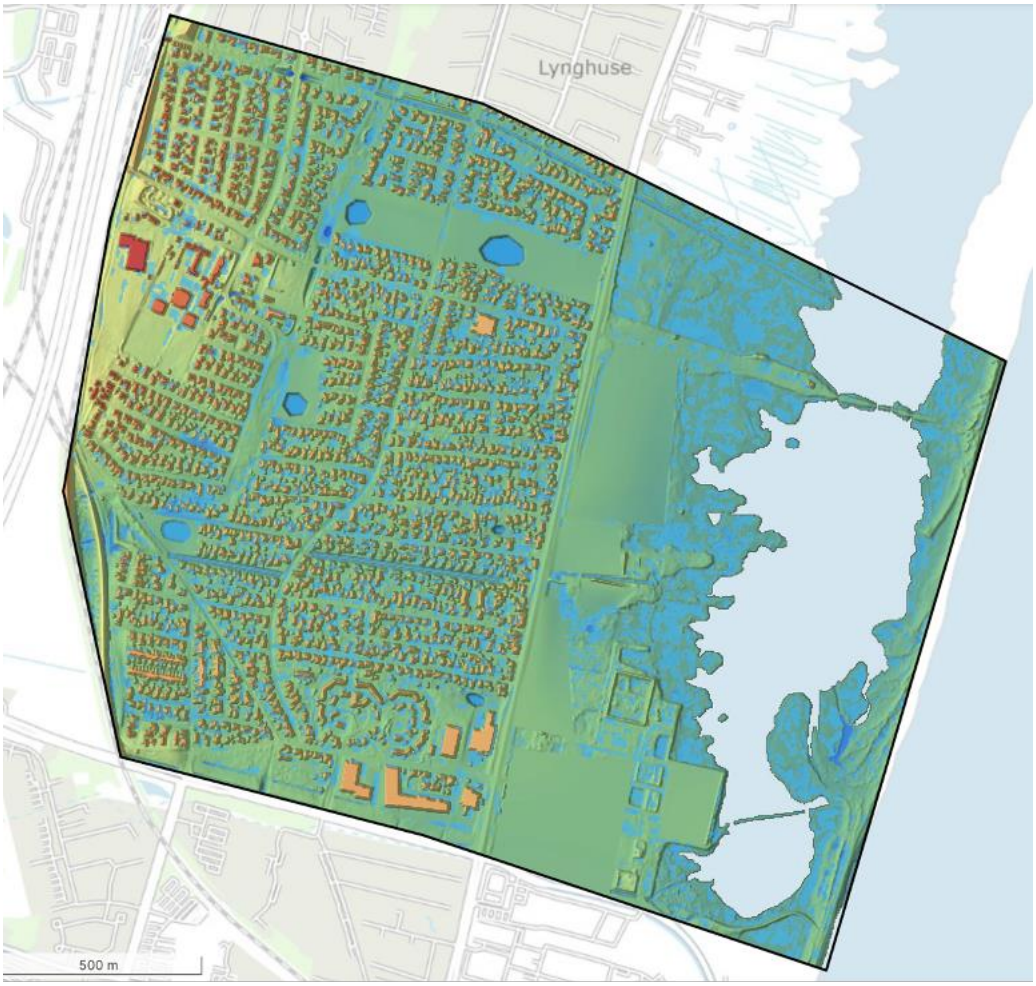


Figure 23: The new terrain of the project area at a 30 mm rain event (Scalgo 2016)

Due to large fortified areas, the rainwater will accumulate on the surface when a bigger rain event hits. In this simulation, we assume a 30 mm rain event. To accommodate the rainfall during such an event, basins and ditches have been added to the project area to see how the water would accumulate when these measures are implemented.

In the area six smaller and larger rainwater basins have been implemented. These basins are established by adding green areas to the project area and by breaking up the properties, so the basins are placed adjacent to housing. Next, ditches by the side of the road are established to manage some of the rainwater. These ditches should be designed as rainwater beds with plants that can absorb some of the water. As this is just a simulation of how water can be led

to these basins and ditches, it is important to incorporate plants to these solutions, as a focus in our proposed redesign is to implement nature-based solutions.

The ponds or lakes that have been established must be established as wet ponds. Since these always have a water surface and can therefore be used as a recreational element like a lake. At the same time, they must be used to store rainwater in the event of a larger rainwater event (Woods-Ballard et. al. 2007, 1-2).

For the project area to better withstand climate change, the proposed redesign suggests that a part of the area should be laid out using managed coastal retreat. Green areas will be created using rainwater basins in the form of lakes. As a result, housing and infrastructure will be removed from the project area, and therefore, both housing and infrastructure must be included in a different way within the area. One proposal by Jacob Skjødt Nielsen is to densify the area close to the station:

> *[...] could imagine that you worked more with the existing terrain and thought the area over and said, well there might be a lake instead of houses here in this area, and then we can in densify some places around the stations [...]* (Jacob Skjødt Nielsen, Pers. Comm. Own translation, Appendix 2, 16)

To densify the area close to the station also makes sense as it will give easy access to public transport, as both trains and busses stop at the station. By densifying around the station using the *Station proximity principle*, one can argue that there is less need for residents to own cars, since there would be easy access to public transport. Therefore, the area can be densified with multiple floors buildings with space for several families. Areas that have previously been designated as parking areas can be used for green areas instead.

In Analysis 1, issues with groundwater near terrain were also identified, the solution for this is to plant some trees, or invest in hedgerows of different plants to absorb some of the groundwater through the roots.

A major principle in our redesign of the area is that residents must learn to live with the water. For instance, it is likely that gardens are very wet during periods of heavy rain. Furthermore, the infrastructure must be reconsidered, if new infrastructure is to be established, such as a main road or additional train tracks, then this new infrastructure must be placed away from the coastline. In terms of infrastructure, Køge Nord Station has an appropriate location, as it is placed further in the land area, which allows residents to travel

over longer distances. Københavnsvej on the other hand is a critical point for flooding. The project area is too fortified, which makes it difficult for water to penetrate the ground. Therefore, more areas where nature-based solutions such as rainwater basins must be established. These measures must be established over time, which is why Køge Municipality must start establishing ditches and basins as soon as possible. Additionally, they must enter into cooperation with the residents on how they can best arrange their properties, so the water can spread out, so that the soil does not become too saturated in one place on the property.

Redesign strategies from Doughnut for Urban Development

In this section, we will introduce which elements and functions need to be implemented in both social practices for human actors and in the urban area of Ølby Lyng and Ølsemagle, which would prevent exceeding the social and planetary boundaries. We will only include the local targets from the Doughnut for Urban Development, which means that in this analysis we will not consider the global targets. The social foundation and ecological ceiling will be categorised within the different social and planetary boundaries. However, it is important to acknowledge that there is a connection between the different boundaries which means they can overlap, and therefore some things might be mentioned more than once (see Figure 24). The social foundation will be categorised within the four categories *Connected*, *Inclusive*, *Equitable* and *Responsible*. For the Ecological ceiling, the categories are *Climate Stability* and *Healthy Ecosystems*.

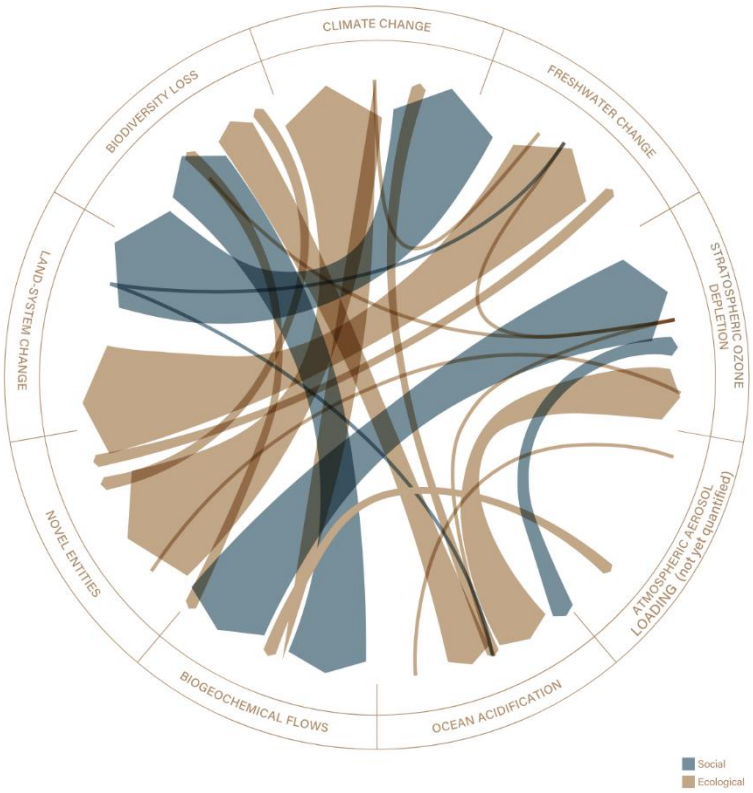


Figure 24: Shows how the social foundation and the ecological ceiling are connected in the nine planetary boundaries (Birgisdottir et. al. 2023, 82).

Social foundation of Doughnut for Urban Development

For the project area to meet the requirements within the social foundation of the Doughnut economy, there must be a focus on various elements to implement in the area. The targets will be grouped in two categories: Connected & Inclusive and Equitable & Responsible. Figure below shows the target within the social foundation.

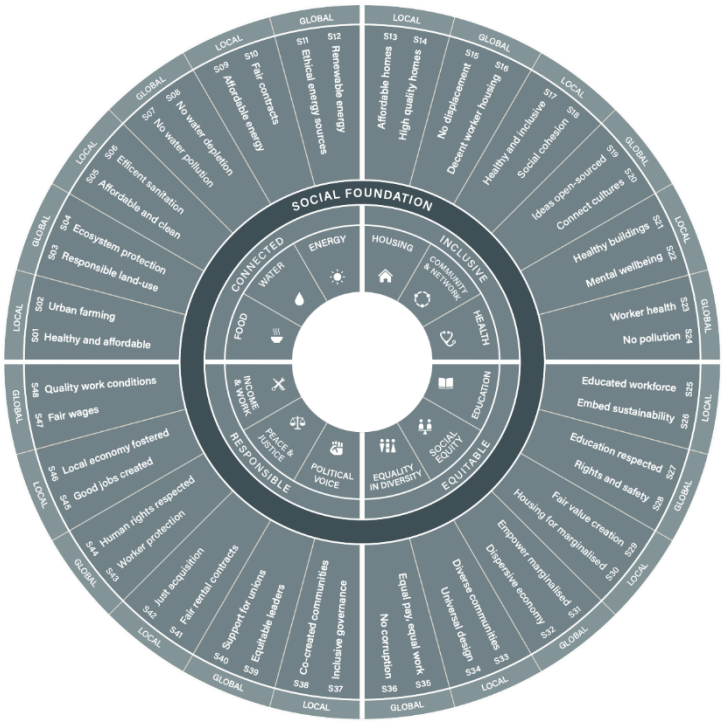


Figure 25: The targets within the social foundation of the Doughnut for Urban Development (Birgisdottir et. al. 2023, 59).

Connected & Inclusive

The practices and elements that relate to the targets pertaining to *food, water, energy, housing, community and network* and *health* are presented in this section. Within the categories of Connected & Inclusive, target S10 has not been included, as this target, which is about fair contracts between residents and the energy utility company (Birgisdottir et. al. 2023, 61), is outside the project scope.

Within the project area, a supermarket must be located, as a supermarket would contribute to easily accessible food for the local area (S01) (Birgisdottir et. al. 2023, 61).

In Analysis 1, it is shown in figure 13 that a supermarket is located in the existing area, therefore it could be an idea to retain this supermarket. Urban farming is also an element that must be implemented in the area, as this would also contribute to the availability of food (S02) (Birgisdottir et. al. 2023, 61). However, urban farming also provides an opportunity to establish a community based on the maintenance of urban farming. Different functions in the project area will be implemented to create a foundation for a good community (S17 & S18)

(Birgisdottir et. al. 2023, 63). These functions are daycare facilities, a school, sports facilities and buildings and other infrastructure that facilitates the presence of associations such as scouts and Kulturfuglen, a volunteer organisation that focuses on residents' connection with nature (Kulturfuglen n.d.), some of these functions are already are located in the existing area (see Figure 13).

Clean drinking water must also be ensured for the project area (S05) (Birgisdottir et. al. 2023, 61). This entails that the drinking water resource must be secured, which also involves the residents, as they are not to use chemicals that can damage the condition of the groundwater. Other sources of pollution must also be minimised so the groundwater, even if it is near terrain, is not polluted. This is crucial as the area will be affected by elevated groundwater (see Analysis 1).

In the project area, optimal waste sorting must be implemented, which must be created by ensuring that the relevant infrastructure is present for handling waste, including bins. In addition, the municipality and the citizens must engage in a dialogue to ensure that citizens comply with the requirements for sorting waste. A communication forum should therefore be formed, which will be further described in the next section, Equitable & Responsible. This forum must also be used to engage in dialogues about how citizens can contribute to a more sustainable lifestyle, including the replacement of sanitation installations to low flow sanitation installations (S06) (Birgisdottir 2023, 61), and installations to improve the indoor climate in homes, as it is not possible to force private individuals to invest in these solutions (S21) (Birgisdottir et. al. 2023, 63).

The local area must be supplied with energy from renewable energy sources (S09) (Birgisdottir et. al. 2023, 61). This can be possible in several ways. One option is for the citizens themselves to invest in solar panels that can be placed on the roofs of houses and thus allowing residents to generate their own energy. Another option could be to set up offshore wind turbines. The investment in renewable energy sources is a point in Køge's DK2020 plan, including wind turbines and solar cells on public and commercial buildings (Køge Kommune 2020).

As some of the houses in the existing area will be removed, the materials must used in these structures must be secured and used in the densification around Køge Nord Station as mentioned in Analysis 2, as this ensures that the materials will circulate. In addition, when homes are to be maintained, this must be done with durable materials that can be used

through the next generations with the option of reusing them if they are to be demolished (S14) (Birgisdottir et. al. 2023, 63).

The urban space must be designed so it creates a feeling of security. Therefore, there is a need for creating a sense of belonging in the urban space. A key component here is to add recreative elements and places which are more private for the residents to get a break from the everyday (S22) (Birgisdottir et. al. 2023, 63). In addition, the nature-based solutions can be included on the properties, if necessary, by building climate garden, which will ensure the connection between the residents and the natural environment (S14) (Birgisdottir et. al. 2023, 63).

Equitable & Responsible

In this section the targets belonging in the categories Equitable & Responsible will be presented. Within these categories are targets relating to *education, social equity, equality in diversity, political voice, peace & justice* and *income & work*. The targets S29, S41 and S42 are excluded as these are outside the project scope, as they deal with the aspects relating to economics (Birgisdottir et. al. 2023, 65-67), which is something we acknowledge but don't consider in this project.

In a residential area like this, there must be housing for people across the social layers of society. Therefore some of the housing or properties must be broken up so that it can be used as student accommodation, social housing etc. At the same time, the area around Køge Nord Station must be densified and there must still be detached houses (Appendix 2). This would ensure diversity in the population. It is possible that the municipality could buy up land through expropriation and split up the houses into smaller units to be able to have more residents. In this way, social housing can be created where the municipality must make a referral before it is possible to live in the specific housing. This must be done to ensure housing for people from all social layers (S30) (Birgisdottir et. al. 2023, 65). This is something Jacob Schjødt Nielsen also touches upon in the interview:

> *"[...] the private ownership means that it is deregistered and, and almost all the plots are privately owned, so how do you get [...] people who are in all sorts of places in their lives to think together and say yes up in the helicopter, we can you see, there is a need for more senior housing, a different and perhaps more updated body of buildings is needed, and you could also continue and make small student apartments or low-rise housing for, for other demographics.*

> *So it is, we are down to a few percentages gradually, there is the nuclear family, although that is often what we design for"* (Jacob Skjødt Nielsen, Pers. Comm. Own translation, Appendix 2, 16-17)

As mentioned in the section above, some of the materials from removing houses, must circulate in the community. Therefore, there must be a local recycling site where the resources can circulate and where residents can pick up or drop off items for reuse and recycling (S26) (Birgisdottir et. al. 2023, 65).

Another target regarding diversity is that mobility must be ensured across population groups (S34) (Birgisdottir et. al. 2023, 65). Therefore, it must be ensured that everyone can use the urban spaces, including the recreational elements in the nature-based solutions. It is essential that the redesigned area incorporates elements that allow people with prams or wheelchair users to move around unhindered.

As part of the Doughnut for Urban Development, people's workplaces must be located in the local area (S45) (Birgisdottir et. al. 2023, 67). However, it is a limited area that we are looking at. Local workspaces would also include workplaces located in, for instance, 3-4 kilometres south of the area. In addition, an educated workforce (S25) (Birgisdottir et. al. 2023, 65), is something there should be a focus on. This can be ensured by cooperation with entrepreneurs, consultants, craftsmen and other relevant professions when establishing solutions and maintaining them. In addition, easy access to the train to Copenhagen can ensure that the area can attract a population that is highly educated.

A communication forum must be established (S38) (Birgisdottir et. al. 2023, 67), which can ensure information and dialogue between the municipality, the utility company and the citizens, and thus promote the implementation of sustainable measures. This could be done at citizens' meetings in a smaller format, or an information point could be established where residents can come and engage in dialogue with the municipality's workers in the field their question relates to.

In addition, a residents' representation, an association, must be set up for the various residential areas (S37) (Birgisdottir et. al. 2023, 67), A residents' association may help ensure that the area is maintained and this association could enter into dialogue with the municipality and the utility company regarding various solutions in the project area.

There must be an opportunity for the associations to meet and spare with each other, and therefore, there should be a gathering space in the project area (S46) (Birgisdottir et. al. 2023, 67). This could be arranged like *Det grønne hus*, where associations have the opportunity to use the premises when the municipality's employees' workday has ended (Grøn Omstilling n.d.). The communication forum and the space for the association also creates the opportunity for different associations and sports organisations to be in the area, which would create diversity in the area's association life, ensuring there are options for all residents in the area (S33) (Birgisdottir et. al. 2023, 65).

Ecological Ceiling

In this section, our main findings from analysing the impact areas from the Ecological ceiling of the Doughnut for Urban Development will be presented. In our analysis, we have examining 24 local impact areas across the two impact areas "climate stability local" and "healthy ecosystem local" (see Figure 26). Not all the impact areas are related to our proposed redesign of the project area or within our project scope.

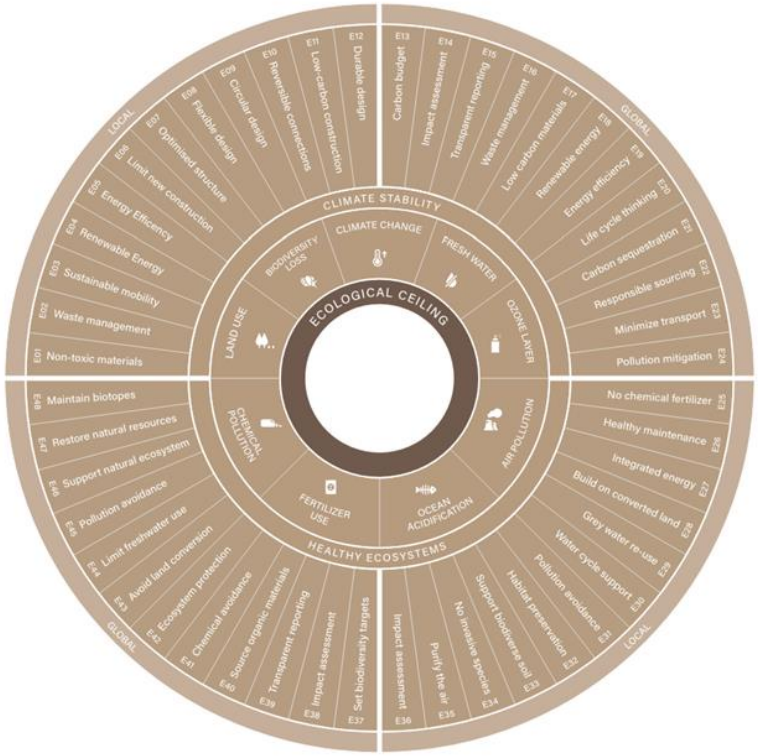


Figure 26: Shows the two local impact areas in the ecological ceiling of the Doughnut for Urban Development. At the top left corner is "the climate stability local" and at the bottom right corner is "the healthy ecosystem local" (Birgisdottir et. al. 2023, 93).

Climate stability

In this section, we will present the most important impact areas that will help improve the redesign of the project area. Some impact areas are left out in this analysis, since, while they are important, they fall outside of the scope of redesigning the detached housing area for climate change adaptation.

Land use, Biodiversity loss and Climate change

Now the practices and elements discovered from analysing the targets that relate to the planetary boundaries *land use, biodiversity loss, and climate change,* will be introduced. Since Target E05 Energy efficiency, is out of the scope of this project, it will not be included.

For the redesign of the project area, it is important that only non-toxic materials are used. For this reason, it will be important to choose natural materials for developing the nature-based solutions (E01) (Birgisdottir et. al. 2023, 95). Furthermore, it is important that the project area has a recycling centre and to make sure that recycled or reused materials do not maintain any hazardous substances (E02) (Birgisdottir et. al. 2023, 95). The recycling centre must be a space for maintaining and repairing objects and city owned inventories (E12) (Birgisdottir et. al. 2023, 95). Furthermore, must the detached houses and nature-based solutions also be maintained and repaired by the residents and landscape gardener. This will help to prolong the life of the houses and infrastructure and help reduce CO2 emission.

From Analysis 2, we were inspired by different nature-based solutions, some of the solutions will include that fences or houses will be removed from the project area. When the nature-based solutions will be implemented in the project area, the construction site must be circular to ensure that the materials that are removed from the area get a new life. The materials should be moved to a materials bank, which will be at the local recycling centre. Moreover, the construction site must be connected to renewable energy (E04) (Birgisdottir et. al. 2023, 95). The municipality must develop requirements for low-carbon construction, which should include low-carbon machinery and waste management practices that support reusing and recycling materials (E11) (Birgisdottir et. al. 2023, 95). These strategies will help reduce dependency on fossil fuels and reduce the CO2 emission.

Part of the redesign of the project area will include building ban, where the strategy is to maintain, reuse and redesign the existing detached houses and the gardens. This will help reduce dependency on virgin materials and reduce carbon emission (E06) (Birgisdottir et. al.

2023, 95). Optimising building design for flexible use could involve the existing detached houses become modular, which means that for example an extension could be selectively demolished and then be attached to another detached house (E08, E10) (Birgisdottir et. al. 2023, 95). For this suggestion we were inspired by Jacob Skjødt Nielsen's concept of dividing the detached house up, so that more residents could live in the same detached house (Appendix 2).

In addition, the garden design must be optimised for flexible use. The gardens must include nature-based solutions that will help prevent the detached houses from being flooded. Gardens must be places for social activities for the residents, who can use the gardens for outdoor activities for example eating outside, gardening, and playing sports. Another design element to reduce CO2 emissions would be to design the nature-based solutions with a material passport, which would help provide an overview of the amount of vegetation being used and to identify the native species that could help reduce the risk of flooding from ground water (E09) (Birgisdottir et. al. 2023, 95).

Both buildings and infrastructure must be designed to reduce materials usage by optimising their design (E07) (Birgisdottir et. al. 2023, 95). For instance, this could consist in a process where detached houses are 'merged'. Specifically, houses could be moved from one area to another and then joined with other detached houses, effectively making the houses two-storey duplexes. The area that is left vacant could then be used for nature-based solutions. This process would make the area as a whole less fortified and make space for nature-based solutions.

The buildings that would be moved to make space for the nature-based solutions must be moved closer to public transportation (E03) (Birgisdottir et. al. 2023, 95). In addition, the planning of mobility patterns must encourage sustainable mobility practices such as walking, cycling, sharing-electrical vehicle, and the use of public transportation. Hopefully this will give an incentive for more residents choose sustainable mobility. Initiatives similar to these are introduced in the DK2020 plan.

Healthy ecosystem

We will here introduce the healthy ecosystem local, which consist of the two planetary boundaries *Air pollution* and *Ocean acidification.*

Air pollution and Ocean acidification

In this section the practices and elements connected to the planetary boundaries *Air pollution* and *Ocean acidification* are introduced. The two targets that was left out of this analysis were E28, Build on converted land, and E31, Pollution avoidance.

To reduce air pollution only organic fertilizers must be used in public parks, at nature-based solutions and in gardens. This will help improve and protect the health of the streams, lakes, oceans, vegetation and soil (E25) (Birgisdottir et. al. 2023, 99). In relation to improving soil, the residents and gardeners must preserve soil by composting. This compost can be used as ecological fertiliser to nature-based solutions and for gardening plants. Moreover, using compost will contribute to maintaining a healthy ecosystem in the project area (E33) (Birgisdottir et. al. 2023, 99).

In terms of reusing, recycling and repairing the urban space, the detached houses, the objects, and city-owned inventories must not include contaminants such as hazardous substances plastics, NOx, SOx, and chemicals. Avoiding these mentioned contaminants would help improve the biodiversity and biosphere (E26) (Birgisdottir et. al. 2023, 99).

To integrate energy production locally solar panels must be installed on the roofs of the detached houses. This would ensure that land is not used for local energy production and would provide more space for nature-based solutions (E27) (Birgisdottir et. al. 2023, 99). Another element that must be improved in the existing detached houses is the use of natural water resources, where grey water use must be in circulations in the detached houses, so that the water can be used more than once. The reuse of grey water in the detached houses happen in the bathrooms, where grey water could be used for both bathing and flushing the toilet (E29) (Birgisdottir et. al. 2023, 99). Reusing grey water would help put less stress on the sewage systems.

To support the naturel water cycle, nature-based solutions like reed beds and bioswales must also be implemented in the project area. Such nature-based solutions would help with cleaning and catching water from prolong periods of rain and cloud burst events. Nature-based solutions should become integral elements of the infrastructure such as roads,

pathways, parking lots, and public spaces. Furthermore, the plant species that are used in the nature-based solutions must be both native species and species combination, that are suitable for the landscape in the project area (E32) (Birgisdottir et. al. 2023, 99). It will be important that Køge Municipality develops a plan about monitor for invasive species (E34) (Birgisdottir et. al. 2023, 99). In addition, more trees must be planted in the gardens and public urban spaces. As trees improve outdoor air quality, since trees help with storing CO2 and purifying the air (E35) (Birgisdottir et. al. 2023, 99).

Lastly, human actors such as Køge Municipality, residents and expert ecologists should help conduct an impact assessment, for the strategies presented.

Sub-conclusion

We have now presented how sustainability and climate change adaptation are related, and both climate change and sustainability should be a crucial ingredient in developing the redesign for Ølby Lyng and Ølsemagle. Below we will present a vision of the redesign of the detached housing area Ølby Lyng and Ølsemagle. The redesign will be presented as a plan for the project area, where the main conclusions from Scalgo and Doughnut for Urban Development will be included. We believe that some of the strategies presented in the following plan can be adapted by other municipalities, which could also help prevent climate change. The plan for the redesign will start in the next page. The plan is a product out of the report, therefore the plan has its own page numbers and reference list.

ØLBY LYNG AND ØLSEMAGLE YEAR 2050

THE VISION

Ølby Lyng and Ølsemagle is an area that creates a path for a sustainable life. Climate change adaptation based on nature is in focus, and recreational elements contribute to a good and healthy life. Nature becomes a part of the area and contributes to managing climate change within the local area.

The vision for the area is to create a community that reduces consumption and focuses on preserving and reusing resources. The area thus contributes to reducing emissions and securing resources for future generations.

TABEL OF CONTENTS

- THE LOCAL COASTAL NATURE PARK
- THE LIFE-STYLE OF LIVING IN DETACHED HOUSES
- SUSTAINABLE MOBILITY AND NATURE-BASED SOLUTIONS
- PUBLIC GREENSPACES
- THE LOCAL RESSOURCE MARKET
- LOCAL CIRCULAR CONSTRUCTION
- COMMUNITY

THE NEW LANDSCAPE OF ØLBY LYNG AND ØLSEMAGLE

THE LOCAL COASTAL NATURE PARK

The coastal nature park consist mostly of a large beach meadow. At the beginning of the park, a forest with native plants is located, and further along the coast, the landscape changes into a beach meadow.

The coastal nature park is aligned with the road Københavnsvej, and a gravel path from Københavnsvej winds through the landscape, providing the opportunity for both residents and tourists to visit the park.

THE LOCAL COASTAL NATURE PARK

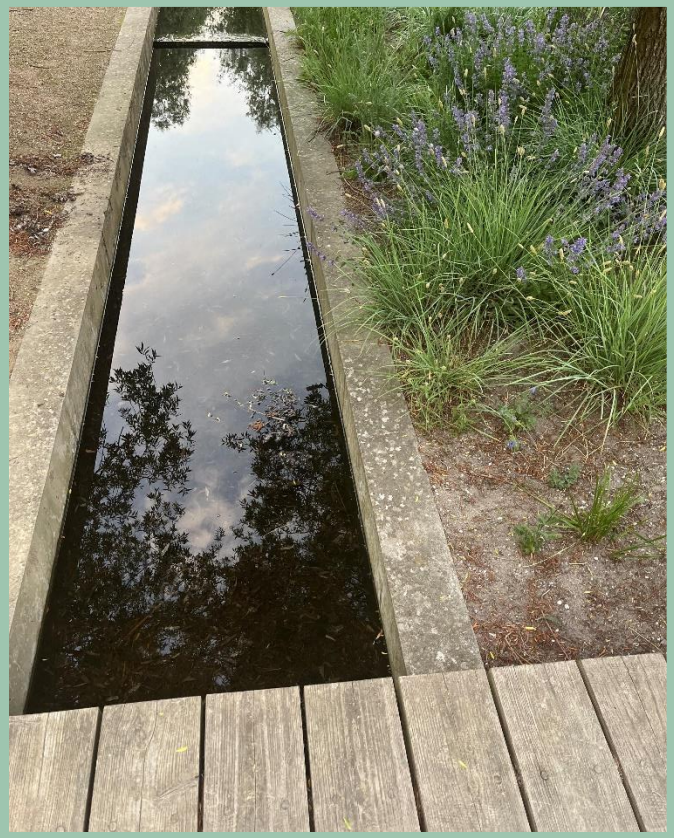
The coastal nature park has been developed only with native plants. Public gardeners maintain the spaces with organic fertilisers.

THE LIFESTYLE OF LIVING IN DETACHED HOUSES

The outer spaces of the detached houses reflect life with a focus on sustainability. There has been a change in the practice of the residents in the sense that they are now involved in the management of water. For periods of time, the residents live with water, where gardens are swampy and the soil saturated. A focus on less pollution has been incorporated to secure the ground water resource as drinking water.

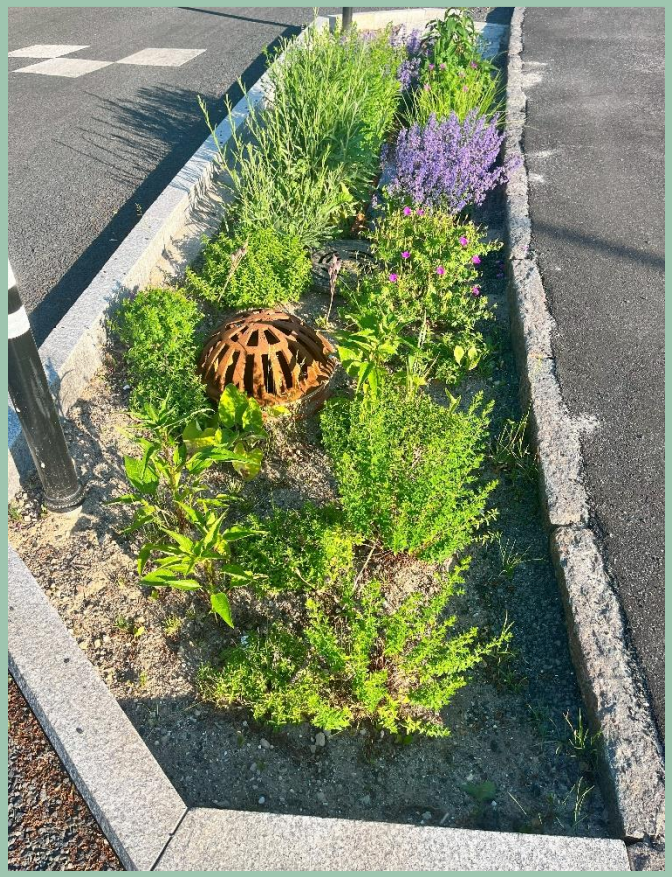
THE LIFESTYLE OF LIVING IN DETACHED HOUSES

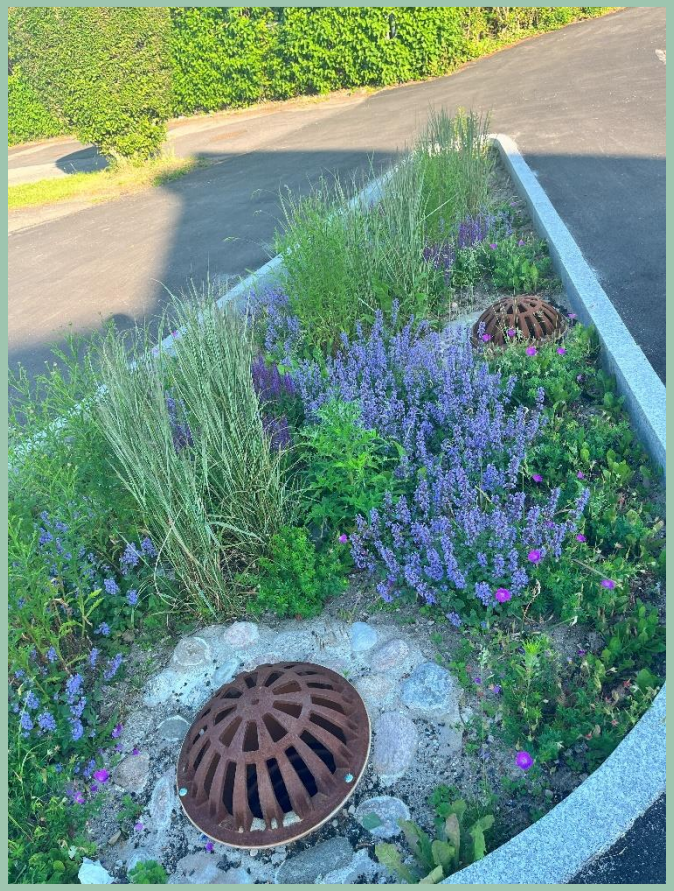
Here, solar panels have been installed to make energy to use in the household. Evaporation walls have been planted to manage some of the rainwater. Roof water is collected in rainwater containers, and the water is then used for climate gardens which the residents have helped to build on their properties.

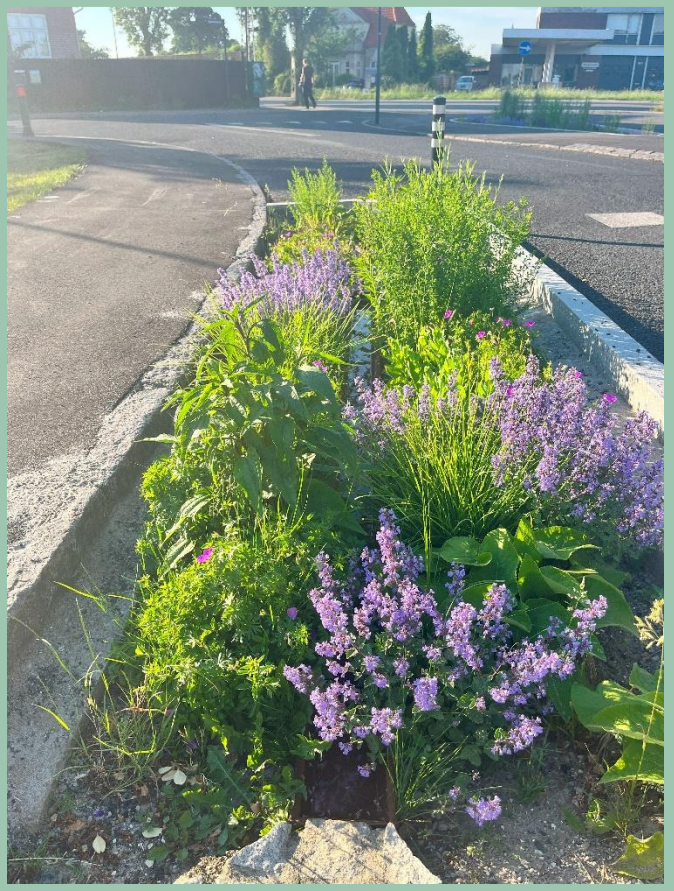


SUSTAINABLE MOBILITY AND NATURE-BASED SOLUTIONS

In the local area the focus is on sustainable mobility such as walking, biking, using public transport or in some cases car sharing. The roads are designed to support these mobility styles, and nature-based solutions are incorporated as elements by the roads such as ditches with either plants or water.





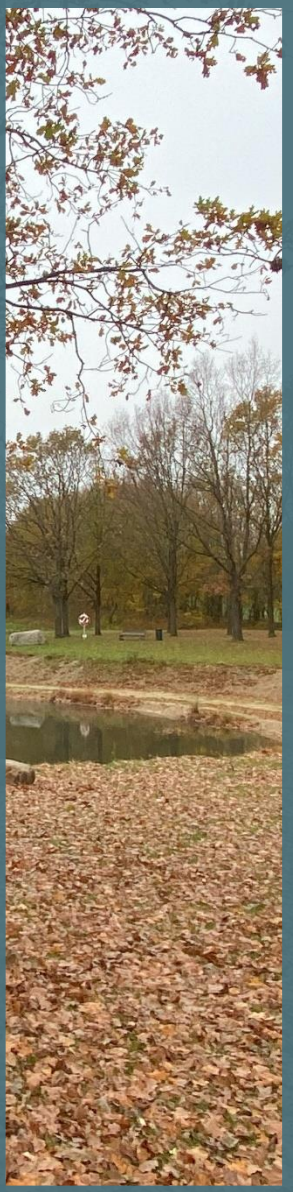


SUSTAINABLE MOBILITY AND NATURE-BASED SOLUTIONS

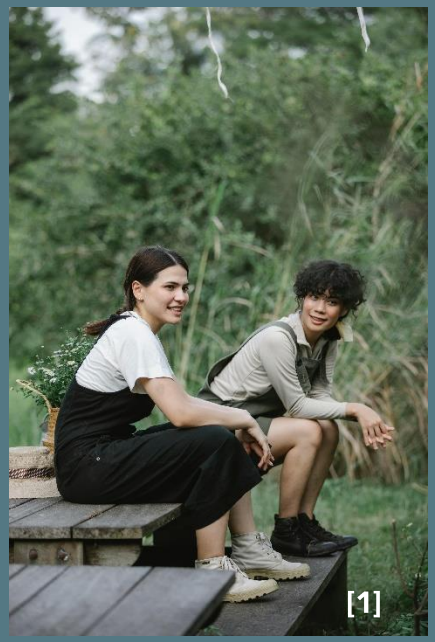
The design of the nature-based solutions has been tailored to each road. Køge Municipality and the residents collaborates with maintaining the nature-based solutions.

PUBLIC GREEN SPACES

Public green spaces have emerged in Ølby Lyng and Ølsemagle. These public green spaces are connected, and a pathway winds through the landscape. In the landscape the terrain changes, so lakes appear in wet season and disappears in dry season. The green spaces consists of native plants, animals and insects. For the residents, the green spaces have become meeting points where they can stay, play and exercise. Public gardeners maintain the spaces with organic fertilisers.



PUBLIC GREEN SPACES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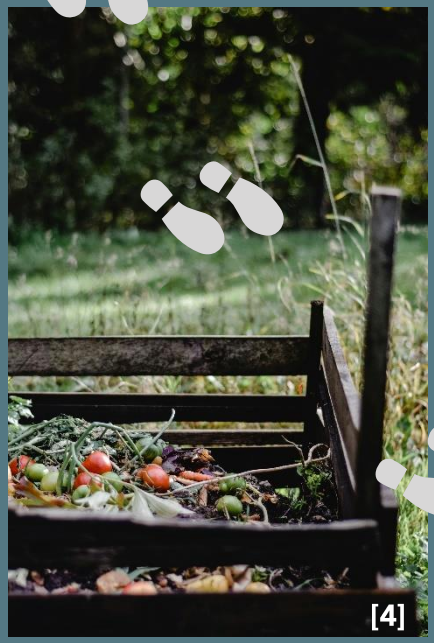
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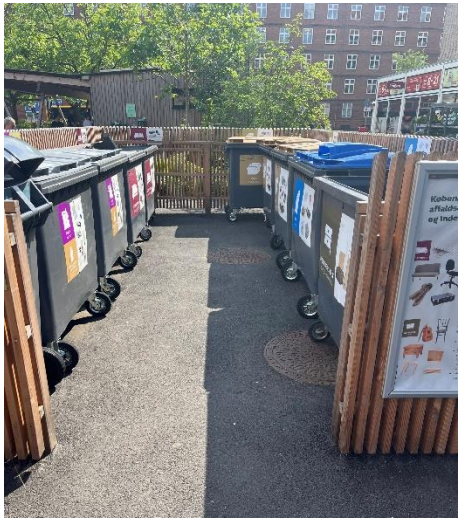
WELCOME TO THE LOCAL RESOURCE MARKET
Bytte

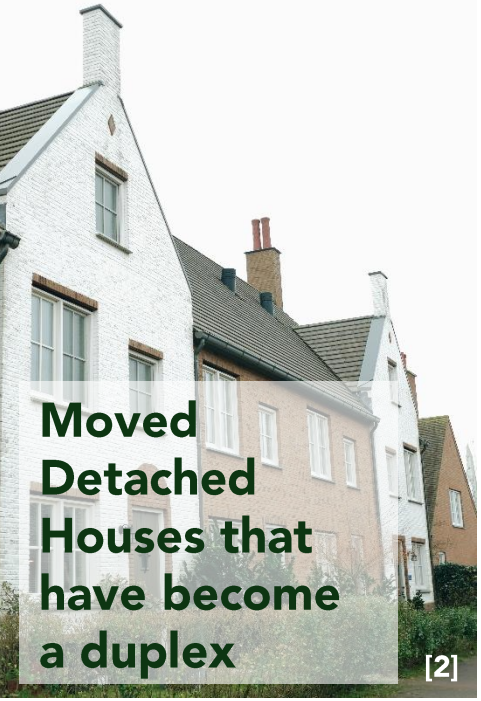


THE LOCAL RESOURCE MARKET

The local resource market is operated by Køge Municipality and local initiatives. At the resource market residents can exchange and repair their belongings.

The local resource market has become a meeting point where residents can join new communities and get advice and learn about waste management and gardening from both public refuse workers, public gardeners and volunteers.

The work of the public refuse workers includes ensuring that the materials and belongings exchanged does not contain any harmful substances. The public refuse worker are therefore in close dialogue with residents.



LOCAL CIRCULAR CONSTRUCTION

The area close to Køge Nord Station has been densified to allow more people to live within the *station proximity principle*, which creates easy access to public transportation and makes space for green areas and managed retreat of the coast.

Green spaces are also incorporated in the area close to Køge Nord Station to help the area withstand climate change and ensure that nature is an element throughout the local area.

COMMUNITY

Ølby Lyng and Ølsemagle have become a diverse community with a vibrant cultural life. The communications forums such as Det Grønne Hus, the local resource market, and leisure and recreational facilities are all places where members of the community can meet and socializing, collaborates with the municipality and the utility company, and join new associations.


[8]


[5]


[3]

A day in the life

It has been raining for several days in the area, the sun is peeking out, the rainwater storage have been filled up and the water is stored in multiple nature-based solutions. Jørn is on his way out to go for a walk, he is happy that his rainwater storage has been filled up but also that the sun is out again, so he can generate some energy through his solar panels, which he has on the roof of his house.

Jørn walks down through the green area with the rainwater lakes and enjoys the presence. He is on his way down to the resource market, hoping to find some new decorative elements for the garden and the house. Later, he will visit his sister in Hundige, Jørn takes the train when visiting his sister, because it is right when there are paths all the way to the station.

Tonight, Jørn is going to a meeting, which is held between the various associations every quarter, to discuss whether they should arrange some events for the local area, he is chairman of the Petanque club.

Jørn appreciates the community he is part of in the local area and enjoys his walks through the green areas and wetlands when he is on his way to the beach, this is where he usually spends his evening right before going home to his bed.

[6]

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The rest of the picture in the plan: The pictures that are not listed in the references list are taken by the group itself during field work. The illustrations are all from Microsoft PowerPoint.

Discussion

In the following section some of elements of the redesign and the use of Doughnut for Urban Development to redesigning an existing area will be discussed. In addition, the collaboration between actors and how this redesign plan can inspire other redesigns of existing areas will be elaborated.

The new collaboration between actors

In analysis 3, it is proposed that the human-actors Køge Municipality, KLAR Forsyning A/S, and the residents take on a greater responsibility for incorporating sustainable practices and climate change adaptation. This means that the residents must assume responsibility for including nature-based solutions on their properties. It also means they must assume responsibility for reducing their own consumption of CO2 emission.
Køge Municipality has the responsibility to implement nature-based solutions on roads or other public areas, buying up properties, hiring staff and developing the recycling centre.
KLAR Forsyning A/S has the overall responsibility for operating the nature-based solutions in close collaboration with the residents and Køge Municipality.

One concern is whether Køge Municipality is ready to take on this kind of responsibility for the proposed redesign plan is to succeed. As shown in the case description Køge Municipality consist of many departments, which have different political and economic interest, not all of which necessarily align with taking greater responsibility for transforming an existing detached housing area into the kind of sustainable area proposed in our redesign.
As mentioned in the interview with Tore Bro, local politicians have an interest in ensuring that companies and residents in Ølby Lyng and Ølsemagle are happy with the redesign plan (Appendix 3), and our proposal includes initiatives that residents may object to for various reasons. Politicians may be reluctant to embrace policies that may alienate groups of voters. Furthermore, the residents are one of the primary actors in our redesign of the project area which means that if the residents are not pleased with the redesign, then it will be difficult for Køge Municipality to continuing with the transformation. This is particularly difficult since most of the properties of the project area are owned by the residents. However, it is possible that the three recent storm surges that have impacted the area (see Case description), could be the driver for the human-actors to change perception. Another driver of change could be the

human-actor Grøn Omstilling. One of Grøn Omstilling's ambitions is to act as consultants in the process of creating sustainable living conditions in Køge. Grøn Omstilling could act as an intermediator by providing new insight and knowledge about sustainability and climate change adaptation, which hopefully would change the perceptions of the residents.

Køge Dyke, DK2020 Plan, The rain and sewage plan are non-human actor which may also impact the perceptions of the network, because they are developed based on the actors' current perception of climate change adaptation strategies and sustainable practices. What is meant by actors' current perception is when the collective decision has been made to for example build a dyke. The current perception of the world creates a discourse that governs what is communicated to society. This also creates the dynamic of actions. As we previously mentioned, Køge Municipality plan of implementing a dyke as the current main solution to protect the residents against storm surges. According to our analysis a dyke is not the best proactive measure, since the human-actors are likely to become too depended on a non-human actor, the dyke. As Ole Fryd mentions in the interview, we conducted with him, the dyke can be considered a paradox, it that it may contributing to protecting residents while also making them more vulnerable in the long run, since it may influence the actors to continue the same approach for urban development and to speed up investing on the area protected by the dyke (Appendix 4). This is a problem, since our analysis shows that other types of flooding can also impact Ølby Lyng and Ølsemagle. A significant problem would also arise if the dyke were to collapse, particularly if the area has not been otherwise adapted to withstand weather event. A collapse of the dyke would also affect the relationship between the municipality and the residents, because the residents could be in good faith that the development of the dyke is the solution and are thus less likely to make other necessary and nature-based solutions.

To elaborate on Analysis 2, there is also a perception that it is KLAR Forsyning A/S and Køge Municipality that have the main responsibility for solving the issues with flooding. This is also expressed in the Danish article "Familie var lige flyttet tilbage efter seneste stormflod – har vandet ødelagt huset på ny" reported by the Danish Media TV 2, where two residents from Køge Municipality were interviewed about the storm surge event on the 3rd of January 2024 (Valentin 2024). It is stated in the article that the interviewees are frustrated that the dyke will only be realised in year 2025 and not sooner (Valentin 2024).

Again, the responsibility for managing the events is thought of as belonging to the municipality. It is clearly not tenable that residents believe the responsibility for managing water is solely with the municipality and utility companies. In our redesign of Ølby Lyng and Ølsemagle we focuses on a retreat of the coast where the municipality, KLAR Forsyning A/S, and the residents must collaborate to manage the water. The consequences of this approach are that the redesign of the area will be implemented over 26 years with the aim to be fully transformed in year 2050. This means that the residents may be subjected to flooding until the plan is fully implemented. On the other hand, the intentions with the redesign are to create awareness about which practices help reduce CO2 emission and which practices that will help the residents, Køge Municipality, and KLAR Forsyning A/S to manage the current issues from water that Ølby Lyng and Ølsemagle are dealing with.

Distribution of responsibilities

There are specific requirements regarding who should manage some of the consequences of climate change and how it should be done. These requirements and limits on who does what and how big a part is their responsibility must be changed. Among other things, the Utility company has a requirement that their sewers can handle everyday rain in the form of a 5-year rain event, thus they can disclaim responsibility for major incidents, as Bettina Simonsen describes:

> *"[...] We are only responsible for everyday rain. That is, a rainwater event that occurs statistically every five years in the future. That's what we make our sewers for. If there is more water than that. Then there is no room for it in the sewer. Then there's the water, if there's a cloudburst that hits, that's it, we have as such, we can sit back and say: it's not our problem. We are only responsible for a 5-year rainwater event, so what is categorised as everyday rain. What exceeds beyond this event aren't our problem, and that is wrong mindset to have. Of course, we cannot take responsibility for the fact that no one ever gets flooded [...]. But we can work together with the private and the municipality, who have joint responsibility for cloudburst management [...]"* (Bettina Simonsen. Pers. Comm. Own translation. Appendix 1, 5)

These requirements must be nuanced, as there may be a difference in how the areas are affected. Bettina Simonsen expresses that a collaboration must be entered into to manage

these extreme events that occur with climate change. The collaboration must help with how water is managed so that the distribution of responsibility becomes more fluid. Therefore, one cannot disclaim responsibility either as a citizen, municipality or utility company, but it must be seen as a shared responsibility to secure areas against the extreme weather events of the future.

In addition, it could be imagined that several actors must be involved in the process, Jacob Skjødt Nielsen emphasizes that you can involve the bank advisers as actors to advising on how to divide a house if, for example, you become single (Appendix 2), so that more housing is generated. The bank adviser could also be an actor to involve, as they can give advice on what house owners should be aware of in areas with flooding and how the value of their property may decrease over time if it is a particularly exposed area. They can inform about the risks involved in buying houses in specific areas, also concerning if the bank has to lend the citizen money for the property, and it then decrease in value due to climate change.

In addition, the insurance company also has an important role in how and if the house can be insured, it may be that the insurance conditions become stricter or it may be that houses close to the coast or in low-elevation areas cannot be insured in the future, which may mean a change in who buys these houses and live in the areas.

Redesign of a local area for sustainability and climate change adaptation

The redesign is of a local area in the areas of Ølby Lyng and Ølsemagle. The redesign has been developed based on the creation of a plan that shows elements and practices that must be implemented in a redesign of an existing area, when focusing on sustainability and climate change adaptation. Therefore, some points can be used as inspiration if others want to redesign an area that is similar to the project area.

The first question is therefore whether an area can become too small when redesigning with a focus on sustainability and climate adaptation. Within such an area there are different human-actors: a number of residents, in addition there is a utility company, in this case KLAR Forsyning A/S, and a municipality, which in this case is Køge municipality. Other human actors, such as consultants, landscape gardeners, entrepreneurs etc. can be good to incorporate when wanting to redesign an area, but these actors might not have a base in a

local area. Therefore, the collaboration of human actors might go beyond the boundaries of this project area.

The second thing is when redesigning a small area and considering water and mobility, these might move beyond the boundaries of the area. These elements cannot be seen in such an isolated perspective in a local area. Therefore, mobility can extend beyond the area, such as Køge Nord station, which is within the boundaries of the project area, but by taking the train, you move beyond the boundaries. In addition, it makes good sense to densify within the *Station proximity principle* of Køge Nord station, as Køge Nord station is located at a higher elevation point in the terrain and good opportunities are created for the use of public transport.

As we know, water does not only move within boundaries, municipal boundaries and so on. Therefore, it is important when managing water within a local area such as in this project, to investigate how these solutions have an impact on the areas next to it or at a larger scale, to ensure that the solutions that are implemented do not affect the neighbour, so they get flooded, so that maladaptation occurs.

The area prepared is a redesign of a low-elevated area where most of the area is below 2 m above sea level. Therefore, it must be considered whether it makes sense to protect a low-elevated area and build new infrastructure, as it is a very exposed area. Especially with rising seas, then large areas are flooded, without there being any real natural solutions for that apart from retreating the coast.

In a way it can contribute to working with a local area is when working with the involvement of the residents. Since it is a smaller local area, where the focus is to involve the community and the participation of the residents, it can be easier to involve the residents since they are a part of the area, rather than a large assembly from the whole municipality. In analysis 3, it is described that a communication forum must be created and a place where the associations in the area can meet. This should also contribute to a sense of local cooperation, where it is possible for the residents and the associations to be heard, and to talk about the things that are happening in the local area.

Pros and cons of Doughnut for Urban Development

In our redesign, the focus was to include as many targets from the Doughnut for Urban Development as possible, so that the redesign of the Ølby Lyng and Ølsemagle are became sustainable. The framework proved difficult to use when the targets included sustainable mobility and energy, since these infrastructures is connected to other areas, such local areas, and other municipalities. For example, this means that it will be unclear if the only energy that runs through the area will be from renewable sources. There are examples where it is possible to incorporate solar panels as a contribution to producing renewable energy, but the energy system is a larger system that reaches across national borders. This mean that the framework must be used in other plans rather than only in one in order to create the synergies that follow from setting the same targets. Such coordinated plans would help ensure the area's redesign is fully sustainable and within the planetary boundaries.
A considerable problem with the framework Doughnut for Urban Development is its aim, which is specifically directed at developers and similar actors, as expressed below:

> "*the aim is to provide developers and other building industry actors with a manual that supports the application and practises of Doughnut principles*" (Birgisdottir et. al. 2023, 4)

This clear direction at actors such as developers, entrepreneurs, architects and demolition companies also influences the chosen targets. An example is the local target (S05), which includes access to clean and affordable water. The target expresses that water is a human right that should be guaranteed to the community. This is a broad target which means that in the current situation, the developer can put an indicator that the community have 100% access to affordable and clean water, obscuring the fact that there may be considerable threats to the water supply. It is complex to use such a framework that is directed to the building industry, because it lacks the ambitions of pointing out what could be a threat to this system. In the framework, different examples of case studies are provided that have included impact categories and most of these case studies have only included some of the categories. Then the question becomes is the framework ambitious enough when it comes to sustainable Urban Development?

An example of a target that is more aligned with redesigning an existing detached housing area including climate change adaptation and sustainable strategies is the target (E32), Habitat preservation, which is about using nature-based solution in infrastructure like gardens and pathways. The example of an indicator that is giving is:

> "*% of nature base solutions integrated into infrastructure design*" (Birgisdottir et. al. 2023, 51)

This can serve as a measurement for how much nature-based solutions are included in the transformation. It can be a good measurement when you are building a new small area, but when redesigning an existing detached housing area, this kind of measurement becomes difficult to measure. This is likely to be a problem, when different kinds of nature-based solutions such as the beach meadow, are implemented.

However, the framework still provides a helpful overview of which strategies that must be implemented when redesigning and constructing the area of Ølby Lyng and Ølsemagle for sustainable living. Combining the framework with the analysis of the flood situation has helped us identify important issues that must be taken into consideration when redesigning the project area. We thus believe the framework Doughnut for Urban Development has proven to be suitable for incorporating sustainable strategies for Ølby Lyng and Ølsemagle. It has also been helpful in identifying how the nature-based solutions should be integrated in the existing area, and that native species should be included in the nature-based solutions.

In the redesign of Ølby Lyng and Ølsemagle, economics and the political agenda has been on a minimal level. This might be something that has to be considered more if wanting to redesign an existing area. In addition, when wanting to expand this redesign to other areas, it is important to see how the solutions within the redesign might have an impact on other areas nearby. We have discovered that Doughnut for Urban Development must be combined with an analysis of how climate change affects the area, to understand how the existing detached housing area can be sustainable to live in.

Conclusion

This project analyses the issues with climate change that the area of Ølby Lyng and Ølsemagle is experiencing and how it will affect the areas in the future. A proposed redesign of the area in 2050 is presented in Analysis 3, which is based on the results of the prior analyses and case study. The case that this study is working with is a detached house area, Ølby Lyng and Ølsemagle. In the Case description and in Analysis 1 it became clear that the area is located in a low-elevation area and at the same time it is a very fortified area. This causes issues during cloudburst or prolong periods of rain, as large amounts of rain must go into the sewers at the same time and the water cannot seep down to the ground due to the fortified areas. At the same time, it is mentioned by Bettina Simonsen from KLAR Forsyning A/S that the sewer system only needs to be able to take care of a 5-year event in relation to everyday rain, which also is a part of why there is issues with rainwater. In addition, the area is located close to the coast, which means that the area is also exposed to storm surges and sea level rises, which has already happened several times, especially the storm surge in 1872 hit large parts of the area. These elements are a part of understanding, how the existing detached house area can be redesigned and what focus should be in the redesign. Therefore, these elements are contributing to answering the research question:

How is it possible to redesign an existing detached house area when focusing on sustainability and climate change adaptation?

To redesign an existing detached housing area, it is important to first investigate and understand which issues the area is experiencing and facing in the future, as we did in Analysis 1. In our case the most pressing issues were how the area is affected by climate change and the high CO2 emissions the detached house areas are contributing to. To redesign the area, the framework Doughnut for Urban Development, helped to create an overview of sustainability measures and made sure that there was a focus on both the social and planetary boundaries.

The redesign entails both physical elements, practice changes and collaboration between actors. The physical solutions are retreat of the coast, nature-based solution in the detached house area in the form of climate gardens, ditches along the roads and the green area. The coastal nature park is created as the area are highly affected by storm surges and rising sea levels, and therefore it must be converted to nature. The solutions along the roads and the

green areas are nature-based solutions that will help with the management of the water during cloudburst or prolong periods of rain. The outer areas of the detached houses have been designed with physical elements such as rainwater storage, solar panels etc. In addition, mobility into the area is planned for, in terms of a focus on densifying the area close to Køge Nord station as et creates easy access to public transport. This densification is also to secure housing in the area for the number of residents who are there now, when some areas are removed for adapting the area to the climate.

In addition, there are some changes in practice that has to happen, as well as collaboration between different actors has to be formed. This collaboration should be a driver for change in the way responsibility is distributed today, as residents must not always see it as others responsible, but also their own when withstanding climate change. At the same time the utility company and the municipality must be more flexible when it comes to climate change adaptation, as what is needed for an area can be different.

This thesis contributes to a sustainable city because the vision is to redesign an existing detached housing area where the focus is for the residents to live within the social and planetary boundaries and to incorporate natural solutions to manage climate change.

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