CLIMATE ADAPTATION IN ENVIRONMENTAL IMPACT ASSESSMENT

- A STUDY OF DANISH TRANSPORTATION INFRASTRUCTURE PROJECTS

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Abstract:

This study investigates climate adaptation in environmental impact assessment (EIA) for Danish transportation infrastructure projects and seeks to answer the research question: *What are the potentials and barriers for increasing the focus on climate adaptation in the EIA process for transportation infrastructure projects?* Requirements and recommendations for integrating climate adaptation in environmental assessment (EA) are investigated, and based on this, an analytical framework is developed. The current integration of climate adaptation in EIA reports is examined through a mapping in the Danish EA-Hub, and using the analytical framework a text analysis is conducted on seven projects with EIA reports including climate adaptation. These findings are supplemented with insight into experiences of challenges in current practice and possible improvement potentials from interviews with four actors within the field. Based on the findings in this study, nine recommendations for future practice are developed, seeking to contribute to handling of the identified regulative, normative, and culture-cognitive challenges and improvement potentials. Overall, the recommendations seek to increase alignment in the content of the assessments and the use of methods and approaches, including the use of tools, time horizons, and climate scenarios. Further, the recommendations seek to contribute to an increase in awareness, understanding, and knowledge of climate change impacts and environmental interrelations. Implementing the recommendations in practice can be challenging due to for example economic costs and required changes in the institutional system, but the societal increasing focus on climate adaptation could indicate a potential and willingness to make changes for a better future.

Preface

This report is the result of a master's thesis conducted during the fourth semester of the master's program *Environmental Management and Sustainability Science* at Aalborg University.

The author of this study would like to thank the following people for their time and valuable contributions to the study:

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Guidelines for reading

Sources are referenced according to the Harvard reference style, where sources are presented as: [author, year of publication]. When quotes are included in the report, page numbers or time intervals from interviews are further applied: [author, year of publication, p. XX/time frame].

The following abbreviations are used throughout the report:

- EA: Environmental assessment
- EIA: Environmental impact assessment
- IA: Impact assessment
- IPCC: The Intergovernmental Panel on Climate Change
- The European EIA Directive: The European Environmental Impact Assessment Directive 2011/92/EU amended by Directive 2014/52/EU
- The Danish Environmental Assessment Act: The Declaration of Law on Environmental Assessment of Plans and Programs and of Specific Projects, 3/01/2023
- IAIA: The International Association for Impact Assessment

Referat (summery)

Klimaet er under pres, og niveauet af menneskeskabte drivhusgasudledninger er højere end nogensinde, hvilket fører til klimaforandringer overalt på kloden, som påvirker både mennesker og natur i stadig voldsommere grad. Derfor er der behov for at indtænke klima på alle planlægningsniveauer, og i denne sammenhæng fremhæves miljøvurdering som et værktøj til at integrere klima i planlægning og adressere sammenhænge mellem klima og andre miljøparametre. Der er behov for både klimaforebyggelse og -tilpasning, men dette studie har et afgrænset fokus på klimatilpasning, idet forskning i miljøvurdering indikerer særlig et manglende fokus herpå. For at indskærpe fokus yderligere afgrænses studiet til danske transport infrastrukturprojekter, idet transportinfrastruktur er essentielt for et velfungerende samfund, og der ses et politisk fokus på at sikre både eksisterende og ny infrastruktur mod fremtidige klimaændringer. Samtidig fremhæves transport infrastruktur som sårbart overfor klimaforandringer, og med en stigning i miljøvurdering af denne projekttype over de senere år, vurderes det relevant at undersøge håndteringen af klimatilpasning i den nuværende miljøvurderingspraksis for denne projekttype. Miljøkonsekvensvurderingen skal indeholde en vurdering af klimapåvirkninger på projektet samt eventuelle klimatilpasningstiltag, hvis vurderingen indikerer påvirkninger af væsentlig negativ karakter. Klimatilpasning har stor sammenhæng til andre miljøemner, og derfor er det vigtigt, at potentielle positive og negative indbyrdes sammenhænge mellem klimatilpasning og andre miljøemner inddrages som en del af vurderingen. Nyere dansk forskning og international litteratur peger på, at klimatilpasning ikke er tilstrækkeligt inkluderet i nuværende miljøvurderingspraksis, og et potentiale for at undersøge nuværende praksis nærmere med formål om at identificere udfordringer og forbedringspotentialer er identificeret. Med afsæt heri undersøges følgende problemformulering: **Hvad er potentialerne og barrierene for at øge fokusset på klimatilpasning i miljøkonsekvensvurderinger for transport infrastruktur projekter?**

Dette er undersøgt gennem tre underspørgsmål. I det første underspørgsmål undersøges lovkrav og anbefalinger til at inkludere klimatilpasning i miljøkonsekvensvurderinger. Dette undersøges gennem tekstanalyse af Miljøvurderingsloven og Det Europæiske Miljøvurderingsdirektiv samt relevante danske og international guidelines og anbefalinger til bedste praksis. Derudover udføres et litteraturstudie på nyere international forskning, og anbefalinger for fremtidig praksis heri identificeres. Baseret på de kortlagte lovkrav og anbefalinger udarbejdes en analyseramme for, hvad der optimalt set bør indgå i miljøkonsekvensrapporter. Analyserammen er på et dialogmøde diskuteret med en ekspert i klimatilpasning og herefter tilpasset. Analyserammen er anvendt til besvarelse af specialets andet underspørgsmål, som omhandler, hvordan klimatilpasning fremgår i miljøkonsekvensrapporter for transport infrastruktur projekter. Først udføres en kortlægning i værktøjet EA-Hub, hvor der identificeres 99 transport infrastrukturprojekter, hvoraf 18 nævner klimatilpasning, klimasikring eller sårbarhed overfor klimaændringer. Dermed ses et begrænset fokus på direkte adressering af klimatilpasning i danske

miljøkonsekvensrapporter for transport infrastrukturprojekter. Syv af de 18 projekter udvælges til nærmere tekstanalyse, hvor det undersøges hvorvidt de opstillede anbefalinger i analyserammen er til stede i rapporterne eller ej. Det tredje underspørgsmål har til formål at undersøge praksis orienterede udfordringer og forbedringspotentialer, hvilket undersøges gennem interview med fire relevante respondenter suppleret med pointer fra dialogmødet. Analyserne af miljøkonsekvensrapporterne og interviewene indikerer en række problemstillinger, som med udgangspunkt i institutionel teori kan karakteriseres som henholdsvis regulative, normative og kultur-kognitive problematikker. Identificerede hovedudfordringer inkluderer blandt andet et manglende fokus på vurdering af klimapåvirkninger og -tilpasninger relateret til andre klimafaktorer end vand, herunder for eksempel stigende temperaturer og ændrede vindforhold. Derudover indikerer analyserne en manglende ensretning af, hvordan klimavurderinger udføres, herunder hvilke metoder, tilgange, tidshorisonter og klimascenarier der bør anvendes, og at klimatilpasning primært indtænkes i det indledende projektdesign og ikke nødvendigvis i den efterfølgende miljøvurdering. Yderligere peger analyseresultaterne på et manglende fokus på overvågning samt usikkerheder og begrænsninger forbundet med klimavurderinger. Dette er tæt forbundet med identificerede udfordringer vedrørende manglende tværfaglighed i vurderingerne samt manglende fokus, viden og forståelse af forskellige klimatiske elementer og potentielle miljøsammenhænge mellem klima og andre miljøparametre.

Med afsæt i de identificerede udfordringer og forbedringspotentialer udarbejdes ni konkrete anbefalinger for den fremtidige praksis med at indtænke klimatilpasning i miljøkonsekvensvurderinger: (1) Vurder påvirkninger relateret til hede, tørke og ændringer i vindforhold og ikke kun vandrelaterede påvirkninger, (2) Betragt klimatilpasning som en miljøparameter på lige fod med de resterende miljøparametre (3) Inkluder klimapåvirkninger og klimatilpasning i alle miljøvurderingsfaser, beslutningstagen og opfølgende overvågning, og ikke kun i det indledende projekt design (4) Øg brugen af en tværfaglig tilgang, (5) Anvend SCALGO til at støtte vurderingen af vandrelaterede påvirkninger, (6) Den anvendte tidshorisont bør stemme overens med den forventede levetid, tilbagebetalingstid og det ønskede beskyttelsesniveau for projektet, (7) Anvend klimascenarier fra IPCC/DMI og argumenter for de valgte scenarier, (8) Vurder både positive og negative miljøsammenhænge relateret til klimatilpasning og (9) Vær opmærksom på og beskriv begrænsninger og usikkerheder forbundet med vurderinger af klimatilpasning.

Implementering af de opstillede anbefalinger i praksis kan være forbundet med øgede økonomiske omkostninger, da nogle af anbefalingerne overstiger de lovmæssige minimumskrav. Omvendt kan der være et potentiale i, at mere dækkende vurderinger kan resultere i færre uforudsete økonomiske omkostninger til at håndtere eventuelt uforudsete klimapåvirkninger på projektet. En anden udfordring ved implementering af anbefalingerne er at sikre, at miljøkonsekvensrapporterne ikke bliver for omfattende, men samtidig har et detaljeringsniveau, som sikrer tilstrækkelig transparens omkring vurderingerne. Implementering af anbefalingerne vil kræve institutionelle ændringer, hvilket kan anses som udfordrende. Omvendt opleves et øget samfundsmæssigt og fagligt fokus på klimapåvirkninger og vigtigheden af klimatilpasning, hvilket kan indikere, at der på nuværende tidspunkt er potentiale for at implementere ændringer, som kan bidrage til at forbedre praksis og håndtere de klimamæssige udfordringer, som samfundet står overfor.

Contents

1 Introduction

The climate is under increasing pressure and there is a need to both mitigate and adapt to future climate change. This is for example made evident by the Intergovernmental Panel on Climate Change (IPCC). The IPCC is an acknowledged international organization providing objective scientific analyses and reports on the state of climate change and related future risks [IPCC, 2024]. Some of the main conclusions derived from their newest report, the Sixth Assessment Report, are:

- The concentration of greenhouse gas emissions in the atmosphere have reached extremely high levels. For example, the concentration of CO_2 in 2019 was the highest seen in at least 2,000,000 years. These levels of greenhouse gas emissions are caused by human activities, leading to global warming [IPCC, 2023b]. In 2011-2020 the global average temperature was 1.1 degree C above the level in 1850-1900. Looking at the development over the last 2000 years, this is the fastest growing temperature rise in a 50-year period [IPCC, 2023b].
- A temperature rise of 1.5 degree C is expected to be reached in the mid-2030s, and it is considered challenging to keep the temperature rise under 2.0 degrees C up until 2100 [IPCC, 2023a]. This calls for deep, rapid and sustained greenhouse gas reductions to slow down the temperature rise [IPCC, 2023b].
- Human-caused climate change occurs in all regions across the world where impacts and damages affect nature as well as humans [IPCC, 2023b]. Future climate related risks are worse than previously thought, and some of the impacts are now unavoidable or irreversible [IPCC, 2023b].
- There is an urgent need for climate-resilient development with focus on both mitigation and adaptation. Currently more focus is on mitigation compared to adaptation, and a significant up-scaling of both approaches is necessary [IPCC, 2023b].

These conclusions indicate a need for urgent action at all levels of society. The IPCC points to a need for political commitment, well-functioning institutional frameworks and action at both local, national, and international levels [IPCC, 2023b]. In this connection, environmental Assessment (EA) is highlighted as an applicable tool to integrate climate into planning processes at both project and plan levels [Larsen og Kørnøv, 2022; Byer et al., 2018; Mayembe et al., 2023; Posas, 2011]. The conclusions from the IPCC further indicate that the consequences of climate change are complex and interrelated, affecting multiple environmental areas as well as human well-being. Also in this context, EA is considered relevant as EA builds upon a broad environmental concept seeking to prevent a tunnel vision on only one environmental factor and includes assessment of interrelations between environmental factors [Larsen og Kørnøv, 2022].

Research highlights, that the integration of both mitigation and adaptation is necessary for handling the climate related consequences [IPCC, 2023b; Larsen og Kørnøv, 2022; Ledda et al., 2021]. Further research also highlights that currently more focus is on mitigation rather than adaptation [IPCC, 2023b; Larsen og Kørnøv, 2022]. This conclusion is supported by previous research by the author of this study which indicates a lack of focus on climate adaptation in both research and practice within a Danish EA context [Mikkelsen, 2024]. Therefore, this study focuses on climate adaptation. Further, the scope of this study is limited to project-level in the Danish context. Climate adaptation will vary among different project types, and it is decided to focus the study on transportation infrastructure projects including railways, highways and larger road infrastructure projects requiring an EIA. Transportation infrastructure is of great importance for the Danish society and an increasing focus on protecting both existing and new infrastructure against future climate change can be identified [Miljøministeriet, 2024b]. Kørnøv og Lyhne [2022] have investigated the development in Danish EA in the period 1994 - 2021 and an increasing number of EIA of "larger linear infrastructure" and "Smaller mixed infrastructure" has been identified over the period. These project types include for example road and railway projects [Kørnøv og Lyhne, 2022], which underline the relevance of focusing on these project types. Also Hands og Hudson [2016] highlight that transportation infrastructure projects are "highly vulnerable" to climate change impacts and therefore should include adaptation measures.

Based on the above, this study investigates the current practice of integrating climate adaptation into EIA for Danish transportation infrastructure projects (railways, highways and larger road infrastructure projects), and identifies challenges in current practice as well as potentials for improving future practice and thereby contribute to handling the major climate related challenges the planet and humanity are facing in the coming years. As a precondition for developing climate adaptation measures, an assessment of climate change impacts on the project is necessary, and further it is deemed relevant to include an assessment of environmental interrelations to obtain a holistic assessment of the consequences of climate change. Therefore climate adaptation is in this study investigated with a particular focus on the assessment of climate change impacts on the project and environmental interrelations.

This report summarizes the findings of the study. The report consists of nine chapters. After this introductory chapter, chapter 2 presents the foundation of the study by elaborating on climate adaptation and EIA and presenting research on the current status of integrating climate adaptation into EIA. Chapter 3 presents the research question and chapter 4 elaborates on the research design of the study. In chapter 5 requirements and recommendation for integrating climate adaptation into EIA is identified and an analytical framework for the following analysis is developed. Chapter 6 presents the results of the analysis of the current practice of integrating climate adaptation into EIA reports and elaborates on the analysis of seven selected transportation infrastructure projects. In chapter 7 practitioners view upon current practice of integrating climate adaptation into EIA is investigated including challenges and future improvement potentials. Based on the findings in this study, chapter 8 finally presents recommendations for future EIA practice. Chapter 9 concludes on the study.

Climate adaptation and EIA 2

To create a foundation for the study, this chapter elaborates on climate adaptation and investigates environmental impact assessment (EIA) as a tool for including considerations of climate adaptation into planning. Lastly, this chapter presents research on the current status of integrating climate adaptation into EIA with the purpose of creating an understanding of current patterns and challenges and identifying potentials for further research.

2.1 Climate adaptation

The consequences of climate change impacts affect both nature and humans [Kørnøv et al., 2023; IPCC, 2023b]. Global examples of climate change impacts are extreme weather events, rising temperatures, sea level rise, flooding, drought, changes and irreversible losses in ecosystems and of species, reduction of food security and destruction of homes, infrastructure and human health [IPCC, 2023b; European Commission, 2013; Kørnøv et al., 2023; IPCC, 2023b]. In Denmark the climate changes are excepted to result in increasing average temperature with more heat waves [DMI, 2023]. In the winter more rain is expected while in the summer the amount of rain will be approximately the same as now, but the amount of the summer rain occurring as extreme rain will increase [DMI, 2023]. The sea level around Denmark will be rising and storm flooding will occur more often and more extreme [DMI, 2023].

To handle the consequences of climate change, climate change adaptation is becoming increasingly relevant for the society. Climate adaptation can be described as: *"...a process, or set of initiatives and measures, to reduce the vulnerability of natural and human systems against actual or expected climate change effects. Adaptation can also be thought of as learning how to live with the consequences of climate change."* [European Commission, 2013, p. 18], or in other words: *"How is the activity expected to be affected by climate change, and how can the activity adapt to this?"* [Larsen og Kørnøv, 2022, p. 44]. Thereby, climate adaptation is about assessing how climate change can affect the given project, and how the project can adapt to these changes by reducing the vulnerability or accepting the consequences. Looking at the definition of climate adaptation sat in relation to EA by Kørnøv et al. [2023], climate adaptation has a clear linkage to the other environmental factors: *"The adaptation aspect is concerned with the effects of climate change on all other environmental factors, and how these need to be considered. The role of environmental assessment is to anticipate potential future developments and adapt to the effects of climate change."* [Kørnøv et al., 2023, p. 20]. Thereby, the adaptation measures should include

considerations on the interrelationship among different environmental factors.

In some cases climate adaptation can have either positive or negative synergies with other climate- or environmental parameters. Larsen og Kørnøv [2022] defines and exemplifies climate- and environmental synergies as follows:

- **Negative climate synergies:** *"Loss of climate mitigation related benefits in return for climate adaptation and vice versa (E.g. urban densification which leads to increased risk of flooding during extreme rain)."*
- **Positive climate synergies:** *"Climate mitigation and/or climate adaptation interact and promote positive effects on climate change (e.g. planting trees and other vegetation that absorb CO2 and at the same time contribute to reduction of the temperature)".*
- **Negative environmental synergies:** *"Loss of other environmental parameters in return for climate mitigation and/or climate adaptation (e.g. urban densification to reduce greenhouse gas emissions which happens at the cost of nature and recreational spaces)".*
- **Positive environmental synergies:** *"Climate mitigation and/or climate adaptation interact with the surroundings and promote other environmental parameters (e.g. robust and sound ecosystems that prevent consequences of climate change)".*

[Larsen og Kørnøv, 2022, p. 45].

Thereby, climate synergies is about the connection between mitigation and adaptation, while environmental synergies is about the connection between climate factors (in this study with focus on adaptation) and other environmental parameters.

Thereby climate change results in different impacts, which require adaptation measures, and when choosing and designing adaptation measures it is important to be aware of both positive and negative interrelations.

2.2 Potentials of EIA to integrate climate adaptation into planning

In this section the legal framework for EIA and the potentials of EIA to integrate climate change considerations into project planning are elaborated.

EIA is within EU regulated by *The European Environmental Impact Assessment Directive, 2011/92/EU* amended by *Directive 2014/52/EU* [European Union, 2014] (The European EIA Directive), which is implemented in Danish legislation through *The Declaration of Law on Environmental Assessment of Plans and Programs and of Specific Projects, 03/01/2023* (The Danish Environmental Assessment Act) [Miljøministeriet, 2023b]. The EIA regulation sets up requirements for assessment of different environmental parameters, including climatic factors [Miljøministeriet, 2023b]. In the 2011 version of The European EIA Directive, "climatic factors" were not elaborated [European Union, 2011]. First with the amending in 2014 the formulation *"...the impact of projects on climate (for example greenhouse gas emissions) and their vulnerability to climate change"* was included as part of the assessment requirements in the Directive [The European EIA Directive, (13)].

The member states had three years to implement the 2014 version of the directive into national law [European Commission, 2024b], and thereby it first became a direct legal requirement from EU to include assessment of the projects vulnerability as part of the climate assessment from 15 May 2017. This of course does not rule out the possibility of the member states to include this aspect in climate assessments prior to 2017. The legal requirements for assessment of climate adaptation will be further elaborated in chapter 5.

The purpose of the EIA regulation is to protect the environment and promote a sustainable development by conducting EIAs of projects that can have a significant impact on the environment prior to the potential permission of the project [The Danish Environmental Assessment Act, § 1]. Furthermore, a main purpose of the law is to ensure public participation early in the process [The Danish Environmental Assessment Act, § 1 (2)].

The European EIA Directive states the importance of integrating climate into the assessments: *"Climate change will continue to cause damage to the environment and compromise economic development. In this regard, it is appropriate to assess the impact of projects on climate (for example greenhouse gas emissions) and* ***their vulnerability to climate change.****"* [The European EIA Directive, (13)]. The relevance of EIA as a tool to integrate climate adaptation into project planning is further highlighted by multiple sources. Tyszer og Gałaś [2020] for example state that EIA is *"...one of the most important tools that can be used by countries to protect the environment"* and that the consequences of climate change should be a part of this assessment and protection [Tyszer og Gałaś, 2020, p. 2]. This is for example supported by Ledda et al. [2021] and Loza og Fidélis [2021] highlighting both EIA and SEA as tools to integrate climate adaptation into different levels of the planning process. Multiple sources indicate a positive view of EIA as an appropriate tool to address climate adaptation and argue that EIA has a potential to integrate climate adaptation into different planning phases, but also highlight an ongoing discussion about whether climate change impacts should be addressed at a higher planning level due to their large-scale nature [Jiricka-Pürrer et al., 2016, 2019; Loza og Fidélis, 2021]. In this connection Larsen [2014] highlights that the effectiveness of EIA as a tool to address climate change considerations, including both mitigation and adaptation, will require that EIA is used actively to improve projects, including climatic factors, rather than just as a tool to gain permission for the project [Larsen, 2014].

Looking at transportation infrastructure projects, Jiricka-Pürrer et al. [2018], which study Austria and German infrastructure projects, and Hands og Hudson [2016] highlight the importance of considering climate change and adaptation in transportation infrastructure projects, as the life-time of these projects typically is long, making adaptation measures for future climate change impacts even more relevant.

Thereby EIA is considered a relevant tool to integrate climate adaptation into project planning of transportation infrastructure projects.

2.3 The EIA process

To understand how climate adaptation can be integrated in EIA, this section elaborated on the EIA process consisting of the following overall steps:

- **Application:** Before a developer establishes, extents or changes a project that can have significant impacts on the environment, the developer must send in an application to the relevant authority [The Danish Environmental Assessment Act, §§ 18 and 19]. The application should contain information on the project, expected significant impacts, results from assessments based on other relevant legislation, and can also contain a description of planned measures to prevent significant negative effects [The Danish Environmental Assessment Act, § 19]. In relation to climate adaptation this could for example include a description of the expected significant climate change impacts on the project and early planned adaptation measures to improve the resilience of the project.
- **Screening (Annex 2 projects):** Projects listed at Annex 1 in The Danish Environmental Assessment Act will automatically require EIA, while projects listed at Annex 2 will be subject to a screening by the authority to determine if an EIA is necessary [The Danish Environmental Assessment Act, § 16].
- **Scoping:** For projects requiring an EIA, the authority develops a scoping note determining the level of detail and information the developer has to include in the EIA report [The Danish Environmental Assessment Act, §23].
- **EIA report:** The developer has to provide an EIA report containing a description of the project, expected significant impacts on the environment (as elaborated in Annex IV and Annex 7), measures to avoid, prevent or reduce and, where possible, neutralize expected significant negative impacts on the environment, investigated alternatives, and a non-technical summary [The Danish Environmental Assessment Act, § 20 (2)]. In the context of climate adaptation, the EIA should thereby contain an assessment on the project's vulnerability to climate change ("the expected significant impact") and a description of adaptation measures if the assessment indicates significant impacts ("measures to avoid, prevent or reduce and where possible, neutralize expected significant negative impacts").
- **Decision:** After public hearing of the EIA report, the authority makes decision on either approval or disapproval of the project [The Danish Environmental Assessment Act, § 25].

2.3.1 EIA as a framework for expert assessments

As illustrated by the overview of the EIA process, the EIA regulation sets out requirements for the procedure and outcome of the assessment [Arabadjieva, 2016; Posas, 2011]. The regulation for example sets up requirements regarding different steps of the assessment and involvement of the public, but specific methods to assess the impacts or potential threshold values etc., are not mentioned in the EIA regulation. For example, specific methods for assessment of the project's vulnerability to climate changes are not elaborated. Thereby, the European EIA Directive and the Danish Environmental Assessment Act can be characterized as procedural regulations.

When making project and environmental planning, other legislation besides the EIA regulation is relevant [European Commission, 2017; Miljøministeriet, 2023a]. Both in the *EU guidance document on Environmental Impact Assessment of Projects (Scoping)* and in the Danish guiding document for the Danish law, it is highlighted that it should always be investigated whether the project is regulated by other EU legislation and

corresponding national legislation [European Commission, 2017; Miljøministeriet, 2023a]. This is also visible in the Danish Environmental Assessment Act where it is stated in relation to both the developers application, the screening decision and the EIA report that results of assessments based on other EU regulation shall be included [The Danish Environmental Assessment Act, § 19 (2), § 20 (6)(3), § 21]. This makes the connection to other environmental legislation central.

Figure 2.1 presents an overview of examples of relevant regulation in relation to planning for climate adaptation and transportation infrastructure projects that can potentially influence the EIA process.

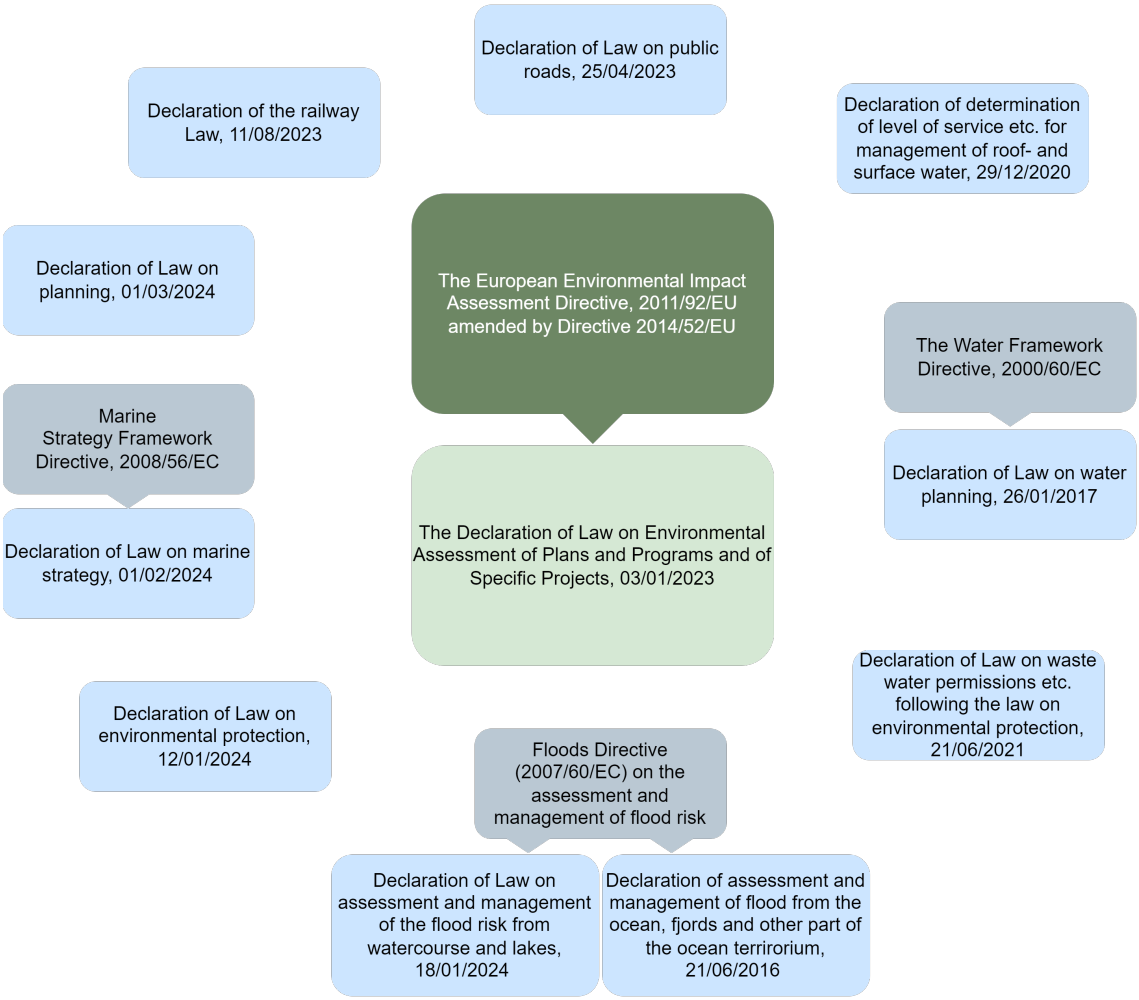

Figure 2.1. Examples of regulation of relevance for climate adaptation and transportation infrastructure projects. Dark green/blue = EU legislation, light green/blue = Danish regulation. Inspired by European Commission [2024a]; Kørnøv et al. [2023]; Miljøministeriet [2024c] and insight from respondents.

As figure 2.1 illustrates, specific regulation regarding different sectors can possibly affect the EIA. For example, the Danish law of flooding, *Declaration of Law on assessment of the flood risk from watercourse and lakes, 18/01/2024*, sets up requirements for mapping of risk areas and risk management plans [Miljøministeriet, 2024a]. If a project area is located in areas or affected by risk management plans it must be of importance for the

project and the EIA. Likewise the Danish Law on water planning, *Declaration of Law on water planning, 16/01/2017*, sets up requirements regarding for example basis analysis and programs of measures for specific water district areas, to fulfill environmental goals for the specific area [Miljøministeriet, 2017], which also can affect the project planning and EIA for a given project.

Besides formal regulation also different guidance documents for specific sectors exist. Regarding climate adaptation and transportation infrastructure projects, this includes for example the scripts by the Danish wastewater committee such as *SCRIPT 27 Functional practice for drainage systems during rainfall*, *SCRIPT 28 Regional variation of extreme rain in Denmark - new analysis (1979-2005)*, *SCRIPT 29 Expected changes in extreme rain due to climate change*, *SCRIP 30 Updated climate factors and dimension affected rain intensities* and *SCRIPT 31 Methods for determination of service level for rainwater at ground level* [Miljøministeriet, 2024b; IDA Spildevandskomiteen, 2024]. Furthermore, also guidance on for example dimension and construction of roads exist including for example *Foundation for the design of traffic areas - construction and planning* [Vejregelgruppen, 2019] and *Dimension of surfacing and strengthening surfacing - construction and planning* [Vejregelgruppen, 2017].

Thereby, the EIA regulation can be described as the procedural framework around the specific expert assessments, which are supported by other relevant legislation and guidance including more specific regulation. This makes the EIA system complex and assessing the transportation infrastructure project's vulnerability to climate change, will require expert knowledge on relevant regulation and guidance. Further to ensure a holistic assessment and handling of interrelations, as elaborated in section 2.1, also the ability to look across the different environmental parameters is necessary.

2.3.2 EIA and the surrounding planning process

EIA is just one step in project planning and execution. Inspired by Goll [2021], who has developed a simplified overview of the phases in construction projects where consultancy is relevant, a construction project includes the following overall phases:

- **Preliminary ideas:** Initial ideas are presented and the requirements, framework and objectives of the project are identified.
- **Project proposal:** Different proposals are investigated further ending up in one final proposal.
- **Authority approval and final project engineering:** The final project proposal requires different approvals by the authorities prior to establishing the project. When the relevant approvals are obtained, the final project design is established and the project is potentially put out to tender.
- **Execution and delivery:** The project is constructed and when delivered to the developer, necessary permits for occupation are obtained.

This overview is related to construction and is developed from a consultancy point of view. Though, the overview can be used to illustrate that a project includes multiple phases of planning. An EIA is part of the authority approval and thereby just one step in a larger planning framework for a project. Looking at climate adaptation, it can be expected that

considerations for example can be included as part of the initial ideas and project designs, where the project can potentially be adjusted to requirements and objectives related to climate adaptation. Further, climate adaptation can be part of the authority approval phase through the EIA, included in the final project design, and of course also needs to be implemented when executing and constructing the project. Therefore, to get a sufficient overview of the considerations on climate adaptation included in a project it is necessary to also look beyond the EIA process.

2.4 Research on practice of integrating climate adaptation in EIA

In this section, research on the current practice of integrating climate adaptation into EIA is presented. First, some of the newest Danish research on the area by Larsen og Kørnøv [2022] is presented, which is supplemented with the main findings of a literature study on international research on the area.

2.4.1 Research on Danish practice

The Danish status of assessment of climate adaptation in EIA is covered through the findings by Larsen og Kørnøv [2022]. This source summarizes 20 years of Danish research on EA and was published in 2022 and is thereby some of the newest Danish research on the area.

Larsen og Kørnøv [2022] conclude that research on the area highlights a holistic approach as necessary for EA to contribute to the handling of climate challenges. However, current practice primarily focuses on climate mitigation while climate adaptation, baseline adaptation, and positive and negative climate- and environmental interrelations are less addressed. Thereby, a holistic approach to climate is not present in current EA practice, and [Larsen og Kørnøv, 2022] highlight that this can be connected to the current organizational structures of for example authorities, where sectors are divided into different silos challenging a holistic approach. Further it is identified as challenging that climate, especially climate adaptation, involves significant uncertainty [Larsen og Kørnøv, 2022].

A lack of knowledge regarding methods and approaches to assess climate is identified, and Larsen og Kørnøv [2022] also point out that the focus on climate in EA in the research arenas has been descaling since 2015. Therefore, there is a need to increase focus on climate in EA in current research.

2.4.2 Research on international practice

To cover current international research on practice for integrating climate adaptation into EIA, a literature study has been conducted with the purpose of identifying the newest research regarding current practice and challenges as well as recommendations for future practice. The findings related to current practice and challenges are presented in this section and will help gain understanding of knowledge gabs and potentials for further research. The findings related to recommendations for future practice will be presented in chapter 5. The methodological approach to the literature study, including delimitation

and description of search string as well as the selected databases, is described in section 4.3.1. The literature study revealed a total of 10 sources. Six of the sources are focused on climate adaptation alone, while the remaining four sources concern both adaptation and mitigation. Eight of the sources have a limited focus on EIA, one focuses on SEA and one focuses on both EIA and SEA. The main conclusions derived from the identified literature on current practice and challenges are presented in the following.

An increased recognition of the importance of integrating climate change considerations (mitigation and adaptation) into both EIA and SEA can be identified [Tyszer og Gałaś, 2020; Mayembe et al., 2023]. In this context Tyszer og Gałaś [2020] for example highlight increased political focus and implementation of more strict requirements regarding adaptation measures in both EIA and SEA [Tyszer og Gałaś, 2020]. Though, multiple of the sources point out that climate change considerations are not implemented sufficiently in current EA practice. This is the case both in sources related solely to climate adaptation [Jiricka-Pürrer et al., 2019; Ledda et al., 2021; Jiricka-Pürrer et al., 2018] and sources related to both adaptation and mitigation [Hands og Hudson, 2016; Mayembe et al., 2023; Álvaro Enríquez-de Salamanca et al., 2016]. The lack of sufficient integration of climate change considerations is for example illustrated by a tendency to only consider adaptation and mitigation at an overall or implicit level [Jiricka-Pürrer et al., 2018; Álvaro Enríquez-de Salamanca et al., 2016]. Further it is emphasized that when adaptation and mitigation are included, it is often only in one or a few phases and not systematically throughout the whole EA process [Jiricka-Pürrer et al., 2018; Álvaro Enríquez-de Salamanca et al., 2016]. In this context it is pointed out that it is questionable how much considerations on adaptation and mitigation affect the final decision-making [Álvaro Enríquez-de Salamanca et al., 2016; Larsen, 2014; Jiricka-Pürrer et al., 2019], and that there is a lack of commitment to implement mitigation and adaptation actions [Hands og Hudson, 2016]. To gain a holistic assessment of climate, Mayembe et al. [2023] highlight that it is necessary to include both adaptation and mitigation, but a general conclusion among multiple of the sources is that mitigation is more sufficiently addressed than adaptation in EIA [Jiricka-Pürrer et al., 2016; Mayembe et al., 2023; Larsen, 2014; Jiricka-Pürrer et al., 2018; Álvaro Enríquez-de Salamanca et al., 2016] as well as in SEA [Ledda et al., 2021]. Though, Loza og Fidélis [2021] and Ledda et al. [2021] highlighted that adaptation is gaining increased focus in both EIA and SEA.

Overall, climate considerations both related to adaptation and mitigation are connected with large complexity making it challenging to integrate in EA [Jiricka-Pürrer et al., 2016; Tyszer og Gałaś, 2020; Mayembe et al., 2023; Jiricka-Pürrer et al., 2019]. In this regard multiple sources highlight that climate change predictions are connected to a large degree of uncertainty both regarding knowledge, data, and methods [Hands og Hudson, 2016; Jiricka-Pürrer et al., 2016, 2019; Loza og Fidélis, 2021]. Moreover, Jiricka-Pürrer et al. [2016] conclude that integrating adaptation measures in EIA can be challenging as short-term impacts from other environmental factors are weighted above long-term impacts from climate changes. Also the need to think across different sectors and planning levels when addressing climate adaptation makes it a complex task [Jiricka-Pürrer et al., 2016, 2019]. Further cost and time both in relation to adaptation and mitigation are highlighted as challenges [Mayembe et al., 2023], and overall this complexity makes it difficult to balance the environmental protection, economic factors, political priorities and public concerns

related to climate change impacts both at EIA [Mayembe et al., 2023] and SEA level [Tyszer og Gałaś, 2020]. The complexity and uncertainties connected to climate adaptation result in a lack of focus on future climate change impacts on the project in the assessments [Ledda et al., 2021; Jiricka-Pürrer et al., 2018, 2019]. In this context, Jiricka-Pürrer et al. [2018] investigate climate adaptation in German and Austria EIA practice for infrastructure projects, where also a lack of focus on future changes in climate and unforeseen events are identified.

Also challenges of lack of understanding, awareness and priority of climate adaptation in EIA are highlighted by more of the sources [Loza og Fidélis, 2021; Jiricka-Pürrer et al., 2016, 2019], which is also a challenge in relation to mitigation [Mayembe et al., 2023]. In this context it is for example emphasized that there is a lack of a common understanding of climate change impacts as well as mitigation and adaptation, and that the practitioners are not capable of sufficiently addressing uncertainties and embrace the importance of climatic factors as part of the EIA [Mayembe et al., 2023; Loza og Fidélis, 2021; Jiricka-Pürrer et al., 2019]. Also limited resources and fear of unpopular decisions are mentioned [Jiricka-Pürrer et al., 2016]. In this context, the literature review also revealed that climate change considerations, both regarding adaptation and mitigation, vary among different actors [Jiricka-Pürrer et al., 2016; Mayembe et al., 2023] and gain different focus depending on the project type [Jiricka-Pürrer et al., 2018; Álvaro Enríquez-de Salamanca et al., 2016]. This can for example be explained by different requirements and practices [Mayembe et al., 2023] and different knowledge, resources, and values among actors [Jiricka-Pürrer et al., 2019].

The legal requirements are touched upon by multiple sources and highlighted as a central framework for implementing climate change considerations into EA. Though three of the sources identify a lack of legal requirements for integrating adaptation and mitigation into EIA [Hands og Hudson, 2016; Jiricka-Pürrer et al., 2019, 2016]. However, it should be noted, that these sources are either published before the specification of the EU regulation on climate assessment, as elaborated in section 2.1, or built upon research conducted before the changes. Mayembe et al. [2023] examine different regulatory frameworks and conclude, that the European legal framework is sufficient for considering adaptation and mitigation in EIA. Though, it is also highlighted, that even though the framing conditions as legal requirements and guidelines are sufficient, it does not necessary result in sufficient implementation in practice [Mayembe et al., 2023; Jiricka-Pürrer et al., 2019; Álvaro Enríquez-de Salamanca et al., 2016]. More of the sources also highlight that there is a lack of guidelines to integrate both mitigation and adaptation considerations in EIA [Mayembe et al., 2023; Jiricka-Pürrer et al., 2019], and in this connection lack of tools and methodological approaches are also emphasized [Jiricka-Pürrer et al., 2016]. The current practice of assessing environmental interrelations related to climate adaptation are only touched upon to a very low degree in the examined sources. Jiricka-Pürrer et al. [2018] address adaptation in EIA and investigates stressors for climate change impacts on infrastructure projects and conclude, that multiple stressors can be identified in the investigated projects, but that there is a lack of systematically explicit handling throughout the whole EIA process. [Hands og Hudson, 2016] and Larsen [2014] highlight, that climate, both in relation to adaptation and mitigation, to a large degree interact with other environmental factors that potentially conflict with each other [Larsen, 2014]. In this

connection Hands og Hudson [2016] identify a tendency to look at climate as an isolated environmental factor instead of addressing the interrelations to other environmental factors, leading to a lack of a holistic assessment in the EIA.

Overall the investigated research indicate that climate change considerations are not included sufficiently in current EA practice, and both Danish and international research highlight, that mitigation is addressed to a higher degree than adaptation. Thereby, a need for increasing the focus and knowledge on especially climate adaptation is identified. Environmental interrelations are only touched upon to a low degree in the international research indicating a knowledge gap within the research field on interrelations. Overall, the examination of Danish and international and research reveals a potential to look further into climate adaptation including the assessment of climate change impacts on the project as well as assessment of environmental interrelations.

2.5 Sub-conclusion

Climate change result in global and national impacts on nature as well as humans and infrastructure. Therefore, adaptation is necessary to handle these impacts and make more resilient projects. Climate adaptation is closely connected to other environmental factors and when making EIA both climate change impacts, adaptation measures as well as environmental interrelations should therefore be assessed. In this regard, EIA is highlighted as an appropriate tool to integrate climate change considerations into project planning and has a potential to integrate assessment of environmental interrelations into planning.

Danish and international research on the current status of integrating climate into EA indicate, that climate change considerations are not sufficiently implemented in current EA practice. For example it is both in international and Danish research pointed out, that when climate is included it is often at an overall level and not systematical throughout all of the EA process resulting in a risk of lack of actual impact on the final decisions and a lack of a holistic approach to the assessment. Further, both the international and Danish research highlight a main focus on climate change mitigation, while adaptation is less addressed, and it is highlighted that there is a lack of focus on climate adaptation in EA in newer research. Further, a lack of focus on environmental interrelations can be identified. Other general identified challenges are for example uncertainties, and lack of data and knowledge regarding climate change impacts. Further international research indicate a lack of understanding, awareness and priority of climate, while Danish research points to organisational challenges, where the sector-divided structure makes it difficult to address climate in a transdiciplinary way.

The findings presented in this chapter indicate a potential for looking closer into the current practice of integrating climate adaptation into EIA practice for transportation infrastructure projects. The findings support the relevance of focusing on assessment of climate change impacts on the project as well as assessment of environmental interrelations, as these elements are underexposed in current research on the area. This leads to development of the research question presented in the next chapter.

Research question 3

The purpose of this study is to investigate how climate adaptation is implemented in current Danish EIA practice for transportation infrastructure projects and identify barriers and potential improvements for future practice. Based on the initial findings, this study seeks to answer the following research question:

What are the potentials and barriers for increasing the focus on climate adaptation in the EIA process for transportation infrastructure projects?

To support the investigation of the research question three sub-questions are developed:

1. **Which legal requirements and recommendations for including climate adaptation in EIA can be identified?**
2. **How does climate adaptation appear in Danish EIA reports for transportation infrastructure projects?**
3. **Which practice oriented barriers for including climate adaptation in current EIA practice can be identified, and what are the possible improvement potentials?**

As presented in chapter 2, an assessment of climate change impacts on the project is a precondition for development of adaptation measures. Further, as also presented in chapter 2, it can be argued that environmental interrelations should be part of the assessment, and it is identified that environmental interrelations are not well investigated in current research.

Thereby, this study investigates inclusion of climate adaptation, including assessment of climate change impacts on the project and assessment of environmental interrelations, in the EIA process for Danish transportation infrastructure projects.

The sub-questions and the research design of this study is further elaborated in chapter 4.

Research design 4

This chapter presents the research design of the study. A research design is a plan for how the research is conducted made before conducting the actual research [Farthing, 2016]. The purpose of the research design is to describe the considerations behind the chosen methods and theory and thereby increase the transparency of the study [Farthing, 2016].

As the scientific theoretical approach behind the study affects how the research is designed [Farthing, 2016; Rienecker og Jørgensen, 2017], this chapter first elaborates on the scientific theoretical approach of the study. This is followed by an overview of the research design including descriptions of methods and theory used throughout the study.

4.1 Scientific theoretical approach

Conducting research will be influenced by the researcher's view of the world and what the world consists of (ontology) and the view of knowledge and how to acquire knowledge (epistemology), as these understandings will affect how the researcher investigates the problem area (methodology) [Farthing, 2016]. Therefore, the purpose of this section is to elaborate on the underlying ontology and epistemology that have influenced the design and conclusions of this study.

This study builds upon post-positivism which posits that personal assumptions will affect how we observe the world and that the researcher's values and views will to some degree affect the research [Farthing, 2016]. Thereby, research according to post-positivism cannot be totally objective, but will always to some degree be influenced by subjectivity. The values of the researcher can for example influence the chosen problem area, the aim and design of the study, the collection and analysis of data, and in the use of the findings [Farthing, 2016]. In this study, the author's values and position in the field have for example influenced the chosen problem area and the delimitation thereof and the development of the research question. Further, the selected methods to investigate the problem area are affected by the author's way of seeing the world and how to obtain knowledge.

In post-positivism, knowledge is thereby to some degree socially constructed [Farthing, 2016], and the epistemological position in this study is therefore based on subjectivism. With a subjectivistic epistemological position, knowledge produced in research should be seen in the light of the subjective understandings and interpretations of the researcher [Rienecker og Jørgensen, 2017]. With a subjectivistic epistemological position, knowledge can be acquired by using qualitative methods that make it possible to obtain insight into the subjective perspectives and elements that are not always visible [Rienecker og Jørgensen, 2017]. Therefore, interviews and discourse analysis are often used to acquire

knowledge about the world [Rienecker og Jørgensen, 2017]. To answer the research question of this study, interviews are considered as a relevant method to obtain knowledge about the practitioner's views upon EIA practice. The practitioners will have subjective understandings of practice, and likewise the results of this study will be affected by the author's values and understandings when analysing the interview material which will affect the final conclusions of the study.

The ontological position of this study is based on idealism. According to the idealistic ontological position, the world and reality are constructed by social structures and is therefore under constant development [Rienecker og Jørgensen, 2017]. In this study, the idealistic ontological position is visible as the EIA process and assessment of climate adaptation is seen as elements in constant development affected by the actors and their interaction. For example, the understanding of central terms will be affected by the structures and interactions among actors. Therefore, also the results of this study are affected by the cultural structures of current practice of EIA and assessment of climate adaptation.

Thereby, the scientific theoretical approach including epistemological and ontological positions has affected the research design of the study and the conclusions, which should be kept in mind when reading the findings of this study.

4.2 Overview of research design

An overview of the research design of this study is presented in figure 4.1.

In the first sub-question the legal requirements for integrating climate adaptation into EIA are examined. To identify recommendations on future practice, text analysis of relevant Danish and international guidelines and IAIA's best practice principles is conducted and findings from a literature review on international research on current practice are presented. The purpose of the first sub-question is thereby to gain an overview of elements that legally and ideally should be considered in EIA assessments. The findings in sub-question one are included in development of an analytical framework used in the analysis of EIA reports in sub-question two. Through a dialogue meeting with an expert on climate adaptation the analytical framework is adjusted and improved.

Sub-question two investigates how climate adaptation appears in Danish EIA reports on transportation infrastructure projects. First, an overall analysis of how often climate adaptation is included in EIA reports related to transportation projects is carried out. This is done by using the EA-Hub, which contains a large number of Danish EIA reports. To help identify relevant search terms and strategies in the EA-Hub, a workshop with employees at Danmarks Miljøportal, who have been part of the development of the EA-Hub, was held. To supplement this overall overview of how often climate adaptation is included, text analysis of seven reports considering climate adaptation is carried out. When making the text analysis of the EIA reports, the analytical framework developed as part of sub-question one is used with the purpose of investigating whether the recommendations appear in the reports.

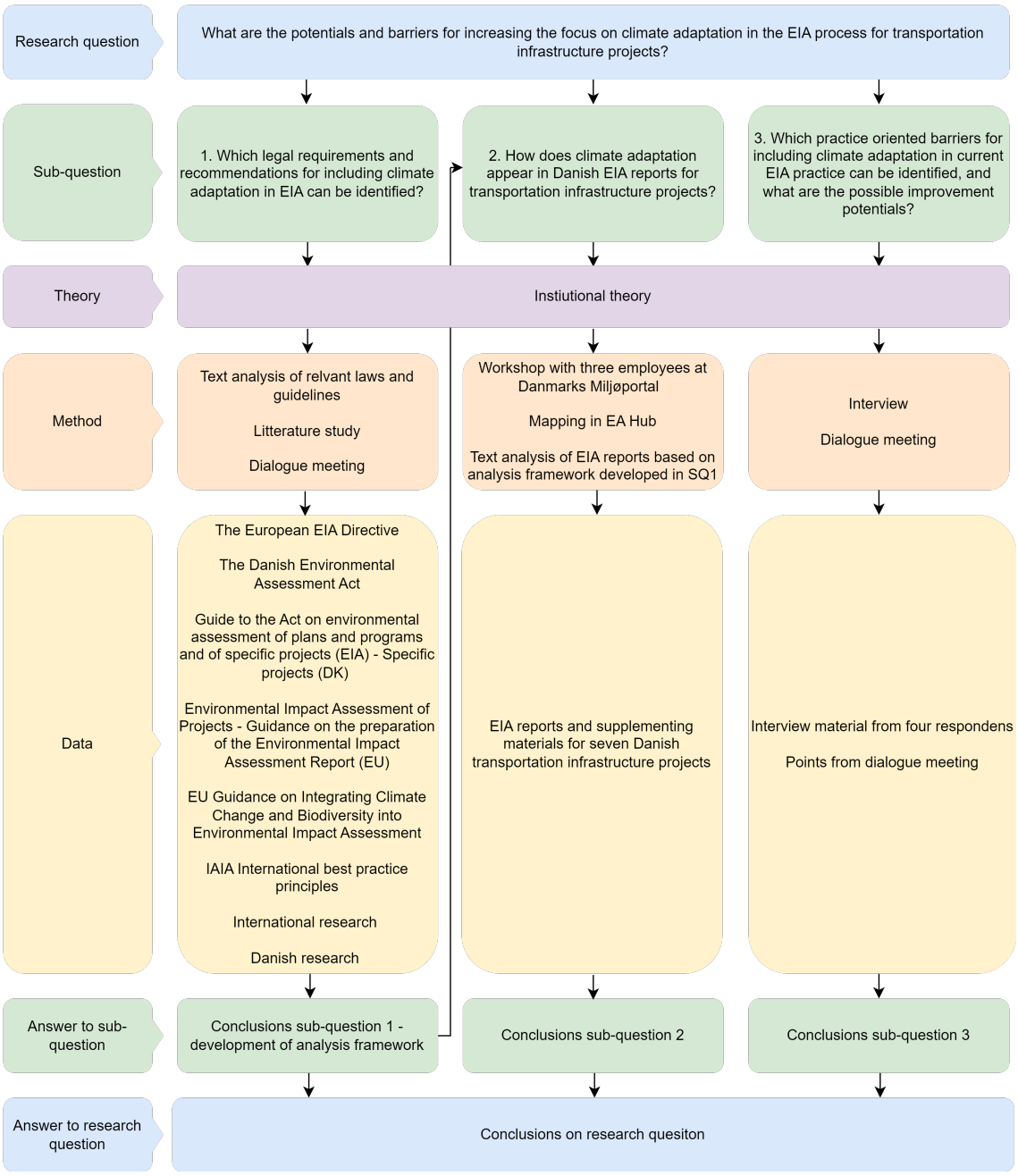

Figure 4.1. Research design.

Lastly, sub-question three investigates challenges in current practice and improvement potentials for the future practice. This is done by conducting interviews with relevant actors within the field to gain insight into the practitioners view of practice and connected challenges and possible improvement potentials. Further points from the dialogue meeting are included.

Institutional theory is included in the study at an overall level to understand the institutional settings of current practice. This is investigated in sub-question one through identification of regulative requirements and normative recommendations and the current appearance of these in EIA reports are examined in the second sub-question. In the third sub-question, the theory is used more actively to develop interview guides and analyse

the interview material to obtain understand regulative, normative and cultural-cognitive elements affecting the EIA process.

The conclusions from sub-question one, two and three are together used to answer the research question and based on the findings specific recommendations for the future practice of integrating climate adaptation into the EIA process for Danish transportation infrastructure projects will be presented.

The next sections elaborate on the methods and theory used throughout the study.

4.3 Methods

In this section the methods used throughout the study are presented.

4.3.1 Literature study

To gain insight into international research on current practice of integrating climate adaptation into EIA, including challenges in current practice and recommendations for the future practice, a literature study is conducted. The findings related to the current practice and challenges are presented in the problem analysis, section 2.4, while the findings related to recommendations for future practice are presented in the first part of the analysis, section 5.3.

A literature study is a method to cover existing knowledge within a specific field and identify knowledge gaps and areas that call for further research [Snyder, 2019]. By conducting a literature study, it is possible to build upon already existing knowledge [Snyder, 2019]. The literature study is conducted using the approach presented by Snyder [2019], which includes four phases, namely: design of the literature study, conducting the study, analysing the results and writing the review.

Design

In the first phase, the literature study is designed. Here the purpose of the literature study is established and a search strategy is developed [Snyder, 2019]. The purpose of the literature study is to identify relevant international research regarding current practice of integrating climate adaptation into EA. Further, the purpose is to identify challenges in current practice according to research as well as recommendations for the future practice.

Taking starting point in this purpose, a search strategy is developed. The following limitations and considerations are all elements of the selected search strategy:

- The literature study includes sources related to both EIA and SEA, as it is assessed that practice at SEA level can inspire the EIA practice
- The literature study has a limited focus on research related to either climate adaptation alone or research on climate adaptation and mitigation in combination. Thereby, sources focusing only on climate change mitigation are outside the scope of the literature study.

- The literature study is conducted for all projects types, and thereby not limited to transportation infrastructure projects, as it is assessed that transportation infrastructure projects can gain inspiration from other project types.
- The literature study is limited to a European context, as the legal framework is the same for all EU countries and it is assessed that climate change impacts on projects are more similar in a European context than in a larger global scope.
- Only sources from 2014 and newer are included, as the purpose is to cover the newest research on the current practice.
- Only peer-reviewed academic sources are included.
- Only English sources are included.

To obtain relevant results it was experienced that the sources have to include both climate adaptation and EA. For example it was found, that searching only on *adaptation*, without connection to climate, resulted in a large number of sources addressing some kind of adaptation that it not related to climate. Therefore, it was experienced, that climate also needs to be included in the search terms to yield the most relevant results. An overview of identified potential relevant search terms related to these two aspects is presented in figure 4.2 and have been tested in different databases.

Relevant terms	Search term
Climate change	climate*
Climate change adaptation	adaptation*
Climate adaptation	
Climate change adaption	adaption*
Climate adaption	
Vulnerability	vulnerabili*
Vulnerabilities	
Resilience	resilience*
Environmental impact assessment	“Environmental impact assessment*”
EIA	EIA
Strategic environmental assessment	“Strategic environmental assessment*”
SEA	SEA
Impact assessment	“Impact assessment*”
IA	IA
Environmental assessment	“Environmental assessment*”
EA	EA

Figure 4.2. Overview of relevant terms and related search terms.

By using "*" different endings of the words are included, and thereby, for example *vulnerabili** will cover results on both vulnerability and vulnerabilities. Using " ", indicates a locked phase. The red search terms are terms, that are not included in the final search term, as these terms resulted in results deemed irrelevant in the initial searches. It was experienced, that *resilience* and *impact assessment* are terms, that can be related to a variety of other subjects than climate such as landscape resilience, nature resilience, health impact assessment or different impact assessment at a more overall or societal level.

In the initial searches it was experienced, that sources addressing climate adaptation not necessarily include the term adaptation in the title, and therefore it was decided, that the title should only include the term "climate". However, this reveals a lot of sources only

related to mitigation. To only include sources that concerns adaptation, it was decided to limit the search to sources that mention either adaptation or vulnerability some arbitrary place in the source. Sources with climate in the title addressing either only adaptation or both adaptation and mitigation will this way occur in the results, while sources only addressing mitigation are sorted out. A challenge when searching on the terms presented in figure 4.2 was that a very large number of irrelevant results related to "sea" occurred due to the abbreviation of strategic environmental assessment, SEA. Therefore, a limitation on the most frequently occurring terms related to "sea" was made for the title. By making this limitation, there is a risk that sources addressing climate in SEA in relation to a specific marine area are sorted out. However, this is only the case if the specific marine area is mentioned in the title, and it is assessed that this would only be a low number of potential sources. Based on the initial searches and the presented experiences, the final search string for the literature study is presented in figure 4.3.

Placing	Search term
Title	Climate* AND “Environmental impact assessment*” OR EIA OR “Strategic environmental assessment*” OR SEA OR “Environmental assessment*” OR EA
Anywhwere	**AND** vulnerabili* OR adaption* OR adaptation*
Title	**NOT** "arabian sea*" OR "Bering sea*" OR "wadden sea*" OR "barents sea*" OR "aral sea*" OR "deep-sea*" OR "North sea*" OR "red sea*" OR "adriatic sea*" OR "black sea*" OR "caspian sea*" OR "Caribbean sea*" OR "mediterranean sea*" OR "yellow sea*" OR "northern sea*" OR "sea breeze*" OR "arabia sea*" OR "China sea*" OR "Chinese sea*" OR "sea level*" OR "sea surface*" OR "sea floor*" OR “the sea” OR "antarchtic sea*" OR "air-sea*" OR "sea basin" OR "baltic sea" OR "sea turtle*" OR sea-level* OR sea-surface* OR "atlantic sea*" OR "indian sea*" OR "seas*" OR "sea ice*" OR "sea-ice"

Figure 4.3. Final search string.

To find the databases yielding the most results, the initial searches with the different search terms were tested in four different databases: EBSCOhost, ProQuest, Scopus and Web of Science Core Collection. These databases were chosen as they are scientific acknowledge databases, and either only contain peer-reviewed sources or include the possibility to filter for only peer-reviewed sources. The search on the final search string is conducted in all four databases. The databases ProQuest and Scopus yielded the most results of the four databases, and therefore these two databases are chosen for the selection of sources.

Conducting

In the second phase the review is conducted by selecting the final sources [Snyder, 2019].

ProQuest yielded 94 results and Scopus yielded 77 results. The titles of the results are gone through manually and sources with irrelevant titles are sorted out. The majority of the sources sorted out based on the title are sources related to a non-European context. After the manual examination of titles, seven sources from ProQuest and 15 sources from Scopos are deemed relevant for further investigation. The sources are put in the reference manger program RefWorks to identify repeating sources. Five repeating sources were identified, thereby resulting in a total of 17 sources for further investigation. The abstracts of the sources are read through and six sources were deemed irrelevance based on the abstract

or lack of availability of the source. The remaining 11 sources are read through to ensure the relevance. One of the sources was assessed irrelevant after it was read through. The sources of the chosen 10 sources are checked to identify potentially overlooked relevant sources. This revealed one additional source but a read through of this source revealed a limited focus on only mitigation. Thereby, 10 sources are identified for further analysis.

Analysing

In the third phase the selected sources are analysed with the purpose of identifying relevant information from the sources [Snyder, 2019]. When analysing the results the following elements were identified for each source:

- Title
- Geography
- Climatic focus (Adaptation/mitigation)
- Planning level (EIA/SEA)
- Aim of the study
- Conclusions on current practice
- Conclusions on challenges in current practice
- Conclusions on recommendation on "good practice"/improvement potentials

Each source is analysed according to the elements and the findings are noted in a table. By using the same elements when analysing each source and noting them in one table, it is possible to identify patterns across the sources.

Writing

In the last phase the findings of the literature study is written [Snyder, 2019]. Considering factors as geography, climatic focus and planning level, the conclusions on current practice and challenges are examined. This part of the review is presented in the problem analysis, section 2.4. Similarly, the findings on recommendations on "good practice"/improvement potentials are examined and presented as recommendations from research on the future practice as part of the analysis of the first sub-question, presented in section 5.3.

4.3.2 Workshop and mapping in EA-Hub

As part of the second sub-question regarding how climate adaptation appears in Danish EIA reports for transportation infrastructure projects, the EA-Hub is used to get an overall overview of the status. The EA-Hub is an online portal where Danish EIA/SEA reports and other relevant documents are gathered [Danmarks Miljøportal, 2024].

To get an overview of how often climate adaptation is included in EIA reports for Danish transportation infrastructure projects, transportation infrastructure projects in the hub are identified, and it is investigated how many of these projects address climate adaptation. To conduct the most relevant searches in the hub, a workshop with three employees at Danmarks Miljøportal was held, where different search terms and search strategies were discussed and tested. The following employees participated in the workshop:

- Dorthe Holme: Project manager on the EA Hub and EA Tool

- Karl Rasmus Sveding: Project manager on the EA Hub and EA Tool
- Rasmus Holm Mogensen: Student assistant

Holme [2024] and Sveding [2024] are both project managers for the EA Hub and EA Tool and therefore have a thorough knowledge of the Hub and the different functions. Mogensen [2024] is student assistant at Danmarks Miljøportal and has been part of the development of guidelines on how to use the EA-Hub.

To identify transportation infrastructure projects, several search terms were tested including for example: road, road constructions, highway, railway, expressway, and by-pass road. At the workshop it was experienced difficult to limit the search as the results of interest can include many different terms. It was for example discovered, that a project of interest could have a title like *Extension of stretch between X and X*, which will be difficult to identify with search terms. Also a large amount of irrelevant results occur, for example *Windmills next to highway X*. Also, all results including "road" occur including road names ending in "road". Based on the experiences gained during the workshop, it was decided to instead limit the project type by using the function of sorting on appendix-category instead of using search terms. The following categories from appendix 1 and 2 are assessed as relevant:

- Appendix 1, 7a) *"New constructions of railways and airports with a runway of at least 2100 m"*
- Appendix 1, 7b) *"Construction of highways and express highways"*
- Appendix 1, 7c) *"Construction of new roads with at least four lanes or straightening and/or extension of an existing road with a maximum of two lanes to provide at least four lanes, if such new road or straightened and/or extended road section has a continuous length of at least 10 km"*
- Appendix 2, 10c) *"Construction of railways and combined transport facilities and of intermodal terminals (projects not included in Annex 1)"*
- Appendix 2, 10e) *"(e) Construction of roads, ports and port facilities, including fishing ports (projects not covered by Annex 1)"*
- Appendix 2, 10h) *"Tramways, elevated and underground railways, cableways or similar railways of a special type of construction used exclusively or principally for the transport of passengers"*

[The Danish Environmental Assessment Act, Annex 1 and 2].

As this study only includes railways, highways and larger road constructions requiring an EIA, not all projects from from the appendix categories are relevant. For example airports and ports are outside the scope of this study. Therefore, the results are gone through manually to only include the relevant EIA reports. Making limitation on projects by appendix categories also have challenges. Holme [2024] for example highlights, that results based on filtering tools such as the appendix categories will depend on whether the data, including appendix category, has been correctly added to the portal. Thereby, human errors can influence the results.

Search terms for identifying how many of the identified transportation infrastructure projects that address climate adaptation are developed. At the workshop different search terms were tested. However, finding the most relevant search terms required more work

than possible during the workshop. Therefore, after the workshop the search terms were tested further and the text bits the tool selects a result based on were investigated further to identify which search terms resulted in the most relevant results. The following search terms were tested in different combinations: climate adaptation, climate proofing and vulnerability towards climate change. At the workshop, it was experienced, that including more search terms in the search string specifies the results and therefore many search terms can result in fewer results. Therefore, it is a balance how many search terms to include in the search string. The searches and investigation of the text bits reveal, that the following search string reveals the most relevant results: **"Climate adaptation or climate proofing, vulnerability to climate change".**

The searches in the EA-Hub are connected with several uncertainties. As visible from the search string, only reports directly addressing climate adaptation or the project's vulnerability towards climate change will occur in the results. This means, that projects potentially addressing climate adaptation at an indirect level will not appear in the results. Therefore, when reading the results of this mapping, it is important to be aware that the results only indicate how often climate adaptation is directly addressed in the EIA reports. Holme [2024] highlights that other points of attention when using the EA-Hub are that the hub is still under development and continuously improvements are made. Further, not all relevant material is included in the EA-Hub, and it is voluntary for the authorities to input data into the portal [Holme, 2024]. Also projects included in the EA-hub can afterwards have been rejected, which is not necessarily visible in the EA-hub [Holme, 2024]. This means, that there is a risk of projects addressing climate adaptation are not included in the EA-hub potentially distort the actual status of integrating climate adaptation in EIA reports. However, the EA-hub is assessed to be the currently best tool to get an overview of practice. Even though it can be questioned how many projects are not included in the EA-hub and how these would potentially affect the conclusions, the EA-hub provides a subset of EIA reports related to transportation infrastructure projects and provides the possibility of mapping how often climate adaptation is addressed in this subset. Thereby, this mapping can provide an indicator of how often climate adaptation is included in EIA reports related to transportation infrastructure projects.

The results from the mapping in the EA-hub are presented in chapter 6.

4.3.3 Text analysis

Text analysis is used both in sub-question one to examine relevant guidance documents and in sub-question two to analyse selected EIA reports. In both cases, the method has been inspired by document analysis, where the purpose is to gain increased understanding of a specific field by investigating documents in a systematic, qualitative manner [Bowen, 2009]. A document analysis should thereby provide a systematic approach to evaluate multiple documents in a similar way [Bowen, 2009].

Analysis of guiding documents

The purpose of the analysis of the guiding documents is to identify recommendations on "good practice" for assessment of climate adaptation. The guidance documents were read through manually and relevant text bits were identified and noted in a document.

To ensure that nothing was overlooked when making the read through, also a search for relevant search terms was conducted in each guiding documents including the search terms climate change, adaptation, vulnerability, resilience, interrelation, synergies and derived effects. The identified recommendations for each guidance document and IAIA best practice principles are presented in chapter 5.

Analysis of EIA reports

Based on the mapping in the EA-Hub 18 transportation infrastructure projects directly addressing climate adaptation are identified. The 18 mapped projects are published between 2013-2021. As assessment of climate adaptation first became a direct legal requirement with the changes to the European EIA Directive i 2016, as elaborated in section 2.1, it is decided to focus the analysis on projects published after 2016. This limitation to newer projects is further supported by the purpose of this study of contributing to investigating the current status of climate adaptation in EIA reports. Nine of the 18 projects are published after 2016 (2017-2021). Two of these nine projects are deselected for further analysis, as these projects are assessed to be significant different from the remaining projects. Figure 4.4 presents an overview of the seven selected EIA reports for further analysis.

Project type	Project	Appendix	Publication year
Railway	New railway Hovedgård - Hesselager	Appendix 1	2019
Railway	New railway Billund	Appendix 1	2018
Railway	Electrification of railway Roskilde - Kalundborg	Appendix 2	2017
Highway	Expansion of highway E45 Aarhus N - Randers N	Appendix 1	2020
Highway	Expansion of highway E45 Vejle - Skanderborg	Appendix 1	2020
Highway	Construction of The 3. Limfjordsforbindelse	Appendix 1	2021
Larger road construction	Bypass road - Nimtofte	Appendix 2	2017

Figure 4.4. Overview of transportation infrastructure projects addressing climate adaptation, published between 2017-2021.

For each of the seven projects relevant background material for the EIA reports, including technical notes and appendices related to the assessment of climate adaptation are identified, and the text analysis is conducted on the reports and the corresponding relevant background material. When analysing the material, the first step was to identify relevant passages related to climate adaptation. After reading potentially relevant chapters, a search is made for "climate", and all identified text bites are read through manually to assess if it concerns climate adaptation. By searching on "climate", results related to climate adaptation, climate change, climate change impacts, climate proofing and similar will occur. An initial search was also conducted for "vulnerability", but this reveals a large amount of irrelevant text bits, as vulnerability is a term used in relation to many of the environmental factors and not only in relation to climate changes. As the vulnerability of interest in this study must be connected to vulnerability to climate change, it is assessed that relevant text bites will occur when searching on "climate". Climate adaptation can potentially also occur indirectly in the reports, which will not be detected in this study. The purpose of the analysis is to determine how expected future changes in climate and

related adaptation measures appear in the presentation of the assessments in the reports, and therefore it is assessed that climate adaptation should be mentioned explicitly.

To support the analysis of the relevant text bits, the analytical framework developed as part of sub-question one is used. The analytical framework is presented in chapter 5, section 5.5 and summarizes legal requirements and recommendations from Danish and international formal guidelines, IAIA's best practice principles and recommendations identified in research. The analytical framework consists of six categories and for each category recommendations are developed. For each recommendation specific criteria are set up for determining if the recommendation appear or does not appear. When conducting the analysis, a large excel spreadsheet with the analytical framework is used. Here relevant passages from the identified text bits are connected to the specific recommendations. Based on the identified relevant text passages it is assessed, using the listed criteria in the analytical framework, whether the recommendation appear or does not appear in the EIA material. An uncertainty of the text analysis is that the analysis will be influenced by the underlying understanding and interpretation of the author of this study. This is attempted taken into account by using a systematically approach in the analysis by using the analytical framework. Thereby, the material is analysed as similar as possible, which is one of the main characteristics of a document analysis [Bowen, 2009].

The assessment considers whether the recommendation appear or does not appear and provides an indication of the quality of the assessment based on the arguments in the identified text bites, but a thorough assessment of the quality is outside the scope of this study. Making a detailed evaluating of the quality of the assessment in the EIA material would require more in-depth knowledge of each assessment and project, which has not been possible to obtain within the time frame of this study. Thereby, the purpose of the text analysis of the EIA reports is to get an overview of whether the recommendations related to the six categories appear or does not appear. This knowledge can be used to identify common patterns and recommendations that could require further focus in future practice.

A couple of factors are important to keep in mind when reading the results. For example the analysis only takes into account the written text in the EIA reports and related background material, and potential further considerations and assessments conducted as part of the surrounding process are not included. Thereby, it is a possibility that the assessments include more nuances than visible in the text material, which can potentially distort the image of practice. Though, the purpose of this part of the analysis is to investigate how climate adaptation appears in the EIA reports and these findings will be supplemented with findings from interviews to get insight into the surrounding process and potential considerations therein. Another related uncertainty is, that background material related to other environmental factors than climate is not included in the analysis. Environmental interrelations related to climate adaptation could potentially be addressed in this background materials, which would not be included in the results of this study. However, if this is the case, it has not been deemed of a level of relevance to be included in the EIA reports. Further, misunderstandings of the text can potentially happen when making the analysis. Transparency and argumentation have therefore been in focus when describing the considerations behind the conclusions, and thereby making the underlying

understanding and interpretation as visible as possible for the reader. Another thing to keep in mind when reading the results of the analysis of the EIA reports is, that more of the recommendations go beyond the legal requirements. Absence of recommendations in the reports can create a negative picture of current practice, even though practice may comply with the minimum legal requirements. However, this approach is chosen as the purpose of this study is to identify how the future practice can potentially be improved. Therefore, it is deemed necessary to look beyond the minimum legal requirements. Further it is important to keep in mind, that the analysis does not evaluate if a recommendation is relevant for the specific project, only if it appears or does not appear. Therefore, the absence of a recommendation can also be because it has been assessed as not relevant in relation to the specific project.

4.3.4 Dialogue meeting

As a result of the investigation of the legal requirements and recommendations for assessment of climate adaptation in EIA in sub-question one, an analytical framework for the following analysis of EIA reports is developed. To support the development of this analytical framework, a dialogue meeting with Anja Wejs is held.

Participant	Position	Organisation	Date of interview	Duration of meeting
Anja Wejs	Market Director	NIRAS	06-05-2024	48 minutes

Figure 4.5. Overview dialogue meeting.

The purpose of the dialogue meeting is to get feedback and input on the analytical framework by a practitioner and expert on climate adaptation. Wejs [2024] is market director for climate adaptation in NIRAS. Wejs [2024] has a PhD in climate planning (from 2013), and has 15 years of experience working with climate adaptation, where she for example has been project leader on multiple projects related to climate adaptation and development. Further, Wejs [2024] is part of Danish and international networks for climate adaptation including *Det Nationale Netværk for klimatilpasning (DNNK)*, *The EURO Local Climate Plans Initiative*, and *The Urban Climate Change Research Network (UCCRN)*. Furthermore, Wejs [2024] works as an external lecturer at Aalborg University teaching in water management and climate adaptation, and she has published several academic publications on climate adaptation, EA, and the involvement of interests. Based on this educational and experiential background, Wejs [2024] is considered as an expert in climate adaptation.

Prior of the meeting, a draft of the analytical framework was sen to Wejs [2024], thereby giving her some time to look more into it before the meeting. At the meeting the draft was discussed and Wejs [2024] contributed with experiences and recommendations. After the dialogue meeting the analytical framework was adjusted taking the inputs into consideration.

Adjusting the analytical framework based on inputs from only one practitioner means that the analytical framework will be highly dependent on the inputs from Wejs [2024]. By involving more practitioners more perspectives could have been included and perhaps a more nuanced framework could have been developed. However, Wejs [2024] is perceived

as an expert on climate adaptation and further relevant literature is used to support the content of the analytical framework.

The final version of the analytical framework is presented in section 5.5.

4.3.5 Semi-structured interview

To answer sub-question three on practical oriented barriers and possible improvement potentials for including climate adaptation in EIA practice, interviews with relevant actors within the field are conducted. Three interviews are hold, and in one of the interview two respondents participated, resulting in a total of four respondents. All the interviews were hold on the online platform Teams and conducted in Danish. An overview of the interviews is presented in figure 4.6.

Informant	Position	Organisation	Date of interview	Duration of interview
Sidsel Kontni Prahm	Chief consultant	Syddjurs Kommune [Syddjurs Municipality]	18-04-2024	40 minutes
Ole Riger-Kusk	Senior project manager	NIRAS	18-04-2024	37 minutes
Niels Fejer Christiansen	Project manager	Vejdirektoratet [The Danish Road Directorate]	19-04-2024	50 minutes
Klara Vanggård Hjortlund	Project manager			

Figure 4.6. Overview interviews.

Sidsel Kontni Prahm is chief consultant at Syddjurs Municipality in the Department of Environment and Climate, and works with climate and sustainability at an overall and strategic level. Further, she works with EIA screenings/EIA. Prior her employment at Syddjurs Municipality, she worked at Aarhus Municipality for 10 years and at Norddjurs Municipality.

Ole Riger-Kusk is senior project manager at the consultancy firm NIRAS, and has primarily worked with EA for last 15-20 years. Riger-Kusk [2024] has been project manager at approximately 35 EIA projects, including transportation infrastructure projects, and has further contributed to a range of additional projects. Before Riger-Kusk [2024] was employed at NIRAS, he worked at Ramboll, and he has been project manager at the project *Bypass road - Nimtofte*, which is one of the projects included in the analysis of this study.

Niels Fejer Christiansen is project manger at Vejdirektoratet [The Danish Road Directorate] where he has long-standing experience, and the last 20 years he has worked with construction projects. Christiansen [2024] was project manager in the project *Construction of 3. Limfjordsforbindelse*, which is one of the projects included in this study. Klara Vanggård Hjortlund is also project manager at Vejdirektoratet. Hjortlund [2024] graduated as a planning engineer in 2023. Thus Hjortlund [2024] has limited experience, but has an insight into some of the latest academic perspectives.

As three of the projects included in the analysis of this study are railway projects, it would have been beneficial to interview Banedanmark [The Danish Railway Agency] and gain insight into the work process in this organisation as potential differences

between the approach to the assessments between different project types could be present. Unfortunately it has not been possible to get an interview with Banedanmark.

The purpose of the interviews is to get an overall and broad insight into the field, and therefore respondents from different organizational types are included. More of the chosen respondents have a professional background that increases their experiences in relation to the organizational type. For example Prahm [2024] has been employed in three different municipalities and Riger-Kusk [2024] has prior working at NIRAS been project manager in Ramboll. Thereby, their experiences related to working procedures in respectively municipalities and consultancy firms are increased. Christiansen [2024] has long-standing experience at Vejdirektoratet and are therefore assessed to have an thorough insight into the working procedures within Vejdirektoratet. However, it should be noted, that it based on one respondent can be challenging to conclude anything general related to the organisational perspective.

All the interviews were conducted as semi-structured interviews. The purpose of semi-structured interviews is to get insight into the respondents' views and experiences on a specific topic [Kvale og Brinkmann, 2015]. In this study the semi-structured interview is thereby used to get insight into the participants' views and experiences upon climate adaptation in the EIA process. As the semi-structured interview enables an comparatively open dialog on a topic, the method allows for follow-up questions on emerging topics and perspectives and thereby enables a dynamic dialogue [Kvale og Brinkmann, 2015]. To ensure relevance of the interview and to help guide the dialogue, an interview guide with predefined questions should be developed [Kvale og Brinkmann, 2015]. In this study the interview guide was developed based on the knowledge obtained throughout the initial investigations and further the institutional theory was used to ensure that the questions cover both the regulative, normative and culture-cognitive pillars. For example the regulative pillar is included in the interview guide by asking if the legal framework and the authorities enforcement are experienced as sufficient. The normative and culture-cognitive pillars are indirectly included by for example asking how the respondents see an optimal assessment or how they describe different terms, whereby it is possible afterwards to interpret the participants interpretations of relevant elements.

All interviews were recorded and afterwards transcribed. As the interviews were conducted in Danish, points and quotes used in the report were translated, which could potentially distort the desired meaning. Further misunderstandings can occur, and therefore all interview material used in the report has been sent to the respondents for verification.

4.4 Institutional theory

This section elaborates on institutional theory. Institutional theory is deemed relevant to understand the current system of institutions that affect current practice of climate change assessments in EIA. The theory can thereby be used to gain insight into rules, norms and interpretations affecting current practice. Further, the theory can help detect elements in the different institutional pillars that either hinder or promote change, and the theory is therefore deemed relevant when suggesting changes in practice.

In this study institutional theory is described using the definitions from Scott [2014].

According to Scott [2014], institutions consist of three elements; the regulative pillar, the normative pillar, and the cultural-cognitive pillar. These are interrelated and work in combination, but to better understand the different elements of institutions it can be useful to separate them and understand the differences between the three elements [Scott, 2014]. Scott [2014] defines institutions as: *"Institutions comprise regulative, normative, and cultural-cognitive elements that, together with associated activities and resources, provide stability and meaning to social life."* [Scott, 2014, p. 56]. Thereby, institutions create some sort of stability and the three pillars as well as associated social behaviour and resources are the elements that either create institutions or promote or uphold change within existing institutions [Scott, 2014].

The regulative pillar:
The regulative pillar of institutions concerns regulatory processes, which include rules, monitoring, and sanctions. Thereby, the regulatory pillar revolves around the ability of establishing rules, checking if the rules are obeyed, and the ability to make sanctions if the rules are not obeyed [Scott, 2014]. This power can for example be institutionalized through authorities [Scott, 2014]. In this connection it is highlighted that in well-functioning institutions, the power is exercised by a neutral party ensuring that own interests are not affecting the enforcement. This is exemplified by a neutral state [Scott, 2014]. Examples of indicators for the regulative pillar are: *"...constitutions, laws, codes, rules, directives, regulations, and structures of control."* [Scott, 2014,p. 62]. According to Scott [2014], some theoreticians describe the regulative pillar as only explicit formal rules and sanctions, but Scott [2014] states that it can also include more informal elements, which is also indicated by the last mentioned indicator, namely structures of control. For example sanctions can, according to Scott [2014], be both formal and legally bounded or they can be more informal including for example shaming. This illustrates the close connection between the different pillars, where for example sanctioning through shaming can be argued to be closely connected to the normative pillar.

Looking at the regulative pillar in an EIA context, examples of indicators could be *The European EIA Directive* and *The Danish Environmental Assessment Act* as well as the authorities enforcement of these laws. Furthermore, it can be argued that also the formal guidelines on implementation of the laws such as the Danish *Guide to the Act on environmental assessment of plans and programs and of specific projects (EIA) - Specific projects* and the European guidance documents *Environmental Impact Assessment of Projects - Guidance on the preparation of the Environmental Impact Assessment Report* and *EU Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* can be seen as part of the regulative pillar as supporting structures of control for a desired development.

The normative pillar:
The normative pillar is about the values and norms that affect the social life [Scott, 2014]. According to Scott [2014], *values* are the preferred or desired, while *norms* defines ways to obtain these values. Another central element is *roles*, and different actors have different roles in relation to how they are supposed to act. Examples of this are different formal roles in an organisation or informal roles developing over time through interaction between actors [Scott, 2014]. In the normative pillar, the given actor considers: *"Given this situation, and*

my role within it, what is the appropriate behaviour for me to carry out?" [Scott, 2014,p. 65]. If the values, norms and roles are not followed, the sanctions are related to morality. This includes for example shame or disgrace and conversely respect or honor if the values and norms are fulfilled, leading to a high level of self-evaluation and Scott [2014] argues, that these feelings are strong drivers to comply with norms. Indicators of the normative pillar can for example be: *"... accreditations or certifications by standard setting bodies such as professional associations"* [Scott, 2014, p. 65].

In an EIA context indicators of the normative pillar are therefore norms, values and roles of different actors in the EIA system. Furthermore, it can be argued, that also the IAIA international best practice principles can be described as part of the normative pillar, as this is guidance on appropriate behaviour stated by an international standard setting body. Further, the identified recommendations in research on "good future practice" can be viewed as part of the normative pillar, as these express a desired practice.

The cultural-cognitive pillar:
The cultural-cognitive pillar of institutions can be described as: *"... the shared conceptions that constitute the nature of social reality and create the frames through which meaning is made"* [Scott, 2014, p. 67]. Different symbols in the external world affect the individuals subjective interpretation or the way they create meaning. Such symbols can be for example words, signs and gestures [Scott, 2014]. In other words, the internal (cognitive) interpretation is influenced and shaped by the external cultural framework. The interpretation of the cultural systems vary among individuals, resulting in different understandings among different individuals [Scott, 2014]. The external cultural systems of common beliefs, shared definitions and so on, exist on different levels from national or international levels to local situations. These levels are nested, meaning that the cultural systems can affect the individuals at the different levels, while also individuals can be part of developing and restructuring cultural systems and thereby changing for example the common belief and share definitions [Scott, 2014]. Also interactions between different individuals will affect the meaning and how meanings arise or are being maintained. If one does not comply with the cultural beliefs it can result in confusion or a negative reputation, while obtaining the belief can result in confidence and a feeling or reputation of being competent [Scott, 2014]. The indicators for the cultural-cognitive pillar are more difficult to identify, but concerns elements that describe how actors understand and interpret the external world, including for example discourses, organizational documents, shared understandings and so on [Scott, 2014].

In the context of EIA the cultural-cognitive pillar concerns the culture around climate adaptation and how symbols in the external world affect how individuals create meaning of the terms. Thereby, it is about how climate adaptation is described and presented in the external world through for example discourses and shared meanings and how the individual practitioners understand and interpret these terms.

Use of the theory:
At an overall level, institutional theory is in this study used to understand the institutional framework of the current system of climate assessments in EIA, and to understand what institutional changes are necessary when making future changes in practice.

In the first sub-question, requirements and recommendations are identified, and this sub-question thereby contributes to the investigation of the regulative and normative pillar. In the second sub-question selected EIA reports are analysed and it is investigated whether these regulative requirements and normative recommendations are present in the reports. In the third sub-question on practical oriented challenges and improvement potentials, the theory is used more actively to investigate how institutional elements affect current practice. The theory is used when developing interview guides to ensure questions that cover all three pillars. It can be difficult to ask questions directly about the normative or cultural-cognitive pillar as norms and interpretations can be unconscious. Therefore more overall questions are asked and the material is afterward analysed using the institutional theory. For example, questions on which climatic factors should be included in an assessment according to the respondents are asked, which is afterwards sat in relation to the theory analyzing which norms and understandings that affect the respondent's answers. Thereby, the theory is in sub-question three used both when developing the interview guide and to interpret the interview material gathered to gain a deeper understanding of the institutional elements that influence practice. Furthermore, the theory is related to the developed recommendations on future practice, assessing how the recommendations can help overcome identified regulative, normative and culture-cognitive challenges of current practice.

In the next parts of the report, the results of the analyses are presented.

Requirements and recommendations for climate adaptation in EIA 5

This chapter presents an overview of identified relevant international and Danish legislation, formal guidelines, best practice principles and recommendations identified in research regarding integration of climate adaptation in EIA. This will create the basis for answering sub-question one. Based on the findings presented in this chapter, an analytical framework for assessment of climate adaptation in EIA reports is developed. The analytical framework is discussed with an expert on climate adaptation and these inputs are taken into account in the final version of the framework. The analytical framework is presented in the last section of this chapter.

5.1 Legal framework

When making EIA different environmental factors need to be considered including climatic factors: *"...biodiversity, population, human health, flora, fauna, soil, land, water, air,* ***climatic factors****, material assets, landscape, cultural heritage (...), major man-made and natural disaster risks and accidents and resource efficiency and* ***the interrelationship between these factors.****"* [The Danish Environmental Assessment Act, § 1 (2)]. This illustrates the broad environmental concept the regulation builds upon where besides looking at the specific environmental factors it is also a requirement to look at the interrelationship between the different factors and assess how impacts on one factor affect other factors.

As mentioned in section 2.3, the EIA report should among other things include assessment of expected significant impacts on the environment and measures to avoid, prevent or reduce and, where possible, neutralize expected significant negative impacts on the environment [The Danish Environmental Assessment Act, § 20 (2)]. Further, it is elaborated that the assessment of climatic factors should contain a description and assessment of: *"...the impact of the project on climate (e.g. the nature and magnitude of greenhouse gas emissions) and the vulnerability of the project to climate change"* [The European EIA Directive, Annex IV, 5; The Danish Environmental Assessment Act, Annex 7, 5]. Also in the requirements regarding assessment of *"major man-made and natural disaster risks and accidents"* [The Danish Environmental Assessment Act, § 1 (2)], both the European and Danish legislation state that: *"...the risk of major accidents and/or disasters which are relevant to the project concerned, including those caused by climate*

change..." should be included as part of the screening, determining whether a project listed in annex 2 are subject to EIA [The European EIA Directive, Annex III, 1 (f); The Danish Environmental Assessment Act, Annex 6, 1 (f)].

Thereby it is a legal requirement to make an assessment of the project's vulnerability to climate change. Further it is a requirement to assess the interrelationship between the different environmental factors under assessment, meaning that it is also a requirement to make an assessment of the interrelations between climate and other environmental factors. Based on the assessment, adaptation measures to reduce the vulnerability of the project should also be presented in the EIA report.

5.2 Guidelines

As elaborated in section 2.3.1 and illustrated in the section above, the EIA regulation does not set up specific requirements for the assessment of the project's vulnerability to climate change and related adaptation measures. Therefore, this section presents relevant Danish and international guidelines and best practice principles for integrating climate considerations into EIA.

5.2.1 Danish guideline

Guide to the Act on environmental assessment of plans and programs and of specific projects (EIA) - Specific projects

Based on the Danish *Guide to the Act on environmental assessment of plans and programs and of specific projects (EIA) - Specific projects* [Miljøministeriet, 2023a], the following recommendations regarding the assessment of the project's vulnerability to climate change and climate adaptation can be derived:

- The assessment of climatic factors should include an assessment of the expected impacts of climate change on the project and the project's ability to adapt to these changes. This could for example be assessment of consequences of rising water levels.
- Climate change should be assessed as part of the assessment criteria for the authorities screening whether an Annex 2 project is subject to EIA *"...the risk of major accidents and/or disasters which are relevant to the project concerned..."* [The Danish Environmental Assessment Act, Annex 6, 1 (f)], where climate related risks for example can occur if the project is located in an area that is vulnerable towards consequences of climate change such as risk of flooding or increasing water levels.

Further, the guidance refers at an overall level to the legal requirements for assessment of the interrelation between the different environmental factors: *"... a requirement for an assessment of the interrelationship between all of these factors. Such an assessment is referred to as a cross-disciplinary environmental assessment."* [Miljøministeriet, 2023a, p. 34]. This is not elaborated further in the guidance.

A reference is made to the EU *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment.*

5.2.2 International guidelines

Environmental Impact Assessment of Projects - Guidance on the preparation of the Environmental Impact Assessment Report

In the EU guidance *Environmental Impact Assessment of Projects - Guidance on the preparation of the Environmental Impact Assessment Report* [European Commission, 2017], the following recommendations related to climate adaptation are present:

- The assessment of climatic factors should include an assessment of the impacts that climate change can have on the project and how the project can adapt to this over all of the lifetime.
- Due to uncertainties related to climate change, assessment of trends and risks should be included in the assessment.
- Use the EU *Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* in the assessment in parallel with this guide.
- Find inspiration in the *EU Strategy on adaptation to climate change*, the *EU platform CLIMATE-ADAPT*, the document *Adapting infrastructure to climate change (SWD(2013) 137 final)* and the *Guidelines for Project Managers: Making vulnerable investments climate resilient (DG Climate Action, Non-paper).*

Thereby, the EU guidance to a large degree builds upon references to other relevant documents and guidelines. The EU guide highlights that assessment of the project's vulnerability to climate changes can be challenging, as it depend on a shift from the normal focus on the project's impact on the environment and that climate changes are connected with large uncertainties.

Interrelations between different environmental factors are not addressed further in the guide.

EU Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment

Both the Danish and the EU guidance refer to the *EU Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment.* From this guide, the following recommendations regarding climate can be derived:

- Include climate early in the EIA process and connect it to the specific project.
- To identify relevant climate change related aspects, bring relevant stakeholders together early in the process and be aware of how climate aspects interact with other environmental parameters.
- Consider the impacts of climate change on the project and the project's resilience and ability to adapt. Relevant parameters could be rising temperatures, changes in rainfall, melting glaciers, sea level rises, floods, and droughts.
- Include a long timescale and use long-term trends in the analyses including environmental baseline trends, which can be supported by a vulnerability assessment.
- Include the complexity of climate change initiatives and be aware of both positive and negative impacts as well as potential cumulative effects and assess synergies. Causal chains or network analyses can help identify the interactions.

- To handle uncertainty use e.g. scenarios such as worst- and best-case and extreme climate situations. If it is not possible to predict an impact, consider possible risks.
- Be transparent about limitations and assumptions and always use a precautionary approach.
- Use an integrated approach in the planning and assessment process. Balance the procedure properly without making it too long, but still leaving time to make sufficient assessments.
- Include alternatives that have an effect regarding climate change.

Thereby, the *EU Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* provides more specific recommendations for the assessment of climate change and the project's vulnerability, and in this guide also the interrelations between different environmental factors are highlighted.

5.2.3 IAIA International best practice principles

The International Association for Impact Assessment (IAIA) is a global network consisting of researchers, practitioners, and users of impact assessments (IA) and aims at providing best practice principles on IA for both policies, programs, plans, and projects [IAIA, 2024]. The publication *Climate Change in Impact Assessment - International Best Practice Principles* aims at promoting considerations on climate change as part of the decision making process for both SEA and EIA [Byer et al., 2018].

The best practice principles relate to both mitigation and adaptation. Regarding adaptation measures the following elements should be included:

- **Adaptation objectives:** National or sectoral objectives for climate adaptation should be used actively, and if not present the objective of projects regarding climate should be stated.
- **Refining baseline:** The baseline for the environment under assessment should be refined by taking consequences of climate change into consideration. If scoping indicates that climate change is important in the given project, three scenarios consisting of minimum, medium and maximum change in baseline should be included in the assessment. If the scoping indicates minor issues a minimum and medium scenario can be sufficient.
- **Vulnerability and effects assessment:** The risk or vulnerability due to climate change on natural, social and economic systems affected by the project should be assessed in short- and long term using different scenarios for climate change. The assessments should focus on potential sub-elements of the project and consider each project phase.
- **Adaptation measures:** Different adaptation measures should be identified and evaluated to choose the most appropriate ones. The focus should be on both resilience, recovery and adaptation, and nature-based measures with focus on ecosystems can advantageously be used.

Besides these recommendations directly related to adaptation, IAIA also presents cross-cutting aspects to be included in the assessments. This includes for example considerations related to equity and transparency regarding uncertainties and validity of the assessment

and potential calculations. Further scientific knowledge should always be used and a precautionary principle should be applied in the decision-making. Follow-up and public participation are further highlighted as central elements of IA [Byer et al., 2018]. Regarding environmental interrelation IAIA states: *"The IA should assess the interactions of mitigation and adaptation consequences and measures. Likewise, mitigation and adaptation have potential synergies with other environmental and social concerns that need to be addressed..."* [Byer et al., 2018, p. 3]. Thereby, both climate- and environmental interrelations are highlighted.

In addition to these best practice principles for climate adaptation, IAIA also highlights factors that are central for operationalizing the principles in practice. This includes financial and employee commitment to address the climatic factors prior decision-making both in authorities and in business, strong institutions and coordination across both disciplines and sectors [Byer et al., 2018]. Further, education of practitioners and development of guidelines are highlighted. Lastly, also using knowledge from local people on for example trends and communication of the findings and the importance of climate factors to decision-makers is recommended [Byer et al., 2018]. These factors relate to the process around the EIA and illustrate that also the surrounding institutional setting will influence the assessments.

5.3 Recommendations from research

The recommendations on future practice according to research presented in this section are identified through the conducted literature study. The methodological approach to the literature study is described in section 4.3.1. In total 10 sources are included in the literature study, six of which concern adaptation alone and four focus on both adaptation and mitigation. One of the sources focuses on SEA, one on both SEA and EIA, and the remaining eight sources have a limited focus on only EIA. The identified recommendations on future practice from the investigated literature are presented in the following.

More of the investigated sources point on a need for increasing focus on both adaptation and mitigation in EIA [Hands og Hudson, 2016; Mayembe et al., 2023; Larsen, 2014]. Further, Larsen [2014] highlights, that enhancement of positive impacts and assessment of negative impacts should also gain more focus in future EIA practice, again both for mitigation and adaptation. In this connection multiple of the sources also state, that climate should be addressed both at SEA and EIA levels considering the global consequences both at regional and local levels and ensuring alignment in global, national and local mitigation and adaptation [Jiricka-Pürrer et al., 2016; Mayembe et al., 2023; Ledda et al., 2021]. Further it is emphasized, that climate needs to bee addressed at all stages of the EA process [Mayembe et al., 2023; Larsen, 2014; Ledda et al., 2021]. Here Mayembe et al. [2023] for example state that climate should be integrated in both screening, scoping, baseline assessment, impact assessment, EIA review and monitoring as well as project design and alternatives addressing both mitigation and adaptation. This is supported by Larsen [2014] stating that both adaptation and mitigation should be part of the whole EIA process and have an actual effect in the decision-making process.

To increase the quality, the assessments should build upon knowledge from studies as

well as current and future climate models and scenarios requiring that data are available [Jiricka-Pürrer et al., 2018]. Further, vulnerability assessment of the project's adaptive capacity as well as assessment of risks is highlighted as relevant tools when addressing the project's vulnerability to climate change and potential adaptation measures [Ledda et al., 2021; Loza og Fidélis, 2021; Jiricka-Pürrer et al., 2018], while it is also recommended to keep developing methods to assess climate change both in relation to adaptation and mitigation [Hands og Hudson, 2016]. Further, it is emphasized that climate assessments need a transdisciplinary approach and that environmental, economic and public concerns need to be well-balanced when addressing adaptation measures both at EIA and SEA levels [Jiricka-Pürrer et al., 2019; Tyszer og Gałaś, 2020].

Another recommendation present in the literature related to adaptation in EIA is to increase the focus within the field on uncertainties and how to handle these [Jiricka-Pürrer et al., 2016, 2019]. Here Jiricka-Pürrer et al. [2016] for example suggest making a common strategy on how to handle uncertainties in projections and data. To integrate the uncertainties in practice, Jiricka-Pürrer et al. [2019] state that there is a need to increase data and knowledge which could be obtained through long-term monitoring, availability of climate prognoses and increased guidance. The use of monitoring as a tool to increase knowledge on climate change baselines and trends as well as generating data in general is highlighted in multiple of the sources both related to adaptation and mitigation [Hands og Hudson, 2016; Jiricka-Pürrer et al., 2016; Mayembe et al., 2023; Jiricka-Pürrer et al., 2019]. In relation to adaptation, Ledda et al. [2021] and Jiricka-Pürrer et al. [2018] recommend including adaptive monitoring indicators as part of the monitoring program. Increasing monitoring is a recommendation identified both at strategic and specific project levels.

In relation to environmental interrelations, Ledda et al. [2021] for example recommend including an assessment of climate change impacts on other environmental factors and considerations on how adaptation and mitigation interact. Also Jiricka-Pürrer et al. [2016] highlight that climate change and adaptation measures interact with multiple other environmental factors and identifies a need for a transdiciplinary assessment of these interactions. [Hands og Hudson, 2016] recommend a more holistic approach considering synergies among climate and other environmental factors and state that to obtain this, there is a need for changes among practitioners and development of guidelines. Also Jiricka-Pürrer et al. [2018] suggest further guidance on the area, potentially supplemented by more strict requirements on for example integrating vulnerability or risk analysis in the assessments.

A recommendation identified in multiple of the sources is to increase the focus on and knowledge about climate change both in relation to adaptation and mitigation [Hands og Hudson, 2016; Jiricka-Pürrer et al., 2016; Tyszer og Gałaś, 2020; Mayembe et al., 2023; Jiricka-Pürrer et al., 2019; Loza og Fidélis, 2021; Álvaro Enríquez-de Salamanca et al., 2016]. At a general level, [Jiricka-Pürrer et al., 2016] and Tyszer og Gałaś [2020] point to a need for raising awareness on climate change. Jiricka-Pürrer et al. [2016] for example highlight expert discussions and increased research on climate change impacts as tools to promote awareness. Jiricka-Pürrer et al. [2019]; Álvaro Enríquez-de Salamanca et al. [2016]; Hands og Hudson [2016]; Loza og Fidélis [2021] and Mayembe et al. [2023] emphasize that the awareness on mitigation and adaptation needs to be raised among all relevant EA

stakeholders, and here especially training and motivation of practitioners are highlighted as central elements, and according to Hands og Hudson [2016] this calls for change in current behavior among the practitioners. Other elements affecting the effectiveness of EIA to integrate climate change considerations in planning are the whole EIA system and accessible material to support the assessments and the actors involved including their know-how, values and roles [Jiricka-Pürrer et al., 2019].

Also the importance of the legal framework and corresponding guidelines on integrating climate change considerations into EA is touched upon in the majority of the sources. It is a general point that for climate change considerations and adaptation and mitigation measures to be sufficiently included in EA, strong, explicit, and well-functioning legal requirements needs to be present [Hands og Hudson, 2016; Jiricka-Pürrer et al., 2016; Tyszer og Gałaś, 2020; Mayembe et al., 2023; Loza og Fidélis, 2021; Jiricka-Pürrer et al., 2018; Álvaro Enríquez-de Salamanca et al., 2016]. Closely connected, almost all of the sources state that integrating climate change considerations into EIA should be supported by guidelines [Hands og Hudson, 2016; Jiricka-Pürrer et al., 2016; Mayembe et al., 2023; Jiricka-Pürrer et al., 2019; Loza og Fidélis, 2021; Jiricka-Pürrer et al., 2018; Álvaro Enríquez-de Salamanca et al., 2016]. In relation to environmental interrelations, Jiricka-Pürrer et al. [2018] highlight that guidelines should contain considerations on how to integrate the effects from climate change on other environmental factors.

The recommendations derived from the investigated literature are summarized in the next section.

5.4 Overview of requirements and recommendations

Figure 5.1 summarizes the identified legal requirements and recommendations presented throughout this chapter. The box *Legal requirements* is based on The European EIA Directive and The Danish Environmental Assessment Act. The box *Danish and international formal guidelines* is a consolidation of the recommendations identified in respectively the Danish and European guides on the EIA law and the European guide on integrating climate change and biodiversity into EIA. *IAIA International best practice principles* summarized the recommendations on best practice developed by IAIA. Finally, the box *Recommendations from research* summarizes the identified recommendations in international research. Further, the recommendations derived from Danish research, presented in section 2.4, are included in these recommendations. The black text represents requirements and recommendations related to the actual assessment, while the purple text indicates recommendations related to the surrounding process.

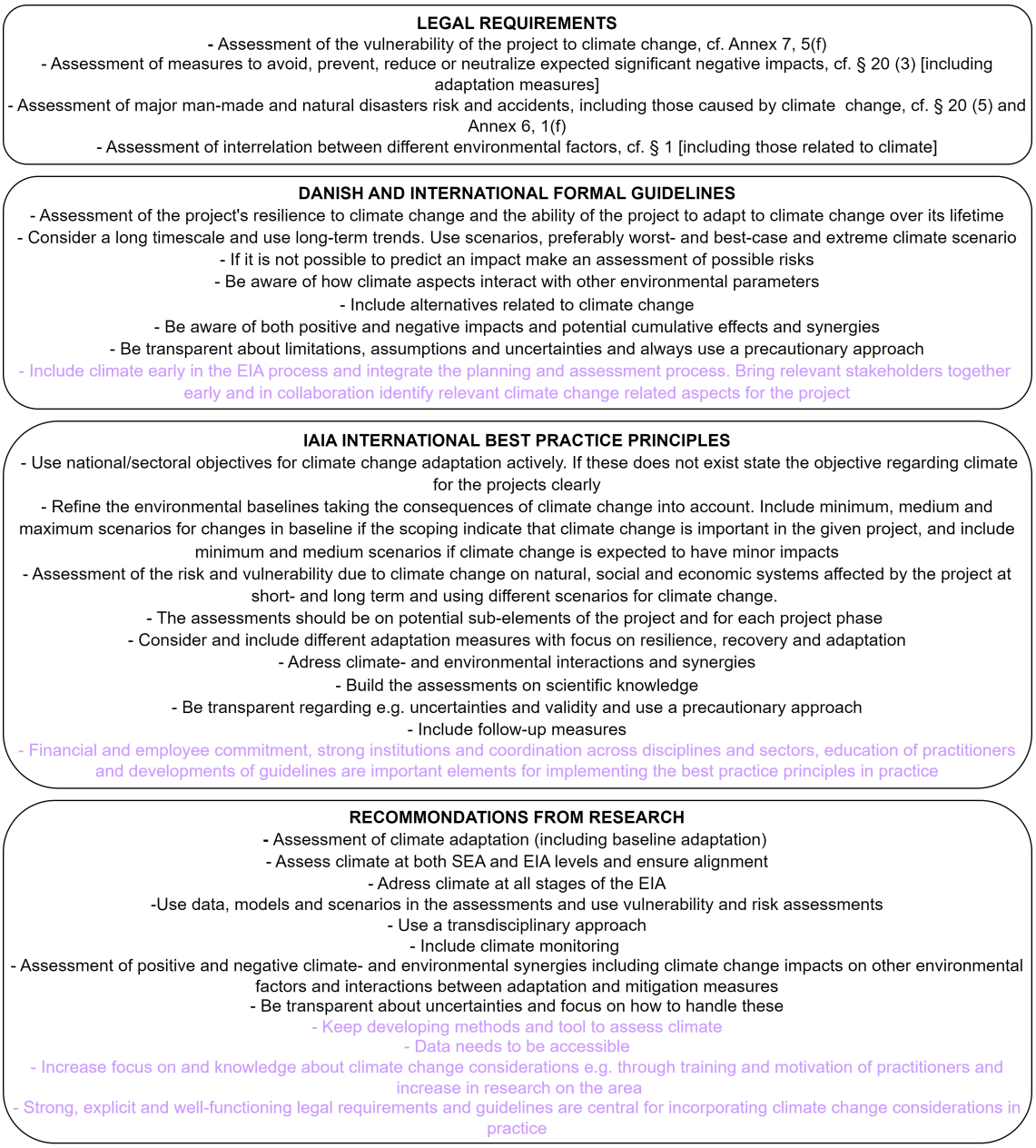

Figure 5.1. Requirements and recommendations on climate adaptation in EIA.

The identified requirements and recommendations are used to develop an analytical framework presented in the next section.

5.5 Analytical framework

Based on the identified requirements and recommendations presented throughout this chapter, an analytical framework for assessment of climate adaptation in EIA reports is developed. The analytical framework is used in sub-question two when analysing the selected EIA reports to investigate whether the identified requirements and recommendation appear or do not appear in the reports.

As the analytical framework will be used to analyse EIA reports, only elements expected

to be part of the EIA reports are included. Therefore, the purple elements from figure 5.1 concerning surrounding elements for the assessment process are not included in the analytical framework. Further, appearance of elements such as using a transdiciplinary approach, making assessment of climate adaptation at all stages of EIA, and following a precautionary approach will likely be difficult to fully assess based only on the EIA reports. The purpose of the analysis of the EIA reports is to get an overall insight into whether the different parameters appear or do not appear in the EIA reports. Therefore these surrounding elements are excluded from the analytical framework, but will be further addressed in chapter 7 and 8.

Also the requirement for assessment of major man-made and natural disasters and risk is excluded from the analytical framework. This is chosen, as this is not a requirement mentioned as part of Annex 7 of the The Danish Environmental Assessment Act regarding the content of the EIA report, but only mentioned as part of Annex 6 on elements to be included in the authorities' screening of whether an annex 2 project is subject to an EIA. As the analytical framework will be used to analyse EIA reports, it has been decided to exclude this requirement from the analytical framework.

Based on the identified requirements and recommendations, six overall categories assessed relevant for EIA reports are put forward: *Assessment of climate change impacts on the project, Assessment of adaptation, Assessment of environmental interrelations, Climate change monitoring, Use of scientific knowledge and data*, and *Transparency*. For each of these categories relevant requirements and recommendations are included. As the legal requirements do not specify how to make the assessments, it has been decided to use the identified recommendations related to the requirements when assessing whether the requirements appear. For some of the categories both requirements and recommendations exist and for other categories only recommendations exist.

To operationalize the assessment of whether the recommendations appear in the reports, criteria for appearance have been put forward. These criteria are based on the knowledge obtained by investigating legislation, guidelines, best practice principles and recommendations in research, supplemented with other relevant information to adjust the framework to a Danish context for transportation infrastructure projects. At a dialogue meeting, a draft for the analytical framework is discussed with Wejs [2024], who is market director at NIRAS working with climate adaptation and planning. Based on inputs from Wejs [2024], the analytical framework is adjusted to the final version presented in figure 5.2.

Legal requirements	Recommendations	Appear/does not appear
Assessment of climate change impacts on the project		
Assessment of the vulnerability of the project to climate change	Include assessment of climate change impacts and how these will affect the project if adaptation measures are not established	Appear: Assessment of the expected impacts on the project due to changes in rain, groundwater, watercourse, sea levels rise, heat, drought, or wind if climate adaptation is not applied to the project. *
	Include a long time horizon	Appear: A time horizon of at least 50 years is used in the assessments. **
	Include assessment for each project phase	Appear: Climate change impacts are assessed for minimum construction and operation phase. ***
Assessment of adaptation		
Assessment of adaptation measures to avoid, prevent, reduce or neutralize expected significant negative impacts	Use national/sectoral objectives for climate change adaptation or alternatively state the objective regarding climate adaptation of the project clearly	Appear: Explicit reference to either national or sectoral objectives or the objective/reason for considering climate change adaptation is stated explicit.
	Include adaptation measures with focus on resilience, recovery and/or adaptation in the design of the project	Appear: Climate change adaptation is included in the design of the project for example through dimensioning of the infrastructure and/or chosen protection levels. This can either be visible in the description of the project and/or the description of the adaptation measures in the EIA report, where a direct reference to climate change adaptation is mentioned.
Assessment environmental interrelations		
Assessment of interrelation between different environmental factors related to climate.	Include assessment of the environmental interrelations between climate change impacts and other environmental factors	Appear: Assessment of interrelation(s) between climate change impact(s) and other environmental factor(s).
	Include assessment of interrelations between adaptation and mitigation measures	Appear: Assessment of interrelation(s) between climate change adaptation and mitigation measure(s).
	Include assessment of both positive and negative environmental and climate interrelations	Appear: Both positive and negative interrelations are assessed.
Climate change monitoring		
	Include follow-up monitoring of the expected climate change impacts and the effects of the planned adaptation measures	Appear: Monitoring regarding climate change impacts and/or adaptation measures are addressed.
Use of scientific knowledge and data (scenarios)		
	Build the assessments on scientific scenarios, knowledge, data, and models	Appear: Use of specific scenarios from IPCC (A1B, RCP4.5 or RCP8.5)/DMI. ****
Transparency		
	Be transparent about limitations, assumptions, and uncertainties in the assessments	Appear: Description of limitations, assumptions and uncertainties directly related to the assessment of climate change impacts and adaptation measures.

Figure 5.2. Analytical framework for assessment of climate adaptation in EIA reports.

* Following the recommendation by Wejs [2024], the included climatic factors in the analytical framework are based on climatic factors included in the Danish Klimaatlas (tool by DMI providing data on the future Danish climate), C40 and DK2020.

** In the Danish *Guidance on using emissions scenario* by DMI [2018] by DMI [2018], it is stated that the time perspective should be chosen based on the project type and requirements for resilience. In the Danish *Guidance on using emissions scenario* it is stated that large infrastructure projects with a long life time should be dimensioned using a long time horizon, but no specific recommendations are presented. Wejs [2024] recommends considering the lifetime of the trace of the infrastructure project as well as the payback time of the project when choosing an appropriate time horizon for the project. As infrastructure projects have a long lifetime of the trace, it is assessed that the considered time horizon should be at least 50 years, and preferable longer.

*** Demolition of transportation infrastructure is not assessed relevant in relation to climate adaptation, which is supported by Wejs [2024].

**** In the Danish *Guidance on using emissions scenario* by DMI [2018], it is stated that planning should be based on the scenarios from IPCC, which is converted to a Danish context by DMI. In 2010 The Danish Environment- and energy minister recommended the municipalities to use the SRES A1B scenario from IPCC for planning up until 2050 [DMI, 2018]. In relation to the newer RCP scenarios from IPCC, the Danish *Guidance on using emissions scenario* recommended using RCP4.5 for planning with a time horizon up until 2050 or for project with a longer time horizon but no strong requirements for resilience. For projects with a time horizon after 2050 or strong requirements for resilience, it is recommended using RCP8.5 [DMI, 2018]. This is supported by the Danish *Guidance on planning for prevention of flooding an erosion* by Bolig- og planstyrelsen [2022] in which it is stated that according to the Danish state, planning for municipal climate adaptation should be based on the scenarios RCP4.5 and RCP8.5. Also Wejs [2024] recommend always using the scenarios from IPCC or the corresponding national scenarios from DMI, as this is the recommendations provided in formal guidelines. As scenarios are a central part of the scientific foundation of the assessment, it is decided to include it as a minimum criteria for this recommendation to be categorized as appearing that an explicit reference is made for either IPCC scenarios (A1B, RCP4.5 or RCP8.5) or corresponding scenarios from DMI.

5.6 Sub-conclusion

Looking at the legal requirements for climate adaptation in EIA, the project's vulnerability to climate change, adaptation measures, and the interrelationship between different environmental factors, including those related to climate, should be included in the assessments. Climate is also relevant in relation to the assessment of disaster risk and accidents as part of the authorities' scoping of the project.

Looking at guidance documents on integrating climate change adaptation into EA, the Danish guideline mentions a few examples of possible assessment areas such as raising water levels, but does not elaborate further on the legal requirements. The EU guidance *Environmental Impact Assessment of Projects - Guidance on the preparation of the Environmental Impact Assessment Report* elaborates that the assessment should

include how climate change can affect the project and how the project can adapt to this over its lifetime, and that the assessment should consider trends and risks due to uncertainties. Otherwise, the climatic element is not elaborated further in the guide. The *EU Guidance on Integrating Climate Change and Biodiversity into Environmental Impact Assessment* provides more specific recommendations and for example highlights the importance of assessing interrelations. IAIA presents best practice principles for integrating climate change considerations into impact assessment and suggests both specific recommendations for adaptation as well as relevant surrounding factors essential for sufficient operationalization in practice.

Identified improvement potentials in research include for example recommendations on assessment of climate at both SEA and EIA level and increasing the focus on and knowledge about climate change through training of practitioners or promoting research on the area. Also an increased focus on adaptation, a holistic approach and assessment of interrelations to other environmental or climatic factors are highlighted as central improvement potentials.

Based on the identified requirements and recommendations, an analytical framework has been developed, which is used in the analysis of EIA reports presented in the next chapter.

Current practice of integrating climate adaptation in EIA reports 6

To answer sub-question two on how climate adaptation appears in Danish EIA reports on transportation infrastructure projects, this chapter summarizes the findings of the analysis of EIA reports. First, a mapping in the Danish EA-hub is conducted to get an overview of how often climate adaptation is included in EIA reports on transportation infrastructure projects. This overall overview is followed by an analysis of seven reports that incorporate climate adaptation with the purpose of investigating how climate adaptation appears, when it is included in the EIA reports.

6.1 Overall overview - mapping in EA-Hub

This section summarizes the findings from the mapping in the EA-Hub with the purpose of identifying how common inclusion of climate adaptation in Danish EIA reports on transportation infrastructure projects is.

To identify transportation infrastructure projects in the EA-Hub, relevant projects from appendix 1, 7a), 7b) and 7c) and appendix 2 10c), 10e) and 10h) are identified. To investigate how many of the identified transportation infrastructure projects that address climate adaptation, a search was made for project that include direct reference to either climate adaption, climate proofing, or vulnerability to climate change. The methodological approach and considerations behind the mapping and are further elaborated in chapter 4, section 4.3.2.

Figure 6.1 presents an overview of the results from the mapping in the EA-Hub.

Transportation infrastructure projects			**Climate adaption**	
Seach	Relevant results		Search	Relevant results
Filtering: projects + Appendix 1, 7a), 7b) and 7c)	47	+	Advanced search: climate adaption or climate profing Vulnerability to climate change	11
Filtering: projects + Appendix 2, 10c), 10e) og 10h)	52	+	Advanced search: climate adaption or climate profing Vulnerability to climate change	7
Total	99			**18**

Figure 6.1. Mapping of climate adaptation in transportation infrastructure projects, EA-Hub.

As illustrated by figure 6.1, a total of 99 transportation infrastructure projects are identified in the hub. When adding the identified relevant search terms related to climate adaptation to the 99 transportation infrastructure projects, the search in the hub reveals that 18 out of the 99 projects directly address climate adaptation. Thereby, the mapping in the EA-Hub reveals that only 18,2 % of the identified transportation infrastructure projects mentions the terms climate adaptation, climate proofing or vulnerability to climate change.

To look closer into how climate adaptation appears in some of the 18 projects that include climate adaptation, the next section presents the findings of an analysis of seven of the projects.

6.2 Analysis of EIA reports

In this section, the findings from the analysis of climate adaptation in seven EIA reports for transportation infrastructure projects are presented. First, an overview of the selected projects is provided. This is followed by an overall overview of the results of the analysis, which is then further elaborated in relation to each of the six categories from the analytical framework presented in section 5.5 (assessment of climate change impacts on the project, assessment of adaptation, assessment of environmental interrelations, climate change monitoring, use of scientific knowledge and data, and transparency).

6.2.1 Description of selected projects

Based on the 18 identified transportation infrastructure projects in the EA-hub addressing climate adaptation, seven projects are selected for further research. In the following sections, each project is described at an overall level. Considerations on the selected projects are elaborated in chapter 4, section 4.3.3.

New railway Hovedgård - Hesselager

This project entails construction of a new railway from Hovedgård north of Horsens to Hesselager south of Aarhus. The railway stretch will be between 23.4 and 24.7 km depending on the final line of the route [Banedanmark, 2019].

A first version of an EIA report was published in 2017 and was sent in public hearing. Relevant inputs from the public hearing are included in the final version of the EIA report published in 2019. Banedanmark has developed the EIA report but the final decision of the project is a political decision taken by the Danish Parliament, and the project is still awaiting this decision [Banedanmark, 2024c].

The material used in this analysis is the final EIA report from 2019 ([Banedanmark, 2019]) and an associated technical note on climate adaptation ([Banedanmark et al., 2018a]), as it is stated in the EIA report that the technical notes are part of the EIA assessment of the project.

New railway Billund

This project includes construction of a new railway from Jelling near Vejle to Billund with stations at both Billund Airport and Legoland Billund. The railway stretch will have a

length of approximately 19-20 km depending on the final line of the route [Banedanmark, 2018].

An EIA report was published in 2018 and sent in public hearing. Afterwards, new information on the project has resulted in a supplementing EIA assessment and hearing. Banedanmark has delivered the final material for a decision and a political settlement of the project is still awaiting [Banedanmark, 2024a].

The analysis in this study is based on the EIA report published in 2018 ([Banedanmark, 2018] and a supplementing technical note on climate adaptation ([Banedanmark et al., 2018b]). Material from the supplementing EIA report is not public available and therefore not included in the analysis.

Electrification of railway Roskilde - Kalundborg

The project of electrification of the existing railway stretch between Roskilde and Kalundborg includes construction of masts and overhead wires every 60-100 meters along a 79 km long stretch [Banedanmark, 2017]. As part of the project, the railway trail needs to be lowered under 12 existing road bridges to make space for the masts and overhead wires, two new road bridges need to be constructed, and one footbridge needs to be raised. Furthermore, construction of two distribution stations and two auto-transformers is necessary [Banedanmark, 2017].

In 2017 Banedanmark published an EIA report for the project, which was sent for public hearing. Afterwards, the material for decision was sent to the Danish Parliament which decided to implement the project, and in September 2020 the electrification work began. It is expected that electric trains will be used on the stretch from December 2024 [Banedanmark, 2024b].

The analysis in this study is based on the EIA report published in 2017 ([Banedanmark, 2017]). No other background material is available.

Expansion of highway E45 Aarhus N - Randers N

This project entails an expansion of the existing highway E45 on a 32 km stretch between Aarhus North and Randers North. This includes expansion of the highway from four to six lanes, and changes in access roads, drainage systems and other constructions [Vejdirektoratet og NIRAS, 2020a]. As part of the EIA, two optional solutions are investigated, one of them being climate adaptation of the highway in the area around Gudenåen [Vejdirektoratet og NIRAS, 2020a].

In 2020 Vejdirektoratet published an EIA report on the expansion, which was sent for public hearing. After the public hearing an appendix for the EIA was developed. The material is sent for political settlement and the final decision is still awaiting [Vejdirektoratet, 2024b].

The EIA report from 2020 ([Vejdirektoratet og NIRAS, 2020a], the supplementing appendix for the EIA report ([Vejdirektoratet og NIRAS, 2020b] as well as a technical background report on drainage ([Ramboll, 2020]) are used as material for the analysis of this study.

Expansion of highway E45 Vejle - Skanderborg

The expansion of E45 Vejle - Skanderborg includes expansion of a stretch of 37.5 km from four to six lanes between Vejle and Skanderborg South. Furthermore, access roads, car pooling areas, and lay-bys will be expanded to meet future needs [Vejdirektoratet og Ramboll, 2020a].

Vejdirektoratet has published an EIA report for the project in 2020, and after inputs from the public hearing, also a supplementing EIA report was published. After political treatment of the decision material the project was approved and is now under construction [Vejdirektoratet, 2024c].

The material used in the analysis of this study includes the EIA report ([Vejdirektoratet og Ramboll, 2020a]), the supplementing EIA report ([Vejdirektoratet, 2020b], a technical background note related to surface water ([Vejdirektoratet og Ramboll, 2020c], and a technical background note on drainage ([Vejdirektoratet og Ramboll, 2020b]).

Construction of 3. Limfjordsforbindelse

3. Limfjordsforbindelse has been under planning for many years. In 2014 it was decided that the connection over the fjord should cross the small island of Egholm [Vejdirektoratet, 2024a]. The project consists of construction of a 20 km long highway going west of Aalborg via Egholm and connect the two existing highways, E45 Nordjyske Motorvej and E39 Hirtshalsmotorvejen [Vejdirektoratet, 2024a]. The highway will have four lanes and includes a tunnel from Aalborg to Egholm and a low bridge from Egholm to Nørresundby [Vejdirektoratet, 2024a].

In 2021 an updated version of the EIA report from 2011 was published that focuses on the Egholm connection. After the public hearing of the 2021 version of the EIA report and the corresponding draft for a construction law, the project was postponed as it was decided that a supplementing EIA focusing on Natura 2000, groundwater and surface water was necessary [Sweco og Vejdirektoratet, 2023]. In 2023 this supplementing material was published and sent to political processing. On 14-05-2024 the Danish Parliament approved a construction law for the project, and the further planning of the construction work has now begun [Vejdirektoratet, 2024a].

The material included in the analysis of this study is the EIA report from 2021 ([Ramboll, 2021a]) and supplementing technical background reports related to respectively drainage ([Vejdirektoratet, 2020a]) and hydraulic dimensioning ([Ramboll, 2021b]). Further, the supplementing EIA report from 2023 ([Sweco og Vejdirektoratet, 2023]) is included as well as a background report on climatic impacts ([Vejdirektoratet, 2023]).

Bypass road - Nimtofte

This project entails construction of a 4.2 km long bypass road around the city of Nimtofte on Djursland. The project further includes a driveway entrance to the parking lot of the entertainment park Djurs Sommerland and construction of a 1.2 km long cycle path [Syddjurs Kommune og Ramboll, 2017].

An EIA report for the project was published in 2017, and the project is now constructed and in use. The EIA report ([Syddjurs Kommune og Ramboll, 2017]) is used as analysis material in this study. No further background material is available.

In the following sections, the results of the analysis of the EIA reports are presented.

6.2.2 Overall overview

For each project, relevant text bites in the EIA material are identified. Here it should be noted that only explicit references to climate adaptation are identified and potential indirect references are not included in this analysis.

The projects are analysed using the analytical framework presented in section 5.5. Based on the identified relevant text bites, it is assessed whether the recommendations from the analytical framework appear or do not appear. The purpose of the analysis is to provide an overall overview of the appearance, but an in depth evaluation of the quality of the assessments in the EIA material is not a part of this analysis. In the following figures, red represents that the recommendation does not appear, while green represents that the recommendation appears. Here it should be noted that red is not necessarily a problem, as not all recommendations will necessarily be relevant for all projects and an assessment in the initial phases can potentially have resulted in that the elements is deemed not relevant and therefore not included in the EIA material. However, when central elements are not addressed in the EIA material, it can create doubt whether it has been considered or not. This is related to an overall discussion of how much to include in the EIA reports to ensure transparency but not including "everything", which will be further addressed in chapter 8. The methodological approach and considerations behind identification of relevant text bites and the analysis are elaborated further in section 4.3.3.

An overall overview of the results of the analysis is presented in figure 6.2 on the next page.

Looking at the figure, the recommendations appear to varying degree. The three projects where the highest number of recommendations appear are *New railway Hovedgård - Hesselager* (7/12), *New railway Billund* (8/12) and *Construction of 3. Limfjordsforbindelse* (7/12). These projects are all construction of new large infrastructure. *Electrification of railway Roskilde - Kalundborg*, *Expansion of highway E45 Aarhus N - Randers N*, and *Expansion of highway E45 Vejle - Skanderborg* are all projects related to existing infrastructure. *Bypass road - Nimtofte* is also construction of a new road, but this is a significantly smaller project than construction of a railway or highways. Thereby, the results of the analysis could indicate that climate adaptation is addressed in greater detail in projects related to larger new constructions than projects related to maintenance or upgrading of existing infrastructure.

Another overall pattern derived from figure 6.2 is that the climate change impacts on the project and adaptation measures can be identified in all of the projects in more or less detail, while the remaining categories only have been identified in a few of the projects.

In the next sections, the results of the analysis related to each category is presented in greater detail.

Legal requirements	Recommendations	New railway Hovedgård - Hesselager	New railway Billund	Electrification of railway Roskilde - Kalundborg	Expansion of highway E45 Aarhus N - Randers N	Expansion of highway E45 Vejle - Skanderborg	Construction of 3. Limfjordsforbindelse	Bypass road - Nimtofte
Assessment of climate change impacts on the project								
Assessment of the vulnerability of the project to climate change	Include assessment climate change impacts and how these will affect the project if adaptation measures are not established							
	Include a long time horizon							
	Include assessment for each project phase							
Assessment of adaptation								
Assessment of adaptation measures to avoid, prevent, reduce, or neutralize expected significant negative impacts	Use national/sectoral objectives for climate change adaptation or alternatively state the objective regarding climate adaptation of the projects clearly							
	Include adaptation measures with focus on resilience, recovery and/or adaptation in the design of the project							
Assessment environmental interrelations								
Assessment of interrelation between different environmental factors related to climate	Include assessment of the environmental interrelations between climate change impacts and other environmental factors							
	Include assessment of interrelations between adaptation and mitigation measures							
	Include assessment of both positive and negative environmental and climate interrelations							
Climate change monitoring								
	Include follow-up monitoring of the expected climate change impacts and the effects of the planned adaptation measures							
Use of scientific knowledge and data (scenarios)								
	Build the assessments on scientific scenarios, knowledge, data, and models							
Transparency								
	Be transparent about limitations, assumptions, and uncertainties in the assessments							

Figure 6.2. Overall overview of the results. Green represents that the recommendation appears, red represents that the recommendation does not appear.

6.2.3 Assessment of climate change impacts on the project

Looking closer at the first category in the analytical framework *Assessment of climate change impacts on the project*, figure 6.3 on the next page provides an overview of the results.

The first recommendation in this category is that an assessment of climate change impacts on the project should be present. It can be argued that such an assessment is fundamental for assessing the vulnerability of the project and thereby complying with the legal requirements. Looking at the results it is also visible that assessment of climate change impacts on the project appears in all of the investigated projects. However, looking closer into the assessments in the different projects, it is clear that the level of detail and the included climatic factors vary among the projects.

A general pattern identified is that all of the projects include assessment of the risk of flooding caused by more frequent extreme rain, changes in groundwater levels, and changes in water flow in watercourses. In *Electrification of railway Roskilde - Kalundborg*, *Expansion of highway E45 Aarhus N - Randers N*, and *Construction of 3. Limfjordsforbindelse* the risk of flooding due to rising sea levels and storm flooding is also included in the assessments. In relation to flooding also the risk of undermining of infrastructure is addressed in *New railway Billund*, while both *New railway Hovedgård - Hesselager* and *New railway Billund* also include the risk of erosion in the assessments. Furthermore, the connection between drought an risk of flooding is included in both *New railway Hovedgård - Hesselager* and *New railway Billund*. This indicates that the two projects related to constructions of railways include more elements in the assessment of the risk of flooding compared to the remaining projects.

The impacts mentioned above are all related to water. Other environmental impacts such as increased temperatures and changes in wind conditions are only included in the assessments of some of the projects. Both *New railway Hovedgård - Hesselager* and *New railway Billund* address potential future impacts due to more frequent and extreme storms. This is exemplified in the following quote from *New Railway Billund: "Changing wind conditions can affect constructions where wind impact requires special design and strength. For railways, this can include overhead wires, masts and other smaller installations or constructions. Increased wind can also have an impact on snowdrifts. The increased wind conditions may eventually require special dimension of railway equipment..."* [Banedanmark et al., 2018b,p. 17]. Though, it is stated that the current climate scenarios for wind does not require climate adaptation for now [Banedanmark et al., 2018b]. The effects of climate change on the conditions in watercourses are addressed in both *Construction of 3. Limfjordsforbindelse* and *Expansion of highway E45 Vejle Skanderborg*, and in *Construction of 3. Limfjordsforbindelse*, also risk of traffic accident or structural collapse of constructions due to flooding are highlighted. In general for the assessments of the impacts due to for example increased temperature and changes in wind conditions, the impacts are in most cases highlighted as potential impacts at a general level but not put in direct relation to the specific project. For example in *Construction of 3. Limfjordsforbindelse* it is highlighted that: *"The condition of Danish water courses is already affected and is expected to be further affected by climate change such as higher temperatures and increased rain."* [Ramboll, 2021a,p. 135], but this is not assessed further

Assessment of climate change impacts on the project			
Legal requirements	**Assessment of the vulnerability of the project to climate change**		
Recommendations	**Include assessment climate change impacts and how these will affect the project if adaptation measures are not established**	**Include a long time horizon**	**Include assessment for each project phase**
New railway Hovedgård – Hesselager	• Risk of flooding and erosion due to more frequent and extreme rain • Risk of flooding due to changes in groundwater levels and watercourses • Risk of flooding due to drought • More frequent and extreme storms (general level)	• Expected lifetime: 120 years • Climate proofing against future climate is necessary • Mapping of flow path and depression at 100 years events	• Assessment of construction and operation
New railway Billund	• Increased risk of flooding and erosion due to more frequent and extreme rain, increased groundwater levels, and increased flow of water in lakes and watercourses • Risks of undermining • Potential impacts due to changes of wind conditions and increased temperatures • Consequences of drought on surface runoff	• Expected lifetime: "the rest of this century and a period in the next" • Assessments in a 50–100-year perspective	• Assessment of construction and operation
Electrification of railway Roskilde – Kalundborg	• Risk of flooding due to more frequent and extreme rain, increased sea levels and storm flooding • Risk of flooding due to storm flooding	• The time perspective is not stated	• Assessment of construction and operation
Expansion of highway E45 Aarhus N - Randers N	• Risk of flooding in the area around Gudenåen due to increased sea levels and risk of storm flooding. • The existing drainage of the remaining stretch is not dimensioned for future changes in rain, but the consequences is not addressed further	• Assessments are made for climate conditions in 2040 (20 years). • Assessment of risk of storm flooding at 100 years events	• Only assessment of impacts in operation • Construction phase included in assessment of environmental interrelations
Expansion of highway E45 Vejle – Skanderborg	• Risk of flooding due to increased water amount in watercourses, lakes, and river valleys • Potential risk of desiccation of water courses due to less rain in the summer (general level)	• The time perspective is not stated	• Only assessment of impacts in operation
Construction of 3. Limfjordsforbindelse	• Risk of flooding due to more frequent and extreme rain, and raising sea and groundwater levels • Effects on the condition of watercourses due to increased amounts of rain • Risk of traffic accident or structural collapse of constructions due to flooding • Possible effects on the conditions of watercourses due to increased temperatures (general level)	• The time perspective is not stated	• Assessment of construction and operation
Bypass road – Nimtofte	• Risk of flooding due to increased amount of rain and more frequent and extreme rain • Possible effects on the conditions of drainage especially around Sorte Å is mentioned but not assessed further	• The used climate change models on Klimatilpasning.dk include calculations for expected rain for the period 2021-2050 (4-33 years)	• Assessment of construction and operation

Figure 6.3. Overview of the assessment of climate change impacts on the project. Green represents that the recommendation appears, red represents that the recommendation does not appear.

in relation to the specific project.

One of the main differences identified related to the level of detail in the assessments is whether the assessment is a qualitative assessment only mentioning that an increased risk of for example flooding is present due to future climate changes, or if the assessment builds upon a quantitative assessment including for example models and calculations for the specific expected impact on the project due to climate changes. For example in the project *New railway Hovedgård - Hesselager*, quantitative screenings of path flows and depressions are mapped, while for example *Expansion of highway E45 Vejle - Skanderborg* only includes an overall description of the increased risk of flooding due to climate changes, but no maps or calculations for the expected impact of this specific location is presented. As *Expansion of highway E45 Vejle - Skanderborg* includes an assessment of the future impacts due to climate changes, the criteria does appear, but the quality of the assessment can be questioned.

The climate change impact will also depend on the project type. For example in the project *New railway Hovedgård - Hesselager*, it is stated that: *"...there are two main factors that make a railway facility generally less vulnerable to extreme rain than, for example, roads [...] First, the majority of the nation's railways run through open countryside [...] Should minor, temporary flooding occur near the railway, it will not have a major impact on the railway operation or the facility itself, as the railway, unlike roads, is often above ground level. [...] Secondly, the railway structure is designed to receive and handle large amounts of rainwater."* [Banedanmark et al., 2018a, p. 13]. This indicates, that some general conditions for railways exist, that influence how this project type is affected by climate change impacts compared to for example a road. Therefore, the project type should also be kept in mind when assessing the impacts.

Thereby, in relation to the first recommendation on assessment of climate change impacts on the project, there seems to be a main focus on water related impacts on the projects, while impacts caused by e.g. heat, drought or wind are only assessed in some of the projects and often at a general level. The level of detail and included climatic factors in the assessment vary among the different projects, and in this context the project type can also play a role.

The recommendation on considering a long time horizon (A minimum of 50 years) only appears in *New railway Hovedgård - Hesselager* and *New railway Billund*. In *Expansion of highway E45 Aarhus N - Randers N* the climate impacts are assessed in relation to the conditions in 2040, while *Bypass road - Nimtofte* includes the expected conditions in 2050. In the three remaining projects the time perspective used in the assessment of climate change impacts is not stated.

The last recommendation connected to assessment of climate change impacts on the project is to make assessments of both construction and operation phases. As illustrated by figure 6.3, five out of the seven projects include assessments of both construction and operation phases. Climate change impacts during construction phase could for example be that excavations creates depressions in the terrain and temporary soil embankments can further create obstacles for the natural flow of surface water, which can create flooding during extreme rain, as explained in *New railway Hovedgård - Hesselager* [Banedanmark, 2019].

Assessing the project's vulnerability to climate change is a legal requirement. Looking at the appearance of the related recommendations it can at an overall level be argued that this legal requirement is present in the EIA reports, as all of the investigated EIA reports at a minimum include an assessment of expected climate change impacts on the project. Though, also some of the recommendations hold a potential for improvement. The level of detail and included climatic factors in the assessment vary among the project and it be questioned whether more focus should be on climatic factors not related to water such as increased temperatures and changes in wind conditions, and if a qualitative assessment of the impacts without a specific analysis of the area in focus is sufficient. Further, including a long time horizon (minimum 50 years) in the assessment of climate change impacts could advantageously be integrated into more of the projects.

6.2.4 Assessment of adaptation

An overview of the results of the analysis of the second category in the analytical framework *Assessment of adaptation* is presented in figure 6.4.

Assessment of adaptation		
Legal requirements	**Assessment of adaptation measures to avoid, prevent, reduce, or neutralize expected significant negative impacts**	
Recommendations	**Use national/sectoral objectives for climate change adaptation or alternatively state the objective regarding climate adaptation of the projects clearly**	**Include adaptation measures with focus on resilience, recovery and/or adaptation in the design of the project**
New railway Hovedgård – Hesselager	• Objective is stated • Reference to IPCC • Reference to Aarhus Municipality's – designated as focus area for flooding	• Water related adaptation measures included in the design of the railway and dimensioning of drainage system • Considerations on surface water runoff, crossing of watercourses and roads, terrain and soil conditions, protection levels, and maintenance of catchwater drains
New railway Billund	• Objective stated with reference to the climate strategy by the Danish ministry of transportation (builds upon goals from FN and EU)	• Water related adaptation measures included in the design of the railway and dimensioning of drainage system • Considerations on as surface runoff, groundwater levels, levelling of the surrounding terrain, undermining of the railway, and maintenance of catchwater drains • Planting of vegetation to handle risk of erosion • Establishment of wind and snow protection belt
Electrification of railway Roskilde – Kalundborg	• National/sectoral objectives or objectives of climate adaptation of the project is not stated	• Placement of distribution stations high in the terrain due to risk of storm flooding • Establishment of pumping stations at vulnerable locations to handle risk of flooding during cloudbursts
Expansion of highway E45 Aarhus N - Randers N	• Objective stated with reference to Randers Municipality's objectives and initiatives to protect the city of Randers again storm flooding in 2040. • Randers is designated as an area of risk in the Floods Directive by EU	• Water related adaptation measures for area around Gudenåen included in the design • Considerations on protections levels, evaluation of terrain, and evaluation of existing and construction of new dikes • Avoidance of crossing of existing watercourses due to future increase in water amounts
Expansion of highway E45 Vejle – Skanderborg	• National/sectoral objectives or objectives of climate adaptation of the project is not stated	• Water related adaptation measures included in the design • Crossing of existing watercourses would be avoided • Construction of fauna passages under the highway for larger surface runoff
Construction of 3. Limfjordsforbindelse	• Objective is stated • Reference to climate adaptation plan and the strategy plan for climate by Aalborg Municipality	• Water related adaptation measures included in the design • Considerations on drainage systems to handle surface water, construction of high walls and bottom of the tunnel, construction of coast dike, avoidance of crossing of existing watercourses, and handling of pumped-up ground water
Bypass road – Nimtofte	• Objective stated with reference to Syddjurs Municipality's plan for climate proofing	• Water related adaptation measures included in the design of the road and dimensioning of the drainage system • Considerations on protections levels, keeping cloudburst roads clear for surface runoff, rainwater basins, and risk of erosion

Figure 6.4. Overview of the assessment of adaptation. Green represents that the recommendation appears, red represents that the recommendation does not appear.

As illustrated by figure 6.4, the two recommendations in this category can be identified in the majority of the projects.

The objective for climate adaptation in the project is stated in five out of the seven projects. For example *New railway Hovedgård - Hesselager* and *New railway Billund* have specific sections, where the need for climate adaptation is elaborated with reference to respectively IPCC (*New railway Hovedgård - Hesselager*) and The climate strategy by the Danish ministry of transportation (*New railway Billund*). The majority of the projects also reference local municipal strategies and objectives for climate adaptation. For *Electrification of railway Roskilde - Kalundborg* and *Expansion of highway E45 Vejle - Skanderborg*, the objective of climate adaptation is not stated directly in the EIA material.

The other recommendation in this category is to include adaptation measures in the design of the project. As illustrated by figure 6.4, adaptation measures appear in all of the investigated projects. Looking closer at the adaptation measures included, it can be concluded that all of the projects includes water related adaptation measures such as dimensioning according to desired protection levels, leveling of the terrain, and avoidance of crossing of existing watercourses. Also the importance of maintenance of catchwater drains is highlighted in several of the projects. Closely connected to handling of flooding a few of the projects include adaptation measures for erosion such as the suggestion for planting of vegetation in *New railway Billund*. The only project where an adaptation measure not related to handling of water is identified, is in *New railway Billund* where it is suggested that it may be necessary to establish wind- and snow protection belts to handle future storms [Banedanmark et al., 2018b]. This supports the findings from the first category, that the main focus is on water related climate change impacts. This is both in relation to the assessment of the impacts and especially when looking at the suggested adaptation measures.

An important point when reading the results of the analysis is that it can vary how much of the project stretch that is included in the assessments and corresponding adaptation measures, which will not necessarily be visible from the results presented in the figures. As visible from figure 6.3 and 6.4, *Expansion of highway E45 Aarhus N - Randers N* for example includes both assessment of climate change impacts and adaptation measures. As explained in section 6.2.1, this project includes an optional solution of climate adaptation of the highway in the area around Gudenåen. Looking closer at the assessments and adaptation measures identified, the analysis shows that climate change impacts and adaptation are only assessed in relation to this optional solution and thereby only connected to this limited stretch of the project around Gudenåen, while assessment and adaptation measures are not assessed for the remaining part of the stretch. It is mentioned, that the existing drainage system for handling of road water on all of the stretch is not dimensioned for future climate changes [Vejdirektoratet og NIRAS, 2020a, section 20.2.1.16], but this is not addressed further. It can be argued, that the assessments need to include all of the stretch to ensure a sufficient assessment and potentially necessary adaptation measures. This also indicates, that a detailed evaluation of the quality of the assessments would require further investigation of the different parts of a stretch. This detailed evaluation of the quality of the assessments is outside the scope of this study.

It is a legal requirement to make an assessment of adaptation measures to avoid, prevent,

reduce, or neutralize expected significant negative impacts from climate change on the project [Miljøministeriet, 2023b]. Overall it can be argued, that the analysis reveals, that this legal requirement is present in all of the investigated projects, as adaptation measures appear in all the reports. The identified adaptation measures are related to impacts connected to water and flooding, while adaptation measures related to for example increased temperatures and changes in wind conditions are only present to very low degree. Though, it should be highlighted that the legal requirement only applies to impacts that are assessed to have a significant negative impact and therefore the absence of adaptation measures related to for example temperature or wind can potentially be explained by an assessment of these impacts revealing that the impact is not significant or not present. Even though the legal requirement is fulfilled in the investigated projects, the analysis indicates that at least considerations on other environmental impacts than those related to water could advantageously be included, and that it is important to make an assessment of all of the project stretch.

6.2.5 Assessment of environmental interrelations

An overview of the results of the analysis of the third category *Assessment of environmental interrelations* is presented in figure 6.5 on the following page.

As indicated by figure 6.5, the recommendations in the third category related to environmental interrelations only appear in the investigated projects to a limited degree. Neither of the three railway projects or *Bypass road - Nimtofte* include assessment of environmental- or climatic interrelations. All three highway projects includes assessments of interrelations between climate change impacts and other environmental factors, but none of the three highway projects include assessment of climatic interrelations between adaptation and mitigation.

For *Expansion of highway E45 Aarhus N - Randers N*, the EIA report contains a section where the impacts on the surrounding environment caused by climate adaptation in the area around Gudenåen are assessed. The main adaptation measure in this project is levelling of the terrain to reduce the risk of flooding. The impact from this levelling of terrain on other environmental factors is assessed including the impact on landscape (visual presentation), archaeology and cultural heritage (impacts on a protected canal and a church), outdoor life and recreational interests (construction work near existing paths), surface water (increased amount of surface runoff affecting an area with lowland soil), and protected nature (temporary and permanent impact on area with protected meadow and bog) [Vejdirektoratet og NIRAS, 2020a]. In *Expansion of highway E45 Aarhus N - Randers N* only negative interrelations are presented.

In *Expansion of highway E45 Vejle - Skanderborg*, a positive interrelation is assessed, as it is highlighted how the construction of fauna passages will function both as climate adaptation and create better conditions for biodiversity [Vejdirektoratet og Ramboll, 2020a]. With reference to Skanderborg municipal plan, it is at a general level further highlighted, that in areas with significant landscape value, elements including those related to climate adaptation measures should be avoided, but that if it cannot be avoided it should always be designed and placed taking the visual character of the landscape into account [Vejdirektoratet og Ramboll, 2020a].

Assessment of environmental interrelations			
Legal requirements	**Assessment of interrelation between different environmental factors related to climate.**		
Recommendations	**Include assessment of the environmental interrelations between climate change impacts and other environmental factors**	**Include assessment of interrelations between adaptation and mitigation measures**	**Include assessment of both positive and negative environmental and climate interrelations**
New railway Hovedgård – Hesselager	• No explicit reference to interrelation between climate change impacts and other environmental factors	• No assessment of climate mitigation measures and their interaction with climate adaptation specific for this project • Connections between climate mitigation and necessary climate adaptation measures highlighted at general level	• No assessment of environmental or climate interrelations
New railway Billund	• No explicit reference to interrelation between climate change impacts and other environmental factors • It is mentioned that planting of vegetation can protect against erosion and that runoff can create wetlands, but the effects and potential interrelations to e.g. flora and fauna is not addressed	• No assessment of climate mitigation measures and their interaction with climate adaptation specific for this project • Connections between climate mitigation and necessary climate adaptation measures highlighted at general level	• No assessment of environmental or climate interrelations
Electrification of railway Roskilde - Kalundborg	• No explicit reference to interrelation between climate change impacts and other environmental factors	• No explicit reference to interrelation between adaptation and mitigation measures	• No assessment of environmental or climate interrelations
Expansion of highway E45 Aarhus N - Randers N	• Impacts from evaluation of terrain (adaptation measure) on landscape, archaeology and cultural heritage, outdoor life and recreational interests, surface water, and protected nature	• No explicit reference to interrelation between adaptation and mitigation measures	• Only negative environmental interrelations are assessed
Expansion of highway E45 Vejle - Skanderborg	• Construction of fauna passages: reduce impacts on biodiversity and will work as climate adaptation (increased possibility of surface runoff) • Construction of climate adaptation measures should be placed and designed taking the visual character of the landscape into account	• No explicit reference to interrelation between adaptation and mitigation measures	• Both negative and positive interrelations are highlighted.
Construction of Limfjordsforbindelse	• Impacts on condition of watercourses (biodiversity) and species due to climate change • Area behind dikes will create increased nature value and biodiversity • Impacts on landscape due to dikes (visual impact). • Adaptation related elements should include considerations on e.g. nature • Inclusion of requirements for fauna passages in construction of underpass of the water causes • Replacement of protected nature areas subject to flooding	• No explicit reference to interrelation between adaptation and mitigation measures	• Both negative and positive interrelations are highlighted.
Bypass road - Nimtofte	• No explicit reference to interrelation between climate change impacts and other environmental factors	• No explicit reference to interrelation between adaptation and mitigation measures	• No assessment of environmental or climate interrelations

Figure 6.5. Overview of assessment of environmental interrelations. Green represents that the recommendation appears, red represents that the recommendation does not appear.

Construction of 3. Limfjordsforbindelse includes assessments of multiple environmental interrelations. For example the impacts caused by future climate change on conditions of watercourses and species in the area are assessed [Ramboll, 2021a; Sweco og Vejdirektoratet, 2023]. Construction of dikes will work as climate adaptation, but also biodiversity and nature considerations are included in the design of this climate adaptation measure as illustrated by the following quote: *"The purpose of the coastal dike is partly to shorten the length of the tunnel and partly to protect the area around the tunnel portal from permanent flooding. It is planned to construct the coastal dike in such a way that there can be occasionally flooded areas and the possibility of exchanging water to and from the fjord. The aim is to create a new nature area with e.g. salt meadows and new breeding areas for the natterjack."* [Ramboll, 2021a, p. 135]. Thereby positive interrelations between climate adaptation and biodiversity and nature are included.

Looking at the compliance with the legal requirement on assessment of interrelations, it can be argued that based on the EIA material, the three railway projects and *Bypass road - Nimtofte* do not comply with this requirement, while the three highway projects do. Overall, it can be argued, that the results of the analysis indicates a need for an increased focus on environmental interrelations. However, it should though be noted that a possible explanation of the absence of assessment of interrelations could potentially be explained by the fact that no relevant interrelations have been identified.

6.2.6 Climate change monitoring

Looking at the fourth category *Climate change monitoring*, figure 6.6 presents an overview of the results of the analysis.

Climate change monitoring	
Legal requirements	
Recommendations	**Include follow-up monitoring of the expected climate change impacts and the effects of the planned adaptation measures**
New railway Hovedgård - Hesselager	• No articulation of climate change related follow-up monitoring
New railway Billund	• Monitoring of drainage system and potential adjustment highlighted as important to adapt to the future water amounts
Electrification of railway Roskilde - Kalundborg	• No articulation of climate change related follow-up monitoring
Expansion of highway E45 Aarhus N - Randers N	• No articulation of climate change related follow-up monitoring
Expansion of highway E45 Vejle - Skanderborg	• No articulation of climate change related follow-up monitoring
Construction of 3. Limfjordsforbindelse	• Monitoring of groundwater after construction can help detect if undesired effects occur such as effects on the constructions
Bypass road - Nimtofte	• No articulation of climate change related follow-up monitoring

Figure 6.6. Overview of monitoring. Green represents that the recommendation appears, red represents that the recommendation does not appear.

From figure 6.6, it can be derived that only *New railway Billund* and *Construction of 3. Limfjordsforbindelse* address monitoring in relation to climate change impacts and/or adaptation.

In *New railway Billund*, besides design and dimensioning of the drainage system and

maintenance of catchwater drains, also monitoring of the drainage system followed by potential continuous adjustment is highlighted as important for adaptation to the future water amounts caused by climate change [Banedanmark et al., 2018b].

In *Construction of 3. Limfjordsforbindelse*, it is recommended to monitor the groundwater after construction to help detect if undesired effects on the surrounding environment have occurred. In this context, climate change is highlighted as it can lead to increased ground water levels, which can potentially affect the constructions [Ramboll, 2021a].

As the remaining projects do not articulate monitoring related to climate change, it can be argued, that this is an area that could advantageously be given more focus in the EIAs, especially considering the uncertainties connected to climate change impacts and the need to create better data foundation for future assessments.

6.2.7 Use of scientific knowledge and data (scenarios)

In figure 6.7 an overview of the results of the analysis of the fifth category *Use of scientific knowledge and data* is provided.

Use of scientific knowledge and data	
Legal requirements	
Recommendations	**Build the assessments on scientific knowledge, data, models, and scenarios**
New railway Hovedgård - Hesselager	• A1B scenario (IPCC) • Terrain model by SCALGO • Standards from Banedanmark, Spildevandskomiteen and Dansk Standard • Instructions from Aarhus, Horsens, Skanderborg and Odder Municipality
New railway Billund	• Climate prognosis from DMI on the 2100 century (builds upon A1B scenario, IPCC) • Blue spot mapping of Denmark (Miljøstyrelsen) • Strategies from Danish government • Standards from Banedanmark and Spildevandskomiteen • Assessments based on experiences, existing knowledge, calculations, models, and common sense
Electrification of railway Roskilde - Kalundborg	• A simple map showing risk of flooding is presented, but not elaborated, and the source of the map or the data used is not articulated • No reference to specific scenarios, models, data, or knowledge
Expansion of highway E45 Aarhus N - Randers N	• Assessments build on model calculations and that knowledge from DMI is • No reference to specific scenarios or models
Expansion of highway E45 Vejle - Skanderborg	• Calculations of waterflow in watercourses based on data from a specific measuring station • No reference to specific scenarios or models
Construction of 3. Limfjordsforbindelse	• Standards from Spildevandskomiteen • It is mentioned that the drainage system is designed in correspondence with relevant legislation and norms, but this is not elaborated • No reference to specific scenarios or models
Bypass road - Nimtofte	• Data from Syddjurs Municipality and climate models from Klimatilpasning.dk • SCALGO • No reference to specific scenarios or models

Figure 6.7. Overview of the use of scientific knowledge and data. Green represents that the recommendation appears, red represents that the recommendation does not appear.

As illustrated by figure 6.7, the recommendation on building the assessments on scientific knowledge, including the use of relevant scenarios for future climate change (IPCC scenarios (A1B, RCP4.5 or RCP8.5) or corresponding scenarios from DMI), is only identified in two out of the seven projects. *New railway Hovedgård - Hesselager* uses the A1B scenario from the IPCC, describing the expected climate changes up until year

2100 [Banedanmark et al., 2018a]. *New railway Billund* uses the climate prognosis from DMI for the expected climate conditions in Denmark in year 2100, and this scenario builds upon the A1B scenario by the IPCC [Banedanmark et al., 2018b]. Thereby, both of these projects are characterized as fulfilled in relation to this category. In the remaining projects no explicit reference to specific scenarios can be identified. Scenarios can potentially have been included in the calculations but this is not stated clearly.

For *New railway Hovedgård - Hesselager*, *New railway Billund* and *Construction of 3. Limfjordsforbindelse* it is highlighted, that present standards such as those from Spildevandskomiteen are used in the dimensioning of the project. It can be argued, that these standards should be used in all of the project. It could be questioned if these standards are actually used in more of the project, but just not mentioned explicit in the material included in the analysis. This is closely connected to last category of the analysis, transparency.

Overall, the results of the analysis of the fifth category indicates, that the use of scientific knowledge and data, including the use of relevant scenarios, could be improved.

6.2.8 Transparency

An overview of the results of the analysis of the last category *Transparency*, is presented in figure 6.8.

Transparency	
Legal requirements	
Recommendations	**Be transparent about limitations, assumptions, and uncertainties in the assessments**
New railway Hovedgård - Hesselager	• Assessments are deemed sufficient, but it is highlighted that the assessments are based on scenarios which will result in uncertainties • Uncertainties of consequences of climate change impacts on railways (general level) • Description of SCALGO and assumption/uncertainties of the tool
New railway Billund	• Assessments are deemed sufficient, but it is highlighted that the assessments are based on scenarios which will result in uncertainties
Electrification of railway Roskilde - Kalundborg	• No description of limitations, assumptions and uncertainties related to the assessment of climate change impacts and/or adaptation measures
Expansion of highway E45 Aarhus N - Randers N	• No description of limitations, assumptions and uncertainties related to the assessment of climate change impacts and/or adaptation measures
Expansion of highway E45 Vejle - Skanderborg	• No description of limitations, assumptions and uncertainties related to the assessment of climate change impacts and/or adaptation measures
Construction of 3. Limfjordsforbindelse	• No description of limitations, assumptions and uncertainties related to the assessment of climate change impacts and/or adaptation measures
Bypass road - Nimtofte	• Basis for assessments are deemed sufficient, but no description of limitations, assumptions and uncertainties related to the assessment of climate change impacts and/or adaptation measures

Figure 6.8. Overview of transparency. Green represents that the recommendation appears, red represents that the recommendation does not appear.

From figure 6.8 it can be derived that transparency related to the assessment of climate change impacts and adaptation measures only appears in *New railway Hovedgård - Hesselager* and *New railway Billund*. In both of these projects, it is stated that the assessments of climate change impacts are deemed sufficiently, but that the assessments are based on scenarios and therefore are connected with uncertainties [Banedanmark et al., 2018a,b]. In *New railway Hovedgård - Hesselager* it is further described, that the

consequences of climate change impacts on railway infrastructure at a general level are connected with uncertainties [Banedanmark et al., 2018a].

In the remaining five projects limitations, assumptions, and uncertainties related to assessment of climate adaptation are not described in the investigated material. A general pattern is that an overall section in the EIA report addressing uncertainties and lack of knowledge at a general level for the EIA is present, but that these limitations are not related to the assessments of climate change impacts. As the recommendation in the analytical framework requires that the limitations, assumptions, and uncertainties are considered specific in relation to the assessments of climate change impacts, these overall sections are considered insufficient.

In *Bypass road Nimtofte*, the basis for assessment is assessed in relation to climate, as illustrated by the following quote: *"It is assessed that the basis for assessing the project's impacts on wastewater, surface water and climate is sufficient to make it possible to carry out the relevant descriptions and assessments."* [Syddjurs Kommune og Ramboll, 2017, p. 101]. This is not elaborated further and no description of limitations, assumptions, or uncertainties is present. As it is deemed unrealistic that no limitation, assumptions, or uncertainties exist at all, this criteria are not deemed fulfilled for *Bypass road Nimtofte*.

Overall, the results of the analysis of the appearance of transparency indicate that an increased focus on describing limitations, assumptions, and uncertainties specific for the assessment of climate adaptation would be beneficial.

6.3 Sub-conclusion

The mapping of EIA reports in the Danish EA-hub reveals that only 18.2 % of the identified transportation infrastructure projects mention climate adaptation, climate proofing or vulnerability to climate change. This indicates a limited focus on climate adaptation in the 99 identified EIA reports. To investigate how climate adaptation is included in EIA material, when it is included, seven of the 18 identified transportation infrastructure projects addressing climate adaptation, are analysed using the analytical framework presented in section 5.5.

The analysis of assessment of climate change impacts on the project (the first category), reveals that all investigated projects assess climate change impacts on the project, but with a varying level of detail and a main focus on water related impacts, while other climatic factors are included to limited degree. Further, the results indicate that also the project type affects the level of detail and the climatic factors included. A long time horizon (at least 50 years) is only applied in two of the projects indicating a potential for improvement. Assessment of both construction and operation phases is present in five out of the seven projects, but with a main focus on operation phase. Looking at the second category, assessment of adaptation, the analysis reveals that the objective of climate adaptation is stated in five out of the seven projects, and adaptation measures related to water are identified in all projects. Only one project includes adaptation measures for other than water related impacts, supporting the finding in the first category that the main focus is on water related impacts on the project. The third category related to assessment of environmental interrelations shows that three out of seven projects assess environmental

interrelations, whereof two assess both positive and negative interrelations. Climate interrelations between adaptation and mitigation are not presented in the investigated material, and overall the analysis indicates a need for an increased focus on interrelations. Related to the fourth category, climate change monitoring, two of the projects address climate change monitoring indicating a potential for an increased focus on this aspect. The analysis indicates that use of scientific knowledge and data, including the use of relevant scenarios (the fifth category) could be improved, as only two out of seven projects have direct reference to relevant scenarios. The last category, transparency, reveals that limitations, assumption, and uncertainties specific for the assessment of climate adaptation are only addressed in two of the projects indicating a potential for increasing transparency on assessment of climate adaptation.

As mentioned previously in this chapter, and elaborated in section 4.3.3, the analysis of the EIA reports builds on identified text bites from relevant EIA material with explicit reference to climate, and text bites with potential indirect references to climate are therefore not included in the analysis. Furthermore, it is important to keep in mind that the analysis identifies whether the recommendations appear or do not appear in the investigated EIA material. An in depth evaluation of the quality of the assessments in the EIA material is outside the scope of this study, and the reason for a recommendation not appearing is not investigated. Here it should be noted, that there can be a reasonable explanation behind not including a recommendation, but at the same time when elements are not mentioned it can create doubt whether it is because the element is not relevant/present in the given project or because it has not been considered and assessed. The dilemma of transparency is further discussed in chapter 8.

To supplement the analysis of the written EIA material and to get insight into the considerations in the surrounding process, the next chapter presents the findings from interviews with relevant actors within the field.

Practitioners view upon current practice 7

In this chapter the results of the analysis of practitioners' view upon current practice of integrating climate adaptation in EIA are presented. The purpose of this chapter is thereby to answer sub-question three on challenges and potential improvement potentials in current practice from a practical point of view. This is investigated through interviews with four actors within the field and supplemented with points from the dialogue meeting with Anja Wejs. This part of the analysis thereby seeks to supplement the findings from the analysis of the EIA reports presented in chapter 6 with considerations on the surrounding EIA process. To get a better understanding of the underlying structures affecting current practice, institutional theory is included to support the analysis of the conducted interview material.

7.1 Correlation between EIA and the surrounding process

As elaborated in section 2.3.2, considerations on climate adaptation can be included in different phases of the project planning and executing and not just in the EIA reports. In this connection, all the respondents explain that climate adaptation is included in the early phases of project design. Riger-Kusk [2024] for example elaborates that in the early project design, potential showstoppers are identified, which are elements that can potentially hinder a project. In this connection climate change impacts related to climate adaptation are highlighted as a potential showstopper: *"Climate [...] is also a show-stopper, because there is no point in putting the road in a place where it will be washed away. So it [climate adaptation] is basically one of the very first things that comes into consideration, and then you slowly get the project in place and then your EIA work starts"* [Riger-Kusk, 2024, 09:30 - 09:55]. This quote illustrates, that climate adaptation is included in the design of the project, and Riger-Kusk [2024] further elaborates, that climate adaptation measures included in the project design becomes a precondition for the remaining project which other environmental parameters must adapt to. As visible from the quote, the EIA according to Riger-Kusk [2024] first begins after the early project design has been established and thereby also after the initial decisions regarding climate adaptation are taken. Furthermore, Riger-Kusk [2024] states, that climate adaptation is already taken care of, when the EIA begins. As elaborated in section 5.3, it is a recommendation identified in literature that climate adaptation should be included in each stage of the assessments, and thereby it can be argued that climate change considerations should be included both in the early phases of the project design and also as part of the EIA process to increase transparency on the assessments made. This can be supported by Wejs [2024], who agrees with Riger-Kusk [2024] that climate adaptation should be

handled in the design of the project, but also highlights that this is not necessarily always the case and that if considerations are not described as part of the EIA report it is not possible to detect how climate adaptation is included in the project [Wejs, 2024]. Thereby, according to Wejs [2024], the decisions taken as part of the project design regarding climate adaptation should always be visible in the EIA reports.

Prahm [2024] agrees that climate adaptation is considered in the surrounding planning process rather than in the EIA process and optimally seen should considered already as part of the project idea. Though, Prahm [2024] also elaborates that it varies among project types whether climate adaptation is included in the project design, and experiences that climate adaptation typically is included more sufficiently in larger new projects compared to for example renovation projects or smaller projects. This is a conclusion that can be supported by the findings of the analysis of the EIA reports, as elaborated in section 6.2.2. Looking at screenings of projects for EIA, Prahm [2024] highlights a lack of correlation between the initial planning of the project design and the EIA screening: *"I would have to say that there is very little correlation [...] There is no professional coordination, and it [the EIA screening] is often a work that just has to be done because it needs to be checked off."* [Prahm, 2024, 06:37 - 06:45]. According to Prahm [2024], EIA holds a greater potential than what is currently utilized: *"People often say that climate adaptation does not really have any legislation and you cannot really make it fit in [in the planning], but in the EIA, that is exactly where you should find that leg."* [Prahm, 2024,07:10 - 07:25], and she further emphasizes: *"It [EIA] could be something more, but mentally it has been reduced to something less"* [08:20 - 08:22]. Thereby Prahm [2024] sees potentials of EIA and EIA screenings to incorporate considerations on climate adaptation, but she *"absolutely not"* experiences, that climate adaptation has a real influence in decisions taken in the screening phase [Prahm, 2024]. As elaborated in section 2.2, and supported by the recommendations identified in international literature presented in section 5.3, the effectiveness of EIA to integrate climate change considerations requires that EIA is used actively to improve projects and affect the decision making and not just a tool to get permission. Thereby, the experiences by Prahm [2024] on the lack of use of EIA to integrate climate change considerations must be described as critical.

While Riger-Kusk [2024] and Prahm [2024] experience a limited correlation between EIA and the remaining planning process in relation to incorporating climate change considerations, it is another experience at Vejdirektoratet (The Danish Road Directorate), where Christiansen [2024] explains the connection between project design and the EIA process as follows: *"In the best version, we work closely together. Project design and EIA actually take place completely simultaneously in an iterative process where some solutions are tested [...] The project design that takes place is constantly assessed against the environmental conditions on the stretch we are working with"* [Christiansen, 2024, 13:20 - 14:05]. The solutions tested are for example in relation to climate change impacts and drainage of the road [Christiansen, 2024]. This is supported by Hjortlund [2024] elaborating that to be able to make EIA there needs to be a project design, but that the two processes work simultaneously to ensure that what is designed is also possible environmentally seen.

Thereby, there seems to be a difference between the experiences of the use of EIA to incorporate climate change considerations among the actors. One possible explanation

could be, that The Danish Road Directorate [Vejdirektoratet] handles larger infrastructure projects, while a consultant or municipality handle projects of different sizes, including smaller projects. This conclusion is further supported by Prahm [2024] and her experience of a greater focus on climate change considerations in new and larger projects than in renovation projects or smaller projects. Thereby, the project types handled in the different organisations of the interviewed actors could be a potential explanation on the differences experienced. Another factor that could potentially explain the differences can be that the expectations and roles among the different actors vary. For example Prahm [2024] explains that a screening of a project for EIA often happens after a project is relatively determined, and that often a political expectation of permission of a project within a fixed time frame is present, resulting in the EIA being a hindrance if the screening gives another result than what is politically desired. Looking at institutional theory, this political pressure can be connected to the regulative pillar. Furthermore, the normative pillar is relevant as the normative pillar for example concerns roles and how specific actors are supposed to act in a given context. These roles are to a high degree driven by sanctions in form of either shame or disrespect when expected roles are not fulfilled and contrary by honor and respect when fulfilling the expected roles [Scott, 2014]. When the political leaders have a clear vision of how a project is supposed to turn out even before an EIA or EIA screening is conducted, it can be argued, that there is a risk that the employees in the municipality can potentially fall into a role of getting a project approved "no matter what" and thereby obtain respect and honor of fulfilling this role. This can potentially create a risk that climate change considerations are not sufficiently included in the EIA process even though potential impacts can be present. Thereby, the experiences from Prahm [2024] could indicate that there in municipalities potentially can be a risk of practitioners getting affected by the hierarchical structure of the organisation in relation to how much climate change considerations are supposed to fill in EIA. It can be questioned if this pressure from above is maybe not present at the same level in for example consultancies. In this connection Riger-Kusk [2024] highlights, that the consult provides an overview of possible solutions and consequences related to climate adaptation, but that the final decisions are made by the developer based on the advising from the consultant. According to Riger-Kusk [2024] it is the responsibility of the consultant to put climate adaptation on the agenda and present these considerations to the developer, as one cannot expect that the developer has the sufficient knowledge on the topic. In this connection Riger-Kusk [2024] highlights that more professional developers such as Banedanmark and Vejdirektoratet (The Danish Road Directorate) handle these considerations and assessments by themselves. This could potentially be part of the explanation why Christiansen [2024] and Hjortlund [2024] from Vejdirektoratet experience a greater coordination and integration of climate change considerations in the EIA process. Thereby, the different roles, as part of the normative pillar, among the actors interviewed can potentially be part of the explanation why they experience the coordination between climate change impacts and the EIA process differently.

Prahm [2024] has been employed in three different municipalities and has experienced that the assessments of climate adaptation are affected by the culture and cooperation in the specific organisation. This can be connected to both the the normative and the cultural cognitive pillar, where norms and values as well as the culture and understanding of climate

adaptation in the organisation affect how people act. At the same time, Prahm [2024] also experiences that within an organisation, the assessments vary depending on the person doing the assessment. Thereby, Prahm [2024] indicates a challenges in current practice of lack of alignment in the way assessments are made. Creating a greater alignment and more standardized approach to the assessments within the field, would require a common understanding across organisations and actors, which will require changes in both the normative and the cultural cognitive pillar.

7.2 Assessment of water related impacts

Looking closer at how the assessment of climate change impacts and corresponding adaptation measures are conducted, all of the interviewed respondents focus on water related impacts and how to handle the future increase in water amounts. This focus on water related impacts corresponds with the findings from the analysis of EIA reports, where other climatic impacts coursed by for example rising temperatures and changes in wind conditions are only addressed to very limited degree, as elaborated in section 6.2.3.

When making assessments of climate change impacts related to water, all of the respondents explain that the risk of flooding in the area is investigated by looking at flow paths and possible drainage of the area. Further, it is a general experience, that models and tools are used to make these analyses, including SCALGO. Also knowledge on the local area and the conditions are highlighted as central in the assessments [Prahm, 2024; Christiansen, 2024]. Both Prahm [2024] and Riger-Kusk [2024] see SCALGO as an appropriate and sufficient tool to make these assessments, but they highlight different challenges. Riger-Kusk [2024] for example highlights that SCALGO and other models do not always provide a true picture. This can be challenging as it is difficult to argue to a developer for implementing expensive adaptation measures, when the calculations for the need of the adaptation measures are not reliable [Riger-Kusk, 2024]. For example Riger-Kusk [2024] experienced a limited use of climate change models in the project *Bypass road - Nimtofte*, of which he was project manager, as the trust in climate change models was still low in the period when this project was made, and therefore models were not used that much. Riger-Kusk [2024] has experienced improvement and increased trust in the models since the project *Bypass road - Nimtofte* was made, but highlights that an ongoing focus should be on improving the models. Here Riger-Kusk [2024] suggests, that this could be through an increased use of follow-up monitoring of projects to investigate whether the climatic impacts are as expected. This approach corresponds with the identified recommendations, as presented in chapter 5, and the results of the analysis of the EIA reports presented in chapter 6 further highlight the improvement potentials in this area.

According to Prahm [2024] another challenge of SCALGO is, that no general guidelines on which layers in the program to include in different analyses exists, making it relatively subjective which parameters are included in the assessments. Therefore Prahm [2024] states that focus should be on developing and improving SCALGO, increasing the understanding of the different functions of the tool, and making it the tool used by all.

7.3 Time horizon and climate change scenarios

A point highlighted by all of the respondents is that the assessments of climate change impacts are always about a balance of the environment and economy. Both Riger-Kusk [2024] and Prahm [2024] connect this to the chosen time horizon for the assessments. According to Riger-Kusk [2024], the time horizon used in the assessments should be a maximum of 50 years, as the uncertainties in a longer time horizon would be too large resulting in a risk of making too conservative assessments: *"You can risk being overly cautious. You can risk wearing both belt and braces, and every time you wear both belt and braces, it costs."* [Riger-Kusk, 2024, 16:16 - 16:32]. A similar view is presented by Prahm [2024], explaining that it is a professional responsibility to choose an appropriate time horizon and climate scenario for the specific project, and that it is about balancing the potential risks and not risk over problematize the impacts due to a too long time horizon. According to Wejs [2024], when choosing a time horizon it is important to be aware of the difference between the lifetime of the materials and the lifetime of the trace of the infrastructure, where, in most cases, the trace will have a longer lifetime than the materials, as the materials, such as asphalt, can be replaced during the lifetime of the trace. According to Wejs [2024], optimally seen, the lifetime of the trace should be included in the considerations when choosing a time horizon for the design and assessments of the project. When not including the lifetime of the trace in the design and assessments, it can result in building infrastructure that will create problems for the future generations, who thereby will be imposed an unreasonable burden, and Wejs [2024] experiences a current tendency of building problems that the future generation will have to handle. An example of this is presented by Christiansen [2024] in relation to the project *Construction of 3. Limfjordsforbindelse* of which he is project manager. Christiansen [2024] explains that it was considered using a longer time horizon resulting in further raising the level of the road and sides of the tunnel, but that this would result in a more expensive solution and a larger visual impact on the area. According to Christiansen [2024] it was decided, that these potential problems of flooding in a longer time horizon must be handled in the future instead, either by changes in the construction or an acceptance of temporary flooding. Following the argumentation by Wejs [2024] on not building problems for future generations to handle, it can be questioned if the approach chosen in *"Construction of 3. Limfjordsforbindelse"* is sustainable. To overcome this challenge, Wejs [2024] points to a need for looking at the payback time of a project, and she states that the payback time of the project should correspond to the lifetime of the trace. Thereby, if a project for example has a payback time of 75 years, the project needs to be designed in a way so that it can handle the climatic conditions present in 75 years [Wejs, 2024]. Thereby it can be argued that an appropriate time horizon will depend on the lifetime of the trace of the infrastructure as well as the payback time of the project.

Both Riger-Kusk [2024] and Prahm [2024] express that no standards for using specific climate change scenarios in the assessments exists in current practice. As highlighted by Prahm [2024] an advantage of this is that it will depend on the specific project what an appropriate time horizon and climate scenario are. On the other hand, Riger-Kusk [2024] also indicates, that it can be challenging to choose the most appropriate climate scenario. In this connection Wejs [2024] highlights that IPCC and the corresponding Danish scenarios from DMI should always be used. As elaborated in section 5.5, the Danish *Guidance on*

using emissions scenario by DMI [2018] recommend using RCP4.5 when planning for municipalities in a time horizon up until 2050 or for projects with a longer time horizon but no strong requirements for resilience, while RCP8.5 should be used when planning for a time horizon longer than 2050 or for project with a need for stronger requirements for resilience. Also in the Danish *Guidance on planning for prevention of flooding and erosion* by Bolig- og planstyrelsen [2022] it is stated that according to the Danish state, planning for municipal climate adaptation should be based on the scenarios RCP4.5 and RCP8.5. With reference to these two documents, Wejs, 2024 states that taken the lifetime of the project into considerations either scenario RCP4.5 or RCP8.5. from the IPCC or the corresponding scenarios from DMI should be used Wejs [2024]. In accordance with this recommendation, Wejs [2024] also highlights, that the desired protection level of for example a road can vary depending on the function of the road. Also Christiansen [2024], who is project manger at *Construction of 3. Limfjordsforbindelse*, explains that this project is critical infrastructure which has affected how large a risk of flooding you can allow. This illustrates that choosing an appropriate scenario depends on multiple factors including the lifetime of the project, the desired protection level for the function of the infrastructure, and the payback time of the infrastructure, but advantageously a standardization of always using appropriate scenarios from IPCC/DMI could be implemented in practice.

Thereby, it can be argued that a standardization among practitioners regarding both the use of climate change scenarios and time horizons could be beneficial. This is connected to the normative pillar and creation of a norm on what an assessment should contain. Further, it is about increasing the common understanding within the field, and thereby a connection to the cultural-cognitive pillar is also present in this regard.

7.4 Uncertainties and transparency

As indicated by the previous section, both Riger-Kusk [2024] and Prahm [2024] express that the challenges of choosing a time horizon and climate scenario to a large degree are connected to the uncertainties regarding the future climate. One of the recommendations identified in this study, and elaborated further in section 2.4 and in chapter 5, is that uncertainties of the assessments should be addressed with transparency, and that this is of special relevance for climate change impacts, as the climate changes are connected with large uncertainties. Though, both Riger-Kusk [2024] and Prahm [2024] experience a limited focus on uncertainties in the current practice. In this connection Prahm [2024] points on the challenge that in current practice there is a tendency to try to provide one specific result rather than presenting the findings as assessments or ranges that the impact could fall within: *"When we have to provide something for an EIA, we always think that we only have to provide factual information [...] You could also provide a consideration or a reflection, but we do not do that - we provide facts. So therefore, the factual information can be very hard, when in reality it is more an assessment or a range"* [Prahm, 2024, 14:30 - 15:11]. Thereby, Prahm [2024] indicates a lack of focus on uncertainties connected to the results presented as part of the EIA, and a norm of providing an accurate result and not a range of possible results. In this regard Prahm [2024] sees a potential for making more nuanced assessments in future EIAs. Looking at institutional theory, this would require a change in norms on how to make the assessments. Though, it can also be argued

that providing assessments with a range of possible results instead of one result could potentially complicate the decision making process, as the basis for decision would thereby be less clear.

Based on this, it can be argued that there is a potential for increasing the focus on uncertainties in EIAs, which also corresponds with the findings of the analyses of the investigated EIA reports, where a limited focus on uncertainties connected to assessment of climate change impacts and adaptation was identified, as elaborated in section 6.2.8. Despite increasing the transparency on uncertainties, an increased use of follow-up monitoring could be beneficial to investigate the actual impacts. This is supported by both Riger-Kusk [2024] and Wejs [2024], who highlight the potentials of monitoring to help evaluate if the adaptation measures in a project were an over- or under dimensioning. Also, it is highlighted that monitoring can be used to ensure that adaptation measures work as expected and that the function of the project is upheld Wejs [2024]. Thereby, follow-up monitoring has the potential to contribute to both ensuring the expected outcome of planned adaptation measures and to increasing knowledge about impacts and adaptation measures for future projects. Increased use of follow-up monitoring is also one of the recommendations identified in guidelines and research as elaborated in chapter 5.

7.5 Assessment of environmental interrelations

According to Christiansen [2024], an overall independent assessment of climate adaptation does not happen in current practice either in the EIA reports or in the discussions in the surrounding process. This indicates, that a potential improvement potential of practice could be to increase the focus on climate change impacts by also having an independent assessment of climate as an environmental factor on equal terms with the remaining environmental factors. However, an independent assessment of climate adaptation cannot stand alone, as climate change impacts affect a range of other environmental factors, as elaborated in chapter 2. Therefore, an assessment of the environmental interrelations with climate is central.

In general the respondents experience a limited focus on interrelation between climate and other environmental factors. This corresponds with the findings of the analysis of the EIA reports presented in section 6.2.5, where environmental interrelations were assessed to a limited degree in the reports. According to Christiansen [2024] and Hjortlund [2024], climate adaptation is indirectly included in the assessments of the different environmental factors, where the relevant professionals should include the impacts of climate changes in the assessment of the specific environmental factors. This could indicate an indirect focus on climate change impacts and interrelations with other environmental factors, but at the same time Christiansen [2024] indicates, that climate considerations are not in focus in relation to all environmental factors. Christiansen [2024] and Hjortlund [2024] highlight that there advantageously could be an increased direct focus on interrelations. According to Christiansen [2024] and Hjortlund [2024], this would require increased knowledge and focus on how climate change can potentially affect the different environmental factors. While Riger-Kusk [2024] views climate adaptation as part of the project design and thereby a precondition for the project and the remaining environmental factors, Prahm [2024] highlights a challenge of lack of interdisciplinary in the assessments of climate and thereby

also experiences a lack of focus on interrelations among climate and other environmental factors. This indicates that one possible explanation for the lack of focus on interrelations could be a lack of knowledge and awareness.

Another challenge and possible explanation for the lack of focus on interrelations is the organisational structures. In this connection Prahm [2024] highlights that a challenge of the current municipal structures is, that everything is divided into silos, making interdisciplinary difficult. This is supported by the findings on challenges in current Danish practice presented in section 2.4, where the current organizational structures of for example authorities, where sectors are divided into different silos, are highlighted as a challenge for obtaining a holistic approach to climate assessments. According to Prahm [2024] an interdisciplinary approach is fundamental for assessment of climate changes, which is also supported by the recommendations presented in chapter 5, and Prahm [2024] explains the challenge of the silo divided structure in the following quote: *"...the reason why people are often allowed to be in these silos is also because, from a management and organizational perspective, you have these nice little white fences around each individual economy and each individual delivery that you have to be measured against as a manager or leader upwards. You do not have an interdisciplinary responsibility for climate, and therefore it is also difficult to lift."* [Prahm, 2024, 21:58 - 22:24]. Thereby, the municipal structure, according to Prahm [2024], hinders the interdisciplinary, and she further elaborates: "*Today, all responsibility is placed on the professionals, but politically you have to be stronger on this. Today, you either have a joint city council or you have a lot of specialist committees, and they do not think interdisciplinary [...] if you want to do this, it requires a cultural change at many different levels..."* [Prahm, 2024, 34:58 - 35:38]. Thereby, according to Prahm [2024] for environmental interrelations to be assessed to greater detail and increased interdisciplinary is necessary which will require changes in the organisational and political structure of municipalities.

Looking at institutional theory it can be argued, that there is a need for changes in the cultural-cognitive pillar, as there is a lack of knowledge of and focus on the interrelations. Further changes in the regulative institution in form of the political structure and organisation would require changes in the regulative pillar.

7.6 Conceptualisation of climate adaptation

All the respondents express that an increased focus on climate change impacts has occurred over the last years. Riger-Kusk [2024] explains that assessment of climate adaptation is much more comprehensive today than just a couple of years ago, and highlights that both politically and from the public the expectations for considering climate change impacts have increased remarkably. Riger-Kusk [2024] was project manager on the project *Bypass road - Nimtofte*, and explains, that the assessment of climate adaptation conducted as part of this project, would not be sufficient today. As elaborated in section 7.2, the practitioners experience a focus on water related impacts while other climate change impacts are only included in the assessments to a limited degree in current practice. This indicates a need for increasing the focus on other climate change related impacts as well. As presented in section 2.4 lack of understanding, awareness and priority of climate adaptation in EIA is a challenge highlighted in the investigated literature. Further, it is a recommendation

in international literature to increase the knowledge on climate adaptation for example through training or motivation of practitioners, as elaborated further in section 5.3. These conclusions are supported by Christiansen [2024] and Hjortlund [2024] who see potential of increasing the understanding and awareness on the different climate change related impacts. Increased knowledge and focus on climate change impacts at a general level could create the foundations for proactive incorporation of climate change considerations in EIA. This need for an increased level of knowledge and awareness and creation of a common understanding can be connected to changes in the culture-cognitive pillar and how the concepts are interpreted. Further, also elements from the normative pillar on what an appropriate assessments contains will be affected by an increased level of knowledge.

7.7 Sub-conclusion

The interviews with practitioners on their experiences of current practice of incorporating climate adaptation in EIA revealed different challenges and improvements potentials. One of the themes investigated is the correlation between EIA and the surrounding planning process, where some of the challenges identified are that climate adaptation is included in the early project design and not always in the following EIA process and does not always have an influence on decision making. This indicates that climate adaptation is not always included in all stages of EIA in current practice. However, also differences between practitioners were experienced and the analysis indicates, that differences among practitioners can be connected to for example different roles, organizational norms, culture and understandings. Looking at the assessment of climate change impacts, a main focus on water related impacts and corresponding adaptation measures is identified. To assess the water related impacts SCALGO is highlighted as an appropriate tool where an ongoing development and improvement should be present. Further, the analysis indicates a lack of alignment in choosing time horizon and climate scenario to be used in the assessments. Here, Danish guidelines and Wejs [2024] recommend using scenarios from IPCC/DMI and including considerations on lifetime of the trace, payback time of the project and the desired protection level when choosing the time horizon. The analysis further indicates a lack of focus on uncertainties and limitations in relation to assessment of climate adaptation, and here more nuanced assessments and increased use of monitoring are highlighted as possible improvements. Looking at environmental interrelations, the interviews indicate a lack of focus on climate adaptation as an independent climatic factor on equal terms with the remaining environmental factors and a lack of focus on environmental interrelations. In this relation, challenges such as lack of an interdisciplinary approach and lack of knowledge and awareness are highlighted. An increased focus on climate adaptation is experienced by all the respondents, but the analysis also reveals a need for increasing focus, awareness, knowledge and understanding of different climatic impacts and potential environmental interrelations. As elaborated throughout this chapter, the challenges and recommendations can be connected to the three pillars of institutional theory. The connection between the identified challenges and the regulative, normative and culture-cognitive pillars is illustrated by figure 8.1 presented in the next chapter.

Recommendations on future EIA practice 8

Based on the conclusions from the analysis in chapter 5, 6 and 7, this chapter presents specific recommendations for increasing the focus on climate change impacts and adaptation in future EIA practice for transportation infrastructure projects. Potentials and challenges of implementing the presented recommendations in practice are discussed.

8.1 Recommendations

Figure 8.1 on the next page provides an overview of challenges related to the three institutional pillars identified in the analysis of the EIA reports (presented in chapter 6) and in the interviews (presented in chapter 7). Further, figure 8.1 presents the developed recommendations on future practice and if the recommendations contribute to handling of respectively regulative, normative or culture-cognitive challenges.

As illustrated by figure 8.1, the majority of the identified challenges in the analysis of EIA reports can be connected to the normative pillar, as most of the recommendations in the analytical framework build upon recommendations and thereby norms on how to make an appropriate assessment. As also illustrated by figure 8.1, the culture-cognitive pillar is not assessed as part of the analysis of the reports, as the culture-cognitive pillar for example relates to the practitioners interpretations and understanding of terms which can be difficult to detect in the EIA reports. In the analysis of practically oriented challenges and potentials, especially normative and culture-cognitive challenges are identified. As it can be derived from the overview in figure 8.1, there is high correlation between normative challenges identified in the EIA reports and challenges highlighted by the respondents.

The recommendations on future practice presented are developed to help overcome the identified challenges in the regulative, normative and culture-cognitive pillars. In this chapter each recommendation is presented, and it is elaborated how it can contribute to handling of the identified challenges and thereby improve practice. As the pillars are interconnected, one recommendation can help handle challenges in more than one of the pillars. Some of the recommendations are directly related to the EIA reports, while other are broader providing recommendations on changes in the surrounding planning process. It should be noted, that the recommendations are developed based on the findings in this study, and a limited focus has been on developing recommendations on elements where the study has identified challenges and the potentials for improvement are high. Therefore, legal requirements and general recommendations on assessment of climate adaptation (as presented in chapter 5) should be followed alongside these recommendations.

	Identified challenges in current practice		Recommendations contributing to handling of challenges
	Analysis of EIA reports	**Analysis of interviews**	
The regulative pillar	• Not all investigated projects assess environmental interrelations (legal requirement) • The level of detail in assessment of legal elements vary significantly	• Silo divided departments challenges transdisciplinarity	4: Increase the use of a transdisciplinary approach 8: Assess both positive and negative environmental interrelations related to climate adaptation
The normative pillar	• Lack of assessment of different climatic factors (mainly focus on water related impacts) • Lack of use of long time horizon • Lack of adaptation measures not related to water • Lack of assessment of assessment of interrelations • Lack of addressing climate change monitoring • Lack of reference/use of relevant climate scenarios • Lack of transparency related to uncertainties and limitations of climate assessments	• Lack of assessment of different climatic factors (only focus on water related impacts) • Lack of alignment in norms on how to make and present assessments – varying assessment methods and approaches to time horizons and scenarios • Only focus on climate adaptation in the initial project design • Norm of not addressing monitoring • Norm of not addressing uncertainties and limitations when presenting results	1: Assess impacts related to heat, drought and changes in wind conditions and not only water related impacts 3: Consider climate change impacts and adaptation in all phases of EIA, decision making, and follow-up, and not only in the initial project design 4: Increase the use of a transdisciplinary approach 5: Use SCALGO to support the assessment of water related impacts 6: The time horizon used should correspond the expected lifetime, payback time and desired protection level of the project 7: Use climate scenarios from IPCC/DMI and argument for the chosen scenarios 8: Assess both positive and negative environmental interrelations related to climate adaptation 9: Be aware off and describe limitations and uncertainties connected to assessment of climate adaptation
The cultural-cognitive pillar		• Lack of common understanding of central terms • Lack of understanding of climate adaptation as an environmental parameter on equal terms with other environmental parameters • Lack of understanding of climatic factors (other than water related) • Lack of understanding / knowledge / awareness of environmental interrelations	1: Assess impacts related to heat, drought and changes in wind conditions and not only water related impacts 2: Consider climate adaptation as an environmental parameter on equal terms with the remaining environmental parameters 8: Assess both positive and negative environmental interrelations related to climate adaptation

Figure 8.1. Overview of identified institutional challenges and corresponding recommendations.

In the following, the recommendations on future practice are presented and elaborated.

1: Assess impacts related to heat, drought and changes in wind conditions and not only water related impacts
As elaborated in chapter 5, one of the recommendations included in the analytical framework is to assess impacts related to changes in rain, groundwater, watercourses, sea levels, heat, drought and wind conditions (see section 5.5). The analysis of the EIA reports reveals a main focus on assessment of water related impacts, while impacts related to heat, drought and wind conditions are only addressed at a general level in three of the investigated projects. Likewise, only one project includes adaptation measures not related to water. The focus on water related impacts is also identified in the interviews, where all respondents focus on water related impacts. Based on the findings of this study, it is therefore recommended to increase the focus on other elements than water related impacts such as temperatures and changes in wind conditions in the future EIA practice for Danish transportation infrastructure projects.

This recommendation can contribute to handling of the identified normative challenge of lack of assessment of different climatic factors where a main focus on water related impacts are identified in both the analysis of the EIA reports and in the interview. To make assessment of impacts related to heat, drought, and changes in wind conditions, knowledge and understanding of these impact types are necessary, and this recommendation is therefore closely connected to the culture-cognitive pillar and the identified challenges of lack of understanding of climatic factors other than water. Therefore, to implement this recommendation in practice it can be argued, that increased knowledge and understanding among practitioners is necessary. This could for example be supported by increased awareness of the different terms and increased research on the area. For example this study can help contribute with increased knowledge and awareness on the area, potentially affecting the future interpretation of climate adaptation among practitioners and thereby leading to changed norms on what to include in the assessments.

2: Consider climate adaptation as an environmental parameter on equal terms with the remaining environmental parameters
Climate is mentioned in the EIA regulation as one of the environmental factors to be assessed. Therefore, it can be argued, that climate including both climate adaptation and climate mitigation is an element, that should be assessed on equal terms with the remaining environmental factors. One of the experiences highlighted by two of the respondents is, that there is a lack of an overall and independent view on and assessment of climate adaptation in current practice. This means that climate impacts and adaptation are not viewed as an independent environmental factor, but only as an element to include in assessments of other environmental factors. Therefore, based on this study, a need for considering climate change as an environmental factor on equal terms with the remaining environmental factors has been identified. Making an overall independent assessment of climate change impacts and adaptation measures on equal terms with the remaining environmental factors could help increase the understanding of and focus on climate change impacts.

Looking at the identified institutional challenges, this recommendation thereby directly corresponds to the identified culture-cognitive challenge on lack of understanding of climate adaptation as an environmental parameter on equal terms with other environmental

parameters.

3: Include climate change impacts and adaptation in all phases of EIA, decision making, and follow-up monitoring, and not only in the initial project design
One of the identified recommendations presented in chapter 5 is to include climate change impacts and adaptation in all phases of the life cycle of the project to ensure a holistic assessment and implementation of climate adaptation. This includes both initial project planning, EIA, design making and following monitoring. It can be argued that the initial considerations and adjustments as well as considerations on follow-up monitoring should be presented in the EIA report to ensure transparency, but as elaborated in section 6.2.6, monitoring is only addressed in two of the investigated projects, thereby indicating a lack of addressing monitoring in EIA reports of Danish infrastructure projects. Also two of the respondents highlight the potentials of follow-up monitoring of the actual climate change impacts and the effects of the planned adaptation measures after project construction to increase knowledge and prevent under- or over problematization of impacts in future projects. Further, two of the respondents experience that climate change impacts and adaptation are included in the early phases of project design rather than in the EIA, and further one of the respondents expresses that climate change assessments and adaptation do not influence the decision making in relation to scoping of transportation infrastructure projects. Thereby, the analysis indicates that the recommendation on assessing climate adaptation in all phases of EIA, as presented in chapter 5, is not fulfilled in current EIA practice. Based on the findings in this study, it is therefore recommended to not only considering climate change impacts and adaptation measures in the initial project design, but also in all phases of EIA (project proposal/application, screening, scoping, assessment) as well as in decision making and follow-up monitoring.

Looking at institutional theory, the findings of the study thereby indicate, that there is a norm in current practice of only integrating climate adaptation in the initial project design, and implementing this recommendation would thereby contribute to handling the identified normative challenges related to lack of addressing monitoring and only focusing on climate adaptation in the initial project design.

4: Increase the use of a transdisciplinary approach
An identified recommendation presented as part of chapter 5 is to use a transdisciplinary approach in the assessment of climate adaptation. A challenge highlighted by one of the respondents is that the use of a transdisciplinary approach is lacking in current practice of assessment of climate adaptation, and the respondent connects this challenge to the sector divided departments in the organisation, making transdiciplinarity difficult. This is further supported by research on the Danish EIA practice, as elaborated in section 2.4. Based on the findings in this study a potential for increasing a transdiciplinary approach within the field to ensure more nuanced assessments of climate change impacts and adaptation measures and to create a better foundation for considering environmental interrelations, is therefore identified.

This recommendation is therefore related to the identified regulative challenge of the silos divided departments that challenge transdiciplinarity. To increase the transdiciplinary approaches, changes in the organisational and political structures would therefore be necessary, which will require changes in the regulative pillar. These changes will be

on a societal level and are not addressed further in this study. Obtaining a more transdisciplinary approach to the assessments would create a better foundation for assessment of environmental interrelations and implementation of this recommendation could therefore also contribute to handling the identified normative challenge of lack of assessment of interrelations.

5: Use SCALGO to support the assessment of water related impacts
The analysis of the EIA reports reveals that the level of detail in the assessments and the methods used to make assessments vary significantly among the investigated projects. Further, it is highlighted by respondents that there is a lack of alignment in methods and approaches to assess climate adaptation. In relation to assessment of water related impacts, all respondents refer to SCALGO as the most appropriate tool, and more of the respondents highlight that focus should be on developing SCALGO and increasing knowledge about this tool, rather than on making new tools. Therefore, it is recommended that SCALGO should be used in the assessments of water related impacts and that an ongoing focus should be on improving the tool and increasing knowledge on the tool.

Implementing this recommendation in practice would contribute to handling the identified normative challenge of lack of alignment in norms on how to make assessments and which methods and approaches to use.

6: The applied time horizon should correspond the expected lifetime, payback time and desired protection level of the project
One of the recommendations identified in chapter 5, is to include a long time horizon in the assessments, and for infrastructure projects it is assessed, that this should be at least 50 years and preferably longer, as elaborated in section 5.5. The analysis of the EIA reports reveals, that only two of the investigated projects use a time horizon of 50 years or more, thereby indicating a lack of use of a long time horizon in current EIA practice for infrastructure projects. Based on the experiences from the respondents presented in chapter 7, there seems to be a lack of alignment in how to choose a time horizon and climate scenarios in current practice. In this context, it is highlighted that an appropriate time horizon depends on the project and the expected lifetime of the trace, the payback time of the project, and the desired level of protection. Therefore, it is recommended to decide upon an appropriate time horizon for the specific project taking these elements into consideration.

Implementing this recommendation could thereby help tackle the normative challenge of lack of alignment in norms on how to make assessments and which methods and approaches to use.

7: Use climate scenarios from IPCC/DMI and argue for the chosen scenarios
It is a general recommendation to build the assessments of climate adaptation on long term climate scenarios, as elaborated in chapter 5. In a Danish context, it is assessed that the current most appropriate scenarios are either IPPC or DMI (RCP4.5 or RCP8.5), as elaborated in section 5.5. The analysis of the EIA reports reveals that only two of the projects refer to the use of scenarios from IPCC or DMI, indicating a potential for improvement. The interviews indicate a lack of standardisation for choosing scenarios, and therefore it is a recommendation by this study to always use appropriate scenarios

from IPPC or DMI (RCP4.5 or RCP8.5), and further it can be argued, that it should be clear in the EIA reports which scenarios the assessments are based upon and why to increase the transparency.

Like the two previous recommendations, this recommendation could also contribute to handling the identified normative challenge of lack of alignment in norms on how to make assessments and which methods and approaches to use and the identified lack of reference and argumentation for climate scenarios in the investigated EIA reports.

8: Assess both positive and negative environmental interrelations related to climate adaptation

One of the recommendations identified in chapter 5 is to make assessments of environmental interrelations, including both negative and positive connections. The analysis of the EIA reports reveals that three of the investigated projects include assessments of environmental interrelations (of which two include both positive and negative interrelations) while none of the projects assess climate interrelations. Three of the respondents also express a limited focus on environmental interrelations in current practice, and challenges such as lack of knowledge and awareness of possible interrelations, lack of transdiciplinarity, and lack of a direct focus on environmental interrelations are highlighted by the respondents. Therefore, based on this study, it is recommended to increase the focus on assessment of positive and negative environmental interrelations by increasing knowledge and understanding of possible interrelations, implementing a more transdiciplinary approach in the assessments, and increasing authoritarian enforcement of the legal requirement of assessment of interrelations.

Looking at institutional theory, implementing this recommendation could thereby contribute to handling of both regulative, normative and culture-cognitive challenges identified in this study. The recommendation can promote the assessment of interrelations in EIA reports, which was identified as a regulative challenge because assessment of interrelations is a legal requirement. Further by changing the norm of how to make assessments by also including environmental interrelations, the normative challenge of lack of assessment of interrelations can be addressed. To include assessment of interrelations a need for an increased understanding is necessary, thereby making the culture-cognitive pillar relevant.

9: Be aware of and describe limitations and uncertainties connected to assessments of climate adaptation

It is a legal requirement to describe limitations, assumptions and uncertainties related to the assessments in the EIA [Miljøministeriet, 2023b]. In this study, it is recommended to include a description of the uncertainties directly related to assessment of climate adaptation as presented in chapter 5. The analysis of the EIA reports shows that only two of the investigated projects address limitations, assumptions or uncertainties related to the climate adaptation assessments, thereby indicating a lack of focus on this in EIA reports for Danish transportation infrastructure projects. A limited focus on uncertainties in current practice are further supported by the conclusions from the interviews. Therefore, it is recommended to increase awareness of limitations, assumptions and uncertainties related specifically to assessment of climate adaptation and to increase transparency by describing limitations, assumptions and uncertainties related specifically to assessment of

climate change impacts and adaptation in the EIA reports.

This recommendation could thereby contribute to handling the identified normative challenge of lack of transparency related to uncertainties and limitations related to assessment of climate adaptation.

8.2 Potentials and barriers of implementing the recommendations

In this section potentials and barriers of implementing the presented recommendations in practice and thereby increasing the focus on climate change adaptation are discussed.

8.2.1 Legal requirements vs. recommendations

Some of the presented recommendations exceed the legal requirements provided by The European EIA Directive and The Danish Environmental Assessment Act. This is closely connected with the EIA legislation being procedural legislation, as elaborated in section 2.3.1. For example it is a legal requirement to describe lack of knowledge and uncertainties in the EIA report [The Danish Environmental Assessment Act, Annex 7 (6)], but the legislation does not specify that this description should be specific for each environmental parameter. The recommendation to increase transparency on limitations and uncertainties specifically related to assessment of climate change impacts and adaptation thereby exceed the legal requirements. Furthermore, the procedural EIA law does not provide requirements on for example time horizons or climate scenarios as provided by the developed recommendations. Therefore, the purpose of the recommendations is to supplement the procedural requirements by for example being more oriented towards the methodological approaches to the assessments. Furthermore, the legal requirements should be considered as the minimum, and as the purpose of this study is to investigate how practice of integrating climate adaptation in the EIA process can be improved, it is deemed necessary to provide recommendations above the legal minimum requirements. However, it can be questioned if it is realistic to implement recommendations that exceed the legal requirements. As highlighted in chapter 7, the analysis indicates, that a balance of economic costs and climate is central in current practice for example regarding not under- or over- problematizing future climate change impacts on the project. A challenge of implementing recommendations that exceed the legal requirements could therefore be the economic costs connected to doing more than what is required by law. On the other hand if more comprehensive assessments lead to better and more resilient projects, the total economic cost of the project, seen over the whole lifetime, can potentially be reduced as the risk of unexpected impacts and the potential cost of handling these unexpected impacts could be reduced.

8.2.2 Correlation between EIA report and surrounding planning process

The analysis of the selected EIA reports presented in chapter 6 reveals that not all aspects of the analytical framework appear in all the investigated EIA reports. Here it should be noted, that a possible explanation for the absence of subjects in the EIA reports could

potentially be because it is assessed in initial assessments, that the given subject is not relevant for the specific project. For example the analysis of the EIA reports shows that assessment of environmental interrelations only appears in three out of seven reports and that the main focus in the assessments is on water related impacts and that adaptation measures related to for example changes in temperature or wind are lacking. A possible explanation for the absence of assessment of environmental interrelations or impacts related to other than water in the EIA reports, could potentially be that initial assessments have shown that no relevant environmental interrelations or no relevant impacts related to for example temperature or wind have been identified, and therefore these subjects are not addressed in the EIA report. However, when environmental interrelations are not mentioned in the EIA reports, or only water related climate change impacts and adaptation measures are addressed, it can create doubt whether these elements are not mentioned because they are deemed not relevant or because they have not been considered. This is part of the overall discussion on how much to include in the EIA reports to ensure transparency related to the underlying assessments and considerations taking place in the surrounding process, but at the same time not including "everything" in the reports and thereby making the reports too comprehensive. Thereby, a challenge of implementing all the recommendations in practice could be that the EIA reports become too comprehensive. On the other hand integrating the recommendations creates a potential for improving transparency regarding the assessments and underlying considerations. Thereby, it is about finding an appropriate balance of providing the sufficient information related to the significance.

8.2.3 Institutional changes

To implement the recommendations in practice, different institutional changes would be necessary. More of the recommendations require increased awareness and knowledge within the field as well as an increased common understanding and greater alignment within the field in relation to how assessments are conducted and how the different climate change impacts and interrelations are interpreted. Implementing the recommendations and thereby increasing awareness, knowledge, and understanding as well as alignment will require changes in both the normative and culture-cognitive pillars. Also changes in the regulative pillar will be necessary. This is for example the case in relation to the recommendation on increasing the use of a transdiciplinary approach where changes in the organisational and political structures of for example municipalities would be necessary. The necessary regulative, normative and culture-cognitive changes can be viewed as barriers for implementing the recommendations in practice. On the other hand the increased focus and awareness of climate change impacts as highlighted by all the respondents could indicate that we are in a time where there is potential for making such institutional changes, as the increased awareness of climate change impacts within the field and in the society in general could lead to an increased willingness to make changes to improve upon practice.

8.3 Sub-conclusion

Based on the challenges identified throughout this study, nine recommendations for future practice of integrating climate adaptation in EIA practice are developed. Each recommendation can typically contribute to handling more than one of the identified challenges. Recommendations on increasing the use of a transdiciplinary approach and assessment of both positive and negative environmental interrelations related to climate adaptation can contribute to handling some of the identified regulative challenges regarding for example silo divided organizational structures. To contribute to handling of normative challenges regarding lack of standardization and alignment on how to make assessments of climate adaptation including the use of methods and approaches, recommendations related to for example climatic factors, environmental interrelations, SCALGO, time horizons and climate scenarios are of relevance, as these recommendations can help increase alignment among practitioners on how to make assessments and what to include in these. Recommendations on assessment of climatic factors related to other than water related impacts and considerations on climate adaptation both as an individual environmental factor and the interrelations with other factors could help contribute to handling the identified challenges of lack of focus, awareness, knowledge and understanding of different climatic impacts and potential environmental interrelations. Implementing the recommendations in practice can for example be connected with challenges of increased economic costs and finding a balance in the EIA reports between transparency and conciseness. Furthermore, implementing the recommendations will require institutional changes, which can be viewed as challenging, but the current increased societal focus on climate adaptation, could indicate an increased willingness to make changes and improve upon practice.

In the next chapter, the conclusions of this study are summarized.

Conclusion 9

This study focuses on climate adaptation in EIA for transportation infrastructure projects and investigates the research question: *What are the potentials and barriers for increasing the focus on climate adaptation in the EIA process for transportation infrastructure projects?*

First, requirements and recommendations for including climate adaptation in EIA are identified. From The European EIA Directive and The Danish Environmental Assessment Act, it can be derived that it is a legal requirement to assess the project's vulnerability to climate change, provide adaptation measures for significant impacts, and assess potential environmental interrelations. Identified recommendations from Danish and international formal guidelines, IAIA best practice principles, and international literature on the topic relate to for example the content and level of detail in the assessments, the use of climate scenarios, time horizons, and follow-up measures, and transparency. Based on the identified requirements and recommendations, an analytical framework is developed including the six categories: *Assessment of climate change impacts on the project, Assessment of adaptation, Assessment of environmental interrelations, Climate change monitoring, Use of scientific knowledge and data*, and *Transparency.*

In the second part of the analysis the current status of integrating climate adaptation in Danish EIA reports for transportation infrastructure projects is investigated. A mapping in the Danish EA-hub reveals 99 transportation infrastructure projects, and 18 of these mention climate adaptation, climate proofing or vulnerability to climate change, and thereby include a direct reference to climate adaptation. This indicates a limited focus on climate adaptation in EIA reports for Danish transportation infrastructure projects. To investigate how climate adaptation is included in EIA reports, seven of the 18 identified projects are analysed using the developed analytical framework. It should be noted that only text bites with explicit reference to climate adaptation from either EIA reports or corresponding background material are included as part of the analysis material. Further, the analysis identifies whether the recommendations from the analytical framework appear, while an evaluation of the reason behind absence of appearance and the quality of the assessment are outside the scope of this study. Taking these reservations into consideration, the analysis of the EIA material indicates a main focus on water related impacts, while other climatic factors such as increased temperatures and changes in wind conditions are only included to limited degree. Further, the analysis indicates a lack of alignment in how assessments are conducted in current practice. Looking at assessment of environmental interrelations connected to climate change impacts and adaptation, the analysis indicates a potential for an increased focus. Furthermore, the analysis indicates challenges and improvement potentials related to the use of a long time horizon, relevant climate scenarios,

follow-up monitoring, and transparency regarding limitations and uncertainties.

To gain insight into the considerations and practices in the surrounding process of EIA, the last part of the analysis looks into practical oriented barriers and possible improvement potentials for including climate adaptation into EIA practice investigated through interviews with four actors within the field. The interviews indicate that climate adaptation is included in the initial project design and not necessarily in the following EIA process. A main focus on water related impacts can be detected, while impacts related to other climatic factors are not in focus. Further, the findings from the interviews indicate a lack of alignment in how assessments are conducted including lack of alignment in the use of methods, time horizons, and climate scenarios. Furthermore, the analysis indicates a lack of focus on uncertainties and limitations connected to assessment of climate adaptation, and a potential for increased use of monitoring is highlighted. The findings support the findings from the analysis of the EIA reports, that the focus on environmental interrelations could advantageously be increased. The analysis indicates a need for increased use of transdiciplinarity and increased knowledge, awareness and understanding of climate adaptation including potential climate change impacts and interrelations.

The findings from the analysis of EIA material and interviews indicate challenges both related to regulative elements (for example silo divided departments), normative elements (for example lack of alignment in how to make assessments) and cultural-cognitive elements (for example lack of awareness, knowledge and understanding of central terms). Based on the findings from this study, nine recommendations on future practice of incorporating climate adaptation into EIA are developed: (1) Assess impacts related to heat, drought and changes in wind conditions and not only water related impacts, (2) Consider climate adaptation as an environmental parameter on equal terms with the remaining environmental parameters, (3) Include climate change impacts and adaptation in all phases of EIA, decision making, and follow-up monitoring, and not only in the initial project design (4) Increase the use of a transdisciplinary approach, (5) Use SCALGO to support the assessment of water related impacts, (6) The applied time horizon should correspond the expected lifetime, payback time and desired protection level of the project, (7) Use climate scenarios from IPCC/DMI and argue for the chosen scenarios, (8) Assess both positive and negative environmental interrelations related to climate adaptation, and (9) Be aware of and describe limitations and uncertainties connected to assessments of climate adaptation.

As some of the recommendations exceed the legal requirements, extra economic costs can potentially challenge the implementation, but contrary more detailed assessments can lead to more resilient projects and thereby reducing cost to handling of potentially unforeseen impacts due to climate change. Another challenge is how to balance the level of information in EIA reports to provide the sufficient information by ensuring both transparency and not making the reports too comprehensive. Also the necessary institutional changes can be viewed upon as a challenge for implementing the recommendations in practice. However, the increased awareness and focus on climate change impacts and the necessity of climate adaptation could indicate increased willingness to change upon current practice and contribute to handling of the major climate challenges the society and humanity are facing.

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