MASTER THESIS

Inter-Municipal Collaboration on Climate Change Adaptation - The Case of Aalborg Municipality

Samuel Schlecht

Joint European Master in Environmental Studies- Cities and Sustainability
Thesis written at Aalborg University

Supervisor: Assoc. Prof. Martin Lehmann (Aalborg University)

Co-Supervisor: Dr. David C. Major (Columbia University, New York)

09.06.2016

AALBORG UNIVERSITY DENMARK

UAB Universitat Autònoma de Barcelona

cisl jemes

universidade de aveiro

TUHH Technische Universität Hamburg-Harburg

Preface

The following document is the final thesis for the joint master's degree in the Erasmus Mundus Program *Joint European Master in Environmental Studies – Cities and Sustainability*. This master's degree is based at Aalborg University, Universitat Autònoma de Barcelona, Universidade de Aveiro and Technische Universität Hamburg-Harburg. The master thesis was written at Aalborg Universitet in the period from February 2016 until June 2016.

I hereby declare that the Master Thesis presented here is, to the best of knowledge and belief, original and the result of my own investigation and has not been submitted in part or whole, for a degree at this or any other university.

All the information derived from the work of others has been acknowledged in the text and in the list of references.

Many sources of this thesis are in Danish language. They were read with the help of translation programs like *Google Translator*. All references are listed in their original language.

Samuel Schlecht Aalborg, 09.06.2016

Abstract

Ongoing climate change in form of global warming is undeniable. Besides reducing greenhouse gas emissions to mitigate climate change, adaptation to the impacts of climate change is becoming more important in recent time. Also with reducing greenhouse gas emissions, impacts from climate change will not be able to be averted. Climate change impacts occur on a local scale. In Denmark municipalities are responsible for climate change adaptation. Nevertheless municipalities are not isolated areas. Especially climate change impacts related to water can occur across municipal borders. Also climate change adaptation is connected to several sectors in a municipality. Therefore collaboration inside municipalities as well as between neighboring municipalities is concluded as important.

At the case of the Danish municipality of Aalborg this theses analyzes inter-municipal collaboration on climate change adaptation. The thesis builds on institutional theory, as municipal planning is determined by institutions. Impacts from climate change trigger institutions to change. In order to analyze and propose inter-municipal collaboration first the implementation of climate change adaptation and the culture of collaboration in Aalborg Municipality are analyzed. Climate change related connections to neighboring municipalities are identified by streams in a shared watershed.

The thesis reveals that there is no active collaboration with other municipalities in Aalborg Municipality. As a main driver of climate change adaption the legal obligation of creating climate change adaption plans is identified. The importance of inter-municipal collaboration in climate change adaptation is seen by the municipality in some extent. There is an increasing culture of internal collaborations and structures of inter-municipal collaboration exist in other fields. On this base inter-municipal collaboration on climate change adaptation can evolve.

Acknowledgements

In order to obtain data for the thesis I conducted interviews with officials from the municipalities of Aalborg and Rebild. I thank all interviewees for their time and effort. Further I thank all participants of the survey which was distributed in Aalborg Municipality and Aalborg Kloak A/S.

I want to thank my supervisor Martin Lehman for his support and guidance throughout the thesis. Also thank you to my co-supervisor David Major for his constructive comments and input.

Table of contents

List of figures

List of tables

CHAPTER I - INTRODUCTION

This thesis is divided into four main chapters. The first chapter gives an introduction and provides the state of the art. The second chapter defines the research question and the methods with which the thesis is approached. After the third chapter presents the results, the thesis finishes with the fourth chapter, which analyzes and discusses the results.

This thesis is mainly related to social sciences. For social research Singleton & Straits (2010) developed seven stages in social research. Social research starts with the formulation of the research question, followed by the preparation of the research design which includes measurement and sampling. With the developed research design data is collected and afterwards processed into a form in which the data can be analyzed and interpreted. This thesis uses these seven stages as a guideline. The relations to the phases are described in the beginning of each chapter.

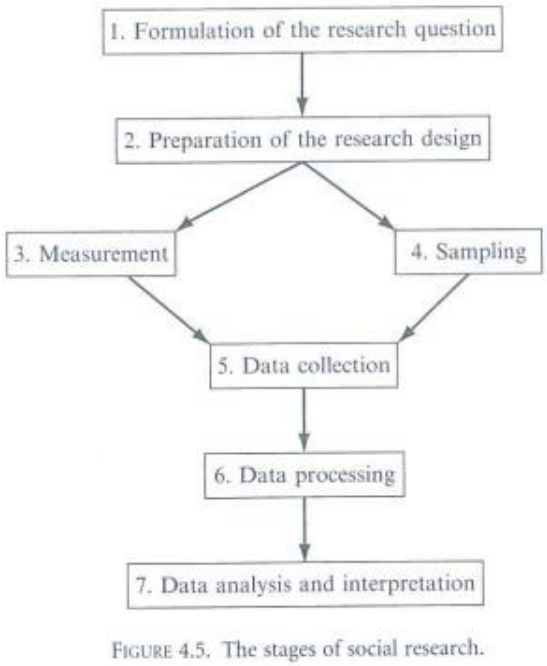


FIGURE 4.5. The stages of social research.

Figure 1: The stages of social research (Singleton & Straits 2010, p.109)

This first chapter provides a discussion of the state of the art as background for the first phase of Singleton & Straits (2010) of formulating a research question. In the first step local climate change adaptation was identified as the field of interest. Also the topic of interdisciplinary and collaborations is part of the interest. Through a literature review connections between the two fields and the current state of the art in research in these fields are presented.

1.1. State of the art

Ongoing climate change in form of global warming is undeniable. Since the 1950s many of the observed changes have not been seen over previous decades and millennia (IPCC 2014b SPM 1.1). Anthropogenic greenhouse gas emissions together with other anthropogenic drivers are *extremely likely*[1] to be the dominant cause of the observed global warming since the 1950s (IPCC 2014b SPM 1.2). Climate change is impacting natural and human systems globally. These include increases in extreme events like extreme high and low temperatures, higher sea levels and increases in the number of intense precipitation events (IPCC 2014b SPM 1.4). Actions and policies related to climate change are commonly distinguished between climate change mitigation and climate change adaptation. IPCC defines adaptation as "*The process of adjustment to actual or expected climate and its effects…"* (IPCC 2014a, p.118). Adjustments are referred to human as well natural systems. Mitigation is defined as *"A human intervention to reduce the sources or enhance the sinks of greenhouse gases…"*(IPCC 2014a, p.125) Also with the reduction of greenhouse gases the need for climate change adaptation is expected to increase with very high confidence. More immediate adaptation actions will enhance adaptation in the future (IPCC 2014b). In general, measures in mitigation focus on the causes that affect the climate on a global scale. The consequences with which adaptation copes are on the other hand set with some exceptions on a local scale (Swart & Raes 2007).

In Denmark municipalities are in charge of climate change adaptation. Since 2013 Danish municipalities are obliged to have a climate change adaption plan (Miljøministeriet Naturstyrelsen 2013). Governing climate change adaptation is challenging. Van Buuren et al. (2015) put climate change adaptation into a multi-actor, multi-sector and multi-level context spreading over various policy fields like water management, spatial planning, infrastructure, agriculture, energy supply, industry, nature and health. In municipal climate change adaptation planning the importance of various collaborations, for example with different governmental levels, other municipalities, municipal sectors as well with private companies and citizens, is gaining increasing attention (Hedensted Lund et al. 2012; Gore 2010; Leck & Simon 2012). The issue of regional collaboration is also part of the agreement at the 21st Conference of Parties (COP21) in Paris (United Nations 2015). All these collaborations are between institutions. Therefore institutions are the context in which climate change adaptation is happening (Tennekes et al. 2013). Institutions have by definition a strong resistance to change, nevertheless they are able to change (Scott 2001). In order to adapt to a changing climate also institutions have to adapt and an institutional change can result in stronger adaptation than actions based on institutional path dependency (Tennekes et al. 2013). Taking into account the already ongoing and for the future, projected increasing climate change impacts and high resilience to change of institutions, needed institutional change for climate change adaption is important to assess.

With this background this thesis aims to analyze the institutional context of collaboration on climate change adaption. Specifically, the focus of this thesis is on collaboration on climate change adaptation between neighboring municipalities. By looking at Aalborg municipality, possible collaborations with neighboring municipalities are revealed and their realization is analyzed with institutional theory.

[1] IPCC likelihood scale: extremely unlikely = 95% probability (InterAcademy Council 2010)

1.1.1 Municipal collaboration on climate change adaptation

In Europe collaboration on climate change adaptation is mainly happening on national, transnational and European levels. A report of the European Environment Agency from 2015 shows an overview of climate change adaptation platforms in Europe (European Environment Agency 2015). Additionally to the European platform *Climate-ADAPT* (European Union 2016) the report analyzes three transnational and 14 national platforms. The main collaborative purpose of the platforms is the sharing of knowledge. Further collaborative networks between municipalities are established. One example is *Mayors Adapt*, an initiative of the European Commission's Directorate General Climate Action, launched to inform, mobilize, support, facilitate and enable municipalities in climate change adaptation (Mayors Adapt 2016). Main results from Mayors Adapt projects are being included in Climate-ADAPT.

In recent years collaboration in local and municipal climate change adaptation has been addressed in literature. Besides looking at how climate change adaption is governed, Hedensted Lund et al. (2012) analyzed Danish municipalities regarding various collaborations. Their survey revealed the existing perception in the municipalities that collaboration is important in climate change adaptation. On the other side it also revealed limited executed collaboration. Adaptation is mainly approached with a technical focus without taking cross-sectoral aspects into account. Also regarding external collaboration, the importance of collaboration between municipalities is seen, but only in a few cases carried out. Leck & Simon (2012) propose a stronger focus on local inter- and intra-municipal relations next to collaborations on international and regional levels.

Further the importance of the municipal collaboration is seen by national governments. For example, in Sweden municipalities have to identify impacts of their master plans on neighboring municipalities and send their masterplan drafts for comments to their neighbors (Lundqvist 2015). In Denmark municipal collaboration is not mandatory but the guidelines for climate change adaptation plans suggest collaboration between municipalities if necessary (Miljøministeriet Naturstyrelsen 2013) Further the Danish environmental department funded municipal climate change adaptation projects which included inter- or intra-municipal cooperation with a total sum of 2.7 million Danish Krones (Miljø- og Fødevareministeriet 2014).

In the introduction chapter of their book about climate change and flood risk management at the local level Keskitalo & Carina (2013) point out the issue of multiple actors in local governance. When water governance and flood management had been scaled down to local levels, more complexity arises as more actors are involved. With having multiple actors involved the risk of maladaptation rises as adaptation for one actor could have negative effects to another. This connects to the question of how benefits and burdens are distributed in climate change collaborations raised by Tennekes et al. (2013). Needed collaboration between municipalities could be hindered because smaller municipalities lack resources to collaborate with other municipalities (Keskitalo & Carina 2013).

The ability to cope with climate change impacts is often described with adaptive capacity defined as "…the capacity of a societal, organizational or other unit to adapt to any impact … determined by institutional, economic and technological factors (among others) as well as by infrastructure, knowledge/information access and structures" (Keskitalo & Carina 2013, p.9). The importance of institutional factors is especially pointed out by Næss et al. (2005). Several studies address adaptive

capacities in transboundary climate change adaptation in shared watersheds on a trans-national level (Milman et al. 2013; Goulden et al. 2009). Also on a local level climate change adaptation is addressed in shared watersheds. In their master's thesis Zamzam and Frederiksen (2013) analyzed horizontal municipal collaborations across sectors, with utility companies and with other municipalities in the Limfjord watershed in Northern Denmark with institutional theory. Their results show that collaboration is happening mainly between municipalities and their utility companies. Collaboration across sectors happened in only one out of six municipalities and none of the sectors in the six municipalities collaborated with other municipalities' sectors. The study looked at institutional motivations and barriers to horizontal collaboration and related them to Scott's three institutional pillars, defined as regulative, normative and cultural-cognitive pillars (Scott 2001).

The Zamzam and Frederiksen (2013) study was done shortly after the Danish national legislation prescribed to establish climate change adaption plans. Most of the municipalities were at that time in the phase of creating their plans. The main motivation to prepare a climate change adaption plan was the national regulation. Only one municipality from their study worked on climate change adaption on their own incentive. Regarding collaboration the legislation became a regulative mechanism to engage in internal municipal collaboration on climate change adaptation. This is mostly located in environmental departments and had to be integrated into spatial planning; therefore collaboration with the planning departments was needed. On the other hand a regulation to privatize former municipal utility companies was seen as a barrier for collaborating between the municipality and the utilities. The results for the normative mechanism revealed a general motivation for horizontal collaboration as there is common perception that horizontal collaboration is necessary. Different political aims on the other hand were identified as normative barriers. For the cultural-cognitive mechanism the culture towards collaboration and climate change was analyzed. There is a culture of participating in networks but collaborating with other municipalities in whole planning processes is not part of the municipal cultures.

CHAPTER II - RESEARCH QUESTION AND METHODS

This chapter concludes the first phase in social research of formulating a research question and continues with the second phase of preparing the research design (Singleton & Straits 2010). The research questions are formulated in order to build on the identified state of the art. After defining an overall research question specific sub questions related to a case study are defined. The second part of the chapter describes the methods how the research questions are approached and how data is collected and processed. The connection to a case study includes Singleton & Straits (2010) third phase of measurements with the aim of connecting concepts to empirical observable events. With the defined case study and the specific sub research questions the unit of analysis and the dependent and independent variables are defined (Fourth Phase of Singleton & Straits (2010). Finally a theoretical and a contextual framework give the background of the research design.

2.1 Research questions

This study takes up on the revealed issues from Zamzam & Frederiksen (2013) and puts them into today's context three years later by looking at inter-municipal collaboration regarding climate change adaption between a specific municipality and one of its neighboring municipalities. The goal of the thesis is to answer the following research questions with the institutional perspective of the theoretical framework describe later in the thesis. The overall research question is formulated as:

How can neighboring municipalities collaborate within climate change adaptation?

In order to answer this general question, it is divided into several sub-research questions. When assessing inter-municipal collaboration on climate change adaptation it has to be first assessed how climate change adaptation is implemented inside a municipality. The research question of this thesis is approached by analyzing the Danish municipality of Aalborg. Aalborg municipality hosts with the city of Aalborg the largest city in the Northern Denmark region. Municipalities in other regions of Denmark have extensive climate change adaption plans prepared like Copenhagen, Aarhus or Vejle (City of Copenhagen 2011; Aarhus Kommune 2014; Vejle Kommune 2014). In the Northern Denmark region climate change adaption plans are less developed. Aalborg municipality is chosen as climate change adaption has been addressed with the Climate Strategy 2012-2015 (Aalborg Kommune 2011) already before it became mandatory by national law. The strategy proposes further examination of possible "climate partnerships" with neighboring municipalities as many of Aalborg's streams originate in neighboring municipalities. This indication makes Aalborg a suitable case study where the research questions can be investigated in a real-life context. This leads to the first sub-research question:

How is climate change adaptation implemented in Aalborg municipality?

The question is interpreted by regulative, normative and cultural-cognitive institutional processes resulting in the implementation status. The theoretical context is described later in Section 2.3.

When analyzing inter-municipal collaboration on climate change adaptation, the connection of neighboring municipalities through climate change has to be analyzed. The southern neighbor of Aalborg municipality is Rebild municipality. Both municipalities are located in the watershed discharging into the

Limfjord which connects the North Sea with the Kattegat Sea. Whereas Aalborg Municipality is directly located on the Limfjord, Rebild is an inland municipality. It is connected with Aalborg municipality and the Limfjord as five streams originating in Rebild flow into Aalborg Municipality where they discharge into the Limfjord. With this close connection, climate change impacts crossing municipal borders are assessed between these two municipalities. Therefore the second sub-research question askes:

How do climate change impacts connect Aalborg municipality to its neighboring municipality Rebild?

These two sub-questions lead to the addition of collaboration in the research question. As the first sub-question analyzes the implementation of climate change adaptation inside Aalborg municipality, also collaboration is analyzed first inside the municipality and then with other municipalities. The third sub-research question askes therefore:

How can collaboration between Aalborg and Rebild Municipality be incorporated in climate change adaptation?

The question is approached by the analysis of the collaborative culture. Further institutional barriers and drivers for prospecting institutional changes are identified. These are analyzed as regulative, normative and cultural-cognitive processes (see Section 2.3.1). Finally new or existing organizational structures are exanimated as potential carriers for inter-municipal collaboration on climate change adaptation.

A summary of the research questions is shown in Table 1.

Table 1: Summary of research questions

Overall question	How can neighboring municipalities collaborate within climate change adaptation?
1st sub question	How do climate change impacts connect Aalborg municipality to its neighboring municipality Rebild? • What are the regulative, normative and cultural-cognitive processes resulting the implementation status?
2nd sub question	How do climate change impacts connect Aalborg municipality to its neighboring municipalities?
3rd sub question	How can collaboration between Aalborg and Rebild Municipality be incorporated in climate change adaptation? • How is collaborative culture in the municipality? • What are institutional barriers and drivers related to regulative, normative and cultural-cognitive processes? • How are institutional changes needed regarding regulative, normative and cultural-cognitive processes? • Which existing or new structures could be used as carriers for inter-municipal collaboration

2.2 Methods

2.2.1 Research method

The research method applied in this thesis is a case study. The scope of using case studies as a research method is defined as:

"*A case study is an empirical inquiry that*

- *Investigates a contemporary phenomenon in depth and within its real-life context, especially when*
- *The boundaries between phenomenon and context are not clearly evident"* (Yin 2009, p.18)

This definition fits to the scope of this thesis as the phenomenon of inter-municipal collaboration on climate change adaptation has no clear boundaries to its context of municipal organizations and climate change impacts. In order to investigate the research question in depth and in its real-life context, two neighboring municipalities are chosen as the case study.

Yin (2009) proposes five important components in case study research design. The first is the research question which is stated in the previous section. Second a proposition should be defined. This study builds on the proposition

- *that neighboring municipalities are connected in climate change adaption issues and*
- *that institutional changes are needed to enhance needed collaboration on climate change adaption.*

The third component in case study research design is definition of the unit(s) of analysis. The unit(s) of analysis describe(s) what the actual case is. It is defined in this thesis as *climate change adaptation in neighboring municipalities.* Further Singleton & Straits (2010) include variables to the unit of analysis which are either independent or dependent. The stated unit of analysis in this thesis builds on the following variables. *Collaboration between municipalities in climate change adaptation* is defined as the dependent variable. The variables on which it depends on are *climate change impacts* and the *institutional context where the municipalities are set.* The fourth and fifth components define the logic linking the data to the proposition and the criteria for interpreting the findings. This is done by connecting the findings to the theory described in Section 2.3.

Four basic types of case studies are described in Figure 2 (Yin 2009). The types distinguish case studies by the amount of cases themselves and the amount of units of analysis in the case. For this thesis the holistic single-case design is chosen by investigating inter-municipal collaboration on climate change adaption between the two neighboring municipalities Aalborg and Rebild.

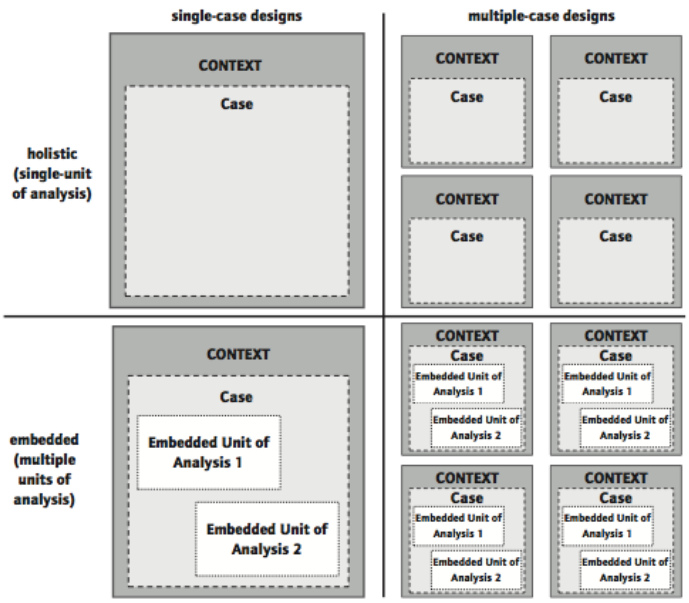


Figure 2: Basic types of designs for case studies (Yin 2009, p.46)

In order to assure validity in the research Yin (2009) proposes tactics to ensure different validities. Construct validity ensures to avoid too subjective findings. In studies where causal relationships are investigated internal validity targets that all causal relationships are identified. As a third validity, external validity tests if the problem can be generalized to other cases. The last validity addressed is reliability. Reliability ensures that the research should reveal the same findings if repeated with the same methods in the same context. Table 2 list the four validities, their proposed tactics by Yin (2009) and how they are implemented in this thesis.

Table 2: Research validity tactics (based on Yin(2009))

Validity	Case study tactic	Implementation in the thesis
Construct validity	• use multiple sources of evidence • establish chain of evidence • have key informants review draft case study report	• data collection by documents analysis, interviews and survey
Internal validity	• do pattern matching • do explanation building • address rival explanations • use logic models	• analysis of different data in relation to the proposition
External validity	• use theory in single-case studies	• Institutional theory as the theoretical context
Reliability	• use case study protocol • develop case study database	• Interview guide, transcriptions and codebooks • Survey

2.2.2 Data collection methods

Several kinds of data are used to answer the research questions. The following describes the type of data and the methods to collect and process the data for the three sub-research questions.

The first sub-research question analyzes how climate change adaptation is implemented in Aalborg Municipality now three years after climate change adaptation plans became mandatory for Danish municipalities. The analysis of the implementation status targets implementation in several ways in relation to the regulative, normative and cultural cognitive pillars of institutions. First it is analyzed how climate change adaptation is incorporated in the various plans of municipal planning. Second compiled guidelines and action plans are identified and their realization checked. Third the question targets the implementation of climate change in the culture of Aalborg Municipality. Data to answer this sub-research question was collected by

- a review of grey literature in terms of various plans of Aalborg and Rebild Municipality
- interviews with three officials from different departments in Aalborg Municipality and the head of the Environmental department in Rebild Municipality (Interview Guides in Annex I)
- a survey distributed to employees of the Environmental and Energy as well the Planning and Landscape departments at Aalborg Municipality and the utility company Aalborg Kloak A/S. (Questions and replies in Annex II)

Besides the mandatory climate change adaption plan, the climate strategy, the municipal plan, local plans, the sewage plan and the water action plan are reviewed for connection to climate change adaption. The realization of guidelines and actions is identified by internal status reports. The review of the plans is backed up by interviews with three officials from the Environmental and Energy as well from the Planning and Landscape department who are working or worked closely with climate change adaptation. Further the interviews are used to elaborate the culture of climate change adaptation in the municipality. All interviews were conducted as semi-structured interviews. The additional survey sent out to a broad range of employees of the Environmental and Energy as well the Planning and Landscape departments Aalborg Municipality and the utility company Aalborg Kloak A/S is aimed to give a larger picture of the implementation status. All together 15 persons took part in the survey. In the Planning and Landscape Department the survey was sent to 11 persons from whom 7 replied. At Aalborg Kloak A/S from 14 persons also 7 replied. In the environmental department the survey was only distributed to three persons from whom 1 replied. All of the persons who replied stated that their work is related to climate change adaptation. Only 5 persons are working in their organization for only a year. All the others are already 3 and more years in their organization, three even more than 10 years. These characteristics of the repliers make them capable to provide significant replies. The questions in the survey are mostly multiple choice questions with the possibility to add answers. The different answers are also asked to be rated.

The second sub-research question examines climate change impacts crossing municipal borders. The sources of data to answer this question are:

- maps
- waste water plans
- interviews
- survey

As water flows are crossing municipal borders, the focus is on water related climate change impacts. Digital GIS maps showing the watershed of Aalborg municipality were analyzed to identify possible impacts. Impacts of changing storm water runoff in neighboring municipalities were calculated on the base of waste water plans. The interviews and the survey are used to collect cross border impacts perceived already by the municipality.

In order to answer the third sub-research question asking how collaboration with neighboring municipalities can be incorporated into climate change adaptation, data from the first two sub-research questions are combined with data focusing on collaboration obtained by the interviews and the survey.

2.2.3 Limitations

The thesis relies on a large extend on the data from the survey and the interviews. It was decided to collect data only from persons who are working in climate change adaptation in order to receive replies backed by experiences in climate change adaptation. With a reply rate of around 50%, conclusions can be made but there could be different results with more answers. Also it is not granted that the survey has been distributed to all relevant persons. Further this study focuses on climate change adaptation in only one Danish municipality and its potential collaboration with one neighboring municipality. Inter-municipal collaboration on climate change adaptation is investigated with this case study. Nevertheless a study which includes a larger amount of cases could provide more perspectives and potential of comparative analyses.

2.3 Theoretical framework

2.3.1 Institutional theory

The concept of institutions has a fundamental part in social studies. Across different social sciences institutions are commonly denoted as an organized established procedure (Jepperson 1991). Ostrom (2009, p.3) defines institutions as prescriptions that humans use to organize all forms of repetitive and structured interactions. This leads to the definition of Scott (2001) who sees institutions as social structures with a high resilience to change. They provide stability in social structures. Nevertheless change in institutions is possible.

The earlier mentioned study of Zamzam and Frederiksen (2013) reveals barriers and motivations for municipal collaboration by connecting them with the three pillars of institutions (Scott 2001). (Scott 2001) identifies regulative, normative and cultural-cognitive elements as his three pillars institutions are built on.

Table 3 shows principal dimensions of institutions related to the three pillars.

Table 3: Three pillars of institutions (Scott 2001)

		Pillars		
		Regulative	**Normative**	**Cultural Cognitive**
Principal dimensions	**Basis of compliance**	Expedience	Social obligation	Taken-forgrantedness Shared understanding
	Basis of order	Regulative rules	Binding expectations	Constitutive schema
	Mechanisms	Coercive	Normative	Mimetic
	Logic	Instrumentally	Appropriateness	Orthodoxy
	Indicators	Rules Laws Sanctions	Certifications Accreditation	Common beliefs Shared logic of action
	Basis of legitimacy	Legally sanctioned	Morally governed	Comprehensible Recognizable Culturally supported

Regulative elements are the most obvious in institutions. Formal rules and laws together with their legal sanctions regulate the institution. Besides formal elements of the regulative pillar, institutions are also built on normative elements based on norms and values. Desires in an institution are conceptualized by values. Norms define the ways how values should be implemented. In the third pillar institutions are based on common beliefs. Actions evolve from the surrounding culture

This framework is also applied in other studies about climate change adaptation. Nielsen (2014) looks at the implementation of sustainable urban drainage systems with the institutional perspective of Scott's pillars of institutions. Cashmore and Wejs (2014) use the framework to analyze legitimacy of municipal climate change planning. Scott (2001) and Wejs (2013) refer to the definition of legitimacy as

"… a generalized perception or assumption that the actions of an entity are desirable, proper, or appropriate within some socially constructed system of norms, values, beliefs, and definitions" (Suchman 1995, p.574).

Scott (2001) identifies institutional frameworks as the socially constructed systems from Suchmans definition and uses each of his three pillars as the basis for legitimacy

In institutional theory structures and agencies are defined. Agencies can be defined as individual or group abilities to affect their environment whereas structures refer to the material and ideological conditions defining the range of actions available (Arts & Van Tatenhove 2006, p.23). This definition is based on the d*uality of structure* elaborated in Giddens' (1979, 1984) structuration theory. He sees structure "… *as recursively organized sets of rules and resources…"* (Giddens 1984, p.25) from which actors draw. The *duality of structure* refers to structure being a medium for social practices of actors and at the same time being an outcome of the actors' practices (Giddens 1979, 1984; Arts & Van Tatenhove

2006). Giddens refers deeply embedded structures as institutions. Wejs (2013, pp.55–56) connects the theory of structures and agencies with Scott's institutional pillars. Institutional legitimacy based on the three pillars is defined as the structure. The concept of agency is added in the way that actors navigate in the structure in order create and shape legitimacy.

In colloquial understanding institutions and organizations are often set equally (Lehmann 2008). In scientific literature the distinction of institutions and organizations is laid out differently. This study follows the following distinctions. DiMaggio & Powell (1983) see organizations as actors who create an organizational field, which constitutes a recognized area of institutional life. Regarding public policies *"Organizations operate at every level … as policy makers, as units of the implementation machinery and as targets of policy reform"* (Scott 2001, p.168)

2.3.2 Institutions and municipal collaboration on climate change adaptation

The setting of municipal climate change adaptation is based on institutions. Institutions are the context in which adaptation measures are developed (Tennekes et al. 2013). At the same time climate change adaptation measures are being institutionalized for example as regulations, policies and support programs (Anguelovski & Carmin 2011). As institutions are subject to stability new adaptation measures are path dependent on institutionalized solutions from the past (Tennekes et al. 2013). There is a need to question this dependence as an institutional change might be equally or even more effective (Tennekes et al. 2013; Matthews 2013). Although institutions are connected to stability Scott (2001) is aware of possible changes and discusses in his Chapter 8, institutional change. In general he identifies institutional change as deinstitutionalization and proceeding reconstruction of institutions. He reviews various studies to identify as well exogenous as endogenous triggers to change. Exogenous triggers are coming from the outside of an institution whereas endogenous triggers derive from inside the institution. Examples of stimuli to institutional changes are also summarized by Matthews (2013) as social phenomena, political changes including influences of lobby groups, collective bargaining, resource depletions and environmental impacts. All of these stimuli could be endogenous as well as exogenous roots. The speed of institutional change can differ related to the institutional pillars. When applying the findings of Roland (2004), who sees changes in cultural institutions slower than in political institutions, to Scott's three pillars, regulative institutions change faster than cultural-cognitive. Further Scott (2001) identifies institutional change over multiple levels. The levels range from the society on the top over organizational fields to actors at the bottom level. These levels connect institutional change to structure and agency. Lower levels work as actors within the higher level as structures. Institutional change can happen in a top-down as well as a bottom up direction. Higher level structures can constrain and empower the lower structures and actors, whereas at the same time lower level actors and structures shape the higher structures as the context where they operate.

In a case of municipal collaboration on climate change adaptation two municipalities and therefore at least two organizations work together. Collaboration could be directly between the two municipalities or through a third party (dashed arrows in Figure 3). In any case, existing institutions are confronted with change. Lintz (2015) developed a framework for analyzing inter-municipal cooperation on environmental aspects. Perceived environmental problems are dealt with in intra- and inter-municipal negotiations.

The negotiations are carried out by actors in an institutional framework. Figure 3 shows the theoretical framework of this thesis, analyzing inter-municipal collaboration on climate change adaption. It is built up on institutional change through multiple levels by Scott (2001) and the framework of inter-municipal collaboration of Lintz (2015) as well as theories of structure and agency. The municipalities set up an organizational field constituting institutions in the way they work (DiMaggio & Powell 1983). The organizational field lies within the higher societal institutions, like the national government or the EU. On the lower level agency is created by actors like individuals or internal organizations in the municipalities. With the impacts of climate change, institutional change is triggered. As described by Giddens (1979; 1984) agency and structure interrelate. Therefore processes of institutional change are top-down from structure to agency as well as bottom up from agency to structure (solid arrows) (Scott 2001). In order to engage in inter-municipal collaboration, the institutions constituting the way the municipalities work have to undergo change (circle arrows). The framework uses Scott's three institutional pillars in order to identify legitimate processes for institutional change leading to collaboration on climate change adaptation. Scott (2001) identifies regulative, normative and cultural-cognitive processes for institutional diffusion which he connects to institutional change. Regulative processes are based on regulations, surveillance and sanctions. Normative processes are identified as often connected to professional and colloquial networks. Cultural-cognitive processes are highly affected by theorization through the actors creating common beliefs and shared understanding.

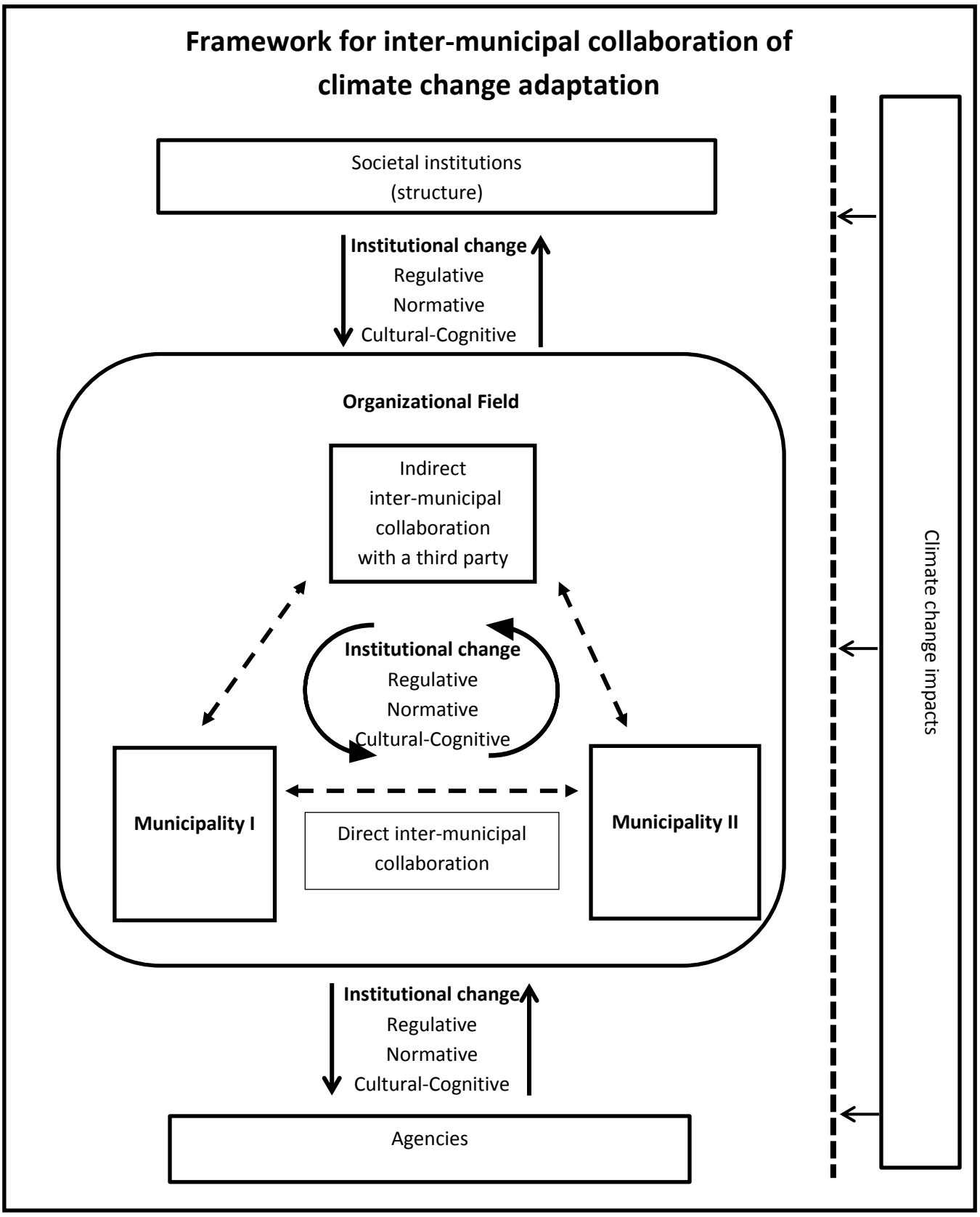


Figure 3: Framework for inter-municipal collaboration of climate change adaptation (based on (Lintz 2015; Scott 2001; Wejs 2013)

2.4 Contextual framework

2.4.1 Climate change adaptation in Denmark

2.4.1.1 Expected changes in the Danish climate

Based on the IPCC AR5 report and other studies, Olesen et al. (2014) reported the projected changes in climate for Denmark. It is expected that the increase of temperature will be accompanied with increased precipitation especially in winter, more frequent extreme weather events and a rising sea level rise. Precipitation in summer is not expected to change much in the next century as Denmark is on the border of areas identified for more summer rainfall and less summer rainfall. Connected to the theoretical framework described above the projected changes in the Danish climate are the exogenous triggers for institutional change seen on the right in Figure 3.

Figure 4 shows the predicted temperature changes in Aalborg for 2021-2050 with the A1B scenario and for 2081-2100 with the RCP45 and RCP85 scenarios. The reference timeframe for the A1B scenario is 1961-1990. The scenarios RCP4.5 and RCP8 are in reference to 1986-2005. The group of A1 scenarios are part of the Special Report on Emissions Scenarios (SRES) used in the Fourth IPCC Assessment Report (IPCC 2007). A1 scenarios are based on prospected emissions in for a future world of very rapid economic growth with global population peaking in the mid-century and declining thereafter. They assume a rapid introduction of new and efficient technologies. In the A1B scenario technology change accounts for fossil energy sources combined with non-fossil energy sources. In the Fifth Assessment Report of IPCC Representative Concentration Pathways (RCPs) were introduced as new scenarios (IPCC 2013). The RCPs are named by their approximate total radiative forcing in year 2100 relative to 1750. The here used RCP4.5 and RCP8.5 stand therefore for 4,5 W m^{-2} respectively 8,5 W m^{-2}. RCP4.5 is a stabilization scenario where radiation will stabilize the year 2100. In the RCP8.5 scenario emissions will continue to rise after the year 2100. The predicted temperature change in Aalborg is 1,3°C for the nearer future and and 1,8°C - 3,4°C for the far future depending on the emission scenario.

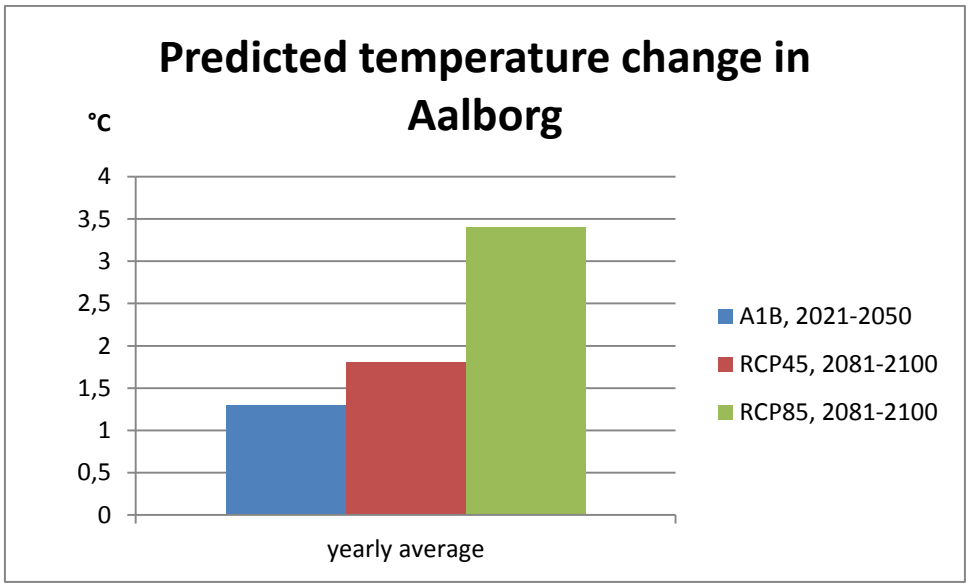


Figure 4: Predicted temperature change Aalborg (The Danish Nature Agency 2016b)

Figure 5 shows the predicted average daily precipitation change grouped by seasons for different scenarios. The A1B scenario for 2021-2050 in relation to the timeframe 1961-199 and for the timeframe 2081-2100 the scenarios RCP4.5 and RCP8.5 in reference to 1986-2005. All three scenarios predict the highest increase of precipitation in winter. Denmark's location at the border of Northern Europe with increasing summer precipitation and southern Europe with decreasing summer precipitation is seen by the differences in spring and summer prediction in Figure 5.

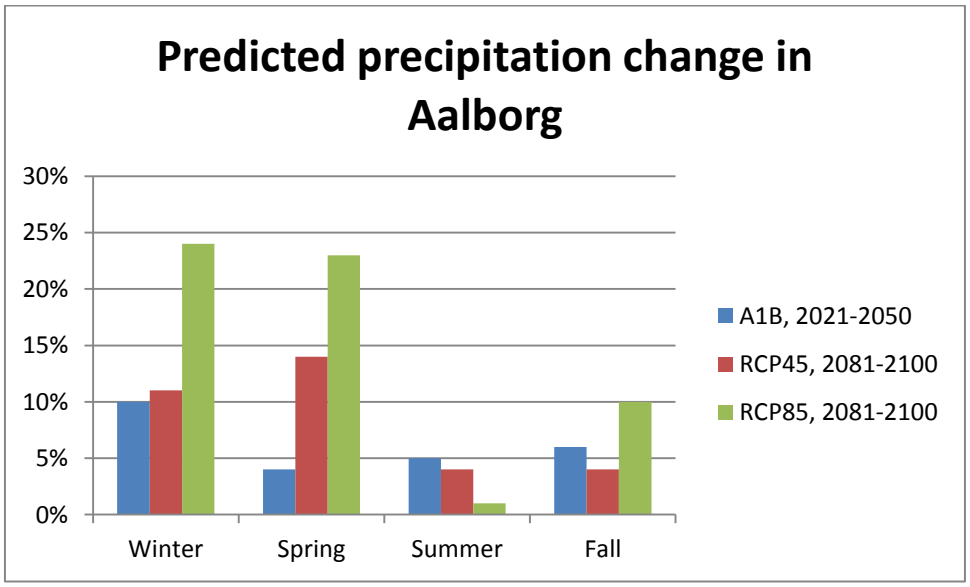


Figure 5: predicted precipitation change in Aalborg (The Danish Nature Agency 2016a)

Besides the increase of average precipitation higher frequency of extreme weather events is expected with climate change. Table 4 compares different extreme weather events predicted for 2050 and 2100

with 1990. Extreme weather events will be more frequent regarding temperature and precipitation. The temperature increase in summer and winter will lead to fewer frost days in winter and to increase of heat wave days in summer. Regarding precipitation extreme events, like rainfall events larger than 10mm and larger than 20mm as well as long lasting rainfall will happen more frequently.

Table 4: Predicted change of extreme weather events in Denmark (Olesen et al. 2014)

Indices	**1990**	**2050**	**2100**
Frost days [days / year]	85 (± 8)	61 (± 7)	29 (± 5.3)
Growing season [days / year]	230 (± 11)	270 (± 12)	300 (± 11)
Hot summer nights [day / year]	8 (± 4)	13 (± 4)	44 (± 13)
Precipitation Events> 10 mm [day / year]	19 (± 2)	22 (± 2)	26 (± 3)
Precipitation Events> 20 mm [day / year]	2 (± 0.3)	3 (± 0.5)	5 (± 0.7)
Year's biggest 1-day rain sum [mm]	70 (± 8)	75 (± 8)	81 (± 10)
Year's largest 5-day rain sum [mm]	94 (± 6)	100 (± 5)	108 (± 7)
Medium intensity of rainfall [mm / day]	5.0 (± 0.2)	5.2 (± 0.2)	5.6 (± 0.2)
Heat wave days [days / year]	1.5 (± 0.6)	2.8 (± 1.0)	5.0 (± 2.6)
Longest heat wave [days]	3.2 (± 0.7)	4.2 (± 0.9)	5.6 (± 1.9)
Heat wave days [days / year]	5.8 (± 1.4)	8.7 (± 2.2)	13.9 (± 4.7)
Longest heat wave [days]	6.9 (± 1.1)	8.2 (± 1.4)	10.1 (± 3.3)

In common discussions about climate change sea level rise is very much in focus, as almost half of the global population is living in coastal areas (UNEP 2010). With its long coastline sea level rise is an important climate change impact in Denmark. Table 5 shows expected sea level rise globally and for Denmark for the different RCP scenarios. As land masses in Denmark, especially the northern part are uplifted, sea-level rise is partially compensated and therefore lower in Denmark than globally (Olesen et al. 2014).

Table 5: **Absolute average sea level rise globally and for Denmark, 1986-2005 to 2081-2100 [m]** (Olesen et al. 2014)

Changes in mean sea level [m]	Global	Denmark	Source
RCP2.6	0,40 (0,26 - 0,54)	0,34 (0,1 - 0,6)	IPCC AR5
RCP4.5	0,47 (0,32 - 0,62)	0,43 (0,2 - 0,7)	IPCC AR5
RCP6.0	0,47 (0,33- 0,62)	0,44 (0,2 - 0,7)	IPCC AR5
RCP8.5	0,62 (0,45 - 0,81)	0,61 (0,3 - 0,9)	IPCC AR5

2.4.1.2 Impacts

Climate change is affecting Denmark in various ways. Its long coastline makes Denmark vulnerable to sea-level rise. Sea-level rise has to be seen in connection with other effects like storm surges. Especially on the west coast sea-level rise will increase the effects of storm surges like coastal erosion. Flooding will also increase strongly with a rising sea level. Return periods of flooding events from the sea will decrease with rising sea level. For example in Esbjerg on the west coast a sea level rise of 1m will change the current 100 year return period of flooding by a 4,05m sea-level caused by storm surges to an event with a 5 year return period (The Danish Nature Agency 2014). The highest climate change effects in urban areas will be from more and more intense precipitation events, leading to flooding. Besides by overflowing of streams and channels, flooding is caused by exceeding the capacity of the sewage system. In urban areas sewage systems are mostly designed as combined or separate systems as described in the following section about climate change adaptation options. Flooding caused by under capacity of combined sewage systems can occur outside but also in homes from the sewage pipes. In separate sewage systems exceeding capacity doesn't lead to flooding inside building but still from outside sewage entries. Changes in rainfall pattern can alternate groundwater levels. Possible dryer summer months for example could lower groundwater levels creating a risk of subsidence. Especially in stream valleys subsidence increases the risk of flooding from streams as the altitude of the ground level above the stream level decreases. Further changes in groundwater levels can cause risk for infrastructure in the sense of undermining of roads, buildings or railway tracks (The Danish Nature Agency 2014). Table 6 gives an overview of climate change impacts and their consequences.

Table 6: **Climate change impacts in Denmark** (The Danish Nature Agency 2014)

Impact of climate change	Consequences
More frequent intense extreme precipitation events	Increased risk of flooding (exceeding the capacity of the drainage system) Increased number of overflows
Sea level rise and increase of storm surges	Increased risk of flooding in coastal areas (overtopping of levees, floodgates, drainage)
Changes in rainfall patterns	Increased risk of subsidence and undermining of buildings, road and rails
Higher temperatures and more and more intense heat waves	Increased health risk Increased risk of microbial and chemical contamination in water supply systems like drinking water.

2.4.1.3 Adaptation options

There are two main approaches to handle rainwater in urban areas. The conventional approach is known by “grey” infrastructure. Since the 1990s the term “green infrastructure” is evolved and covers a broad variety of alternative options to handle rainwater (Nickel et al. 2014). With increasing precipitation and stronger and more frequent extreme weather events adaption to the and by green and grey infrastructure is needed. This grey approach is based on collecting and conveying the water. Typical grey infrastructures are sewage systems, both combined and separate sewers. In combined systems rainwater from impermeable surfaces is diverted in the same pipes as waste water. In this way wastewater treatment plants have to treat wastewater amounts increased by the rainwater. To avoid exceeding the wastewater treatment capacities rainwater combined with wastewater is discharged directly into streams of other water bodies in the case of intense precipitation. The discharge of untreated wastewater is the less harmful option compared to an overflow at wastewater treatment plants where pollutants are highly concentrated. In separate sewage systems, rainwater is diverted in separate pipes and is discharged into water bodies without treatment in wastewater treatment plants. However, in Denmark rainwater from roads has to be treated before being discharged (Danish Technological Institute n.d.). This happens mostly locally.

In contrast to the focus to lead water away with grey infrastructure, approaches in green infrastructure focus local management of water at the source. Green infrastructure is widely referred to Sustainable Urban Drainage Systems (SUDS). By managing water at its source the aim of SUDS is to delay and reduce water volumes for example by infiltration or evaporation. Charlesworth (2010) groups SUDS into soft and hard systems. Examples for soft SUDS are vegetated surfaces and green roofs to reduce water volume by evaporation as well as retention and detention basins to delay water. Examples for hard SUDS are porous paving systems or harvesting rainwater for further uses, like plant watering or the usage as flush water in sanitation systems. Besides water quantities SUDS target also water quality, conservation of ecosystems and biodiversity (Nickel et al. 2014; Charlesworth 2010). Whereas grey infrastructure is hidden SUDS are designed to be visible and to offer besides handling water also social and recreational benefits (Zhou 2014). SUDS were introduced to counter flash flooding in former countryside areas transformed into urban and industrial areas. This makes them applicable to adapt to increasing precipitation through climate change (Charlesworth 2010).A combination with existing conventional grey infrastructure must be assessed as SUDS might not be able to cope with high precipitation in extreme weather events (Zhou 2014). SUDS that drain water locally are not applicable in all places. Local drainage increases the groundwater level which could lead to new flooding (Randall et al. 2013).

Directly related to streams, climate change adaptation plays an important role in restoration of streams and their riparian areas. Streams have been altered by human activities and at the same time they are facing impacts resulting from climate change as well as from further human activities in their watersheds. The main goal of riparian restoration projects is to improve the riparian ecosystems highly affected by climate change. On the one hand climate change is altering streamflow which has to be taken into account in restoration projects. For example changes in flow have to be taken into account when designing floodplains. On the other hand restoring riparian areas can also be itself an adaptation to climate change impacts related flood damages to human infrastructure. Restored floodplains in areas

where they don't harm infrastructure store and delay water, in order to divert flooding from unwanted areas with vulnerable infrastructure. (Perry et al. 2015)

2.4.2 Danish planning system and climate change adaptation

Spatial planning in Denmark is regulated by the Planning Act (Danish Ministry of the Environment 2007). In 2007 the Danish planning system was reformed by creating a strongly decentralized system. The counties were abolished and former 271 municipalities were turned into now 98 municipalities. The municipalities are located in five regions with their elected regional councils. With the reform the municipalities gained a strong responsibility of planning and land-use regulations. Whereas the region's regional development plan has more a strategic function, the municipalities are in charge of legally binding planning regulations. Nevertheless municipal planning is subject to national planning rules. These are implemented by national planning reports and national planning directives as well as national vetoes. Municipal planning is carried out in municipal and local plans. Municipal plans provide in their general structure a summary of the overall political development objectives of a municipality. They are renewed every four years. The municipal plans cover the towns as well the countryside in the municipalities. Further the municipal plans include a framework for the local plans in order to promote a cohesive urban structure and the overall municipal opportunities. Future opportunities and possible changes of land use are included in the municipal plans. The local plans concretize the political strategy and objectives of the municipal plan. They have to be developed for any major new development. Local plans are legally binding for property owners. (Østergård & Witt 2007)

2.4.2.1 Climate change adaptation regulations

Climate change adaption was introduced in Denmark by the Danish Strategy for adaptation to a changing climate in 2008 (Danish Energy Agency 2008).The strategy identified sectors which are impacted by climate change and was the start of further research in Danish climate change adaptation.

As a result of the agreement of municipal funding for 2013 between the National Advocacy Organization of Danish Municipalities (KL) and the national government, the municipalities were obliged to develop a climate adaptation plan by the end of 2013 (Miljøministeriet Naturstyrelsen 2013). The climate change adaptation plans can be either incorporated directly into the municipal plans or added as a supplement (Miljøministeriet Naturstyrelsen 2013). In order to support the municipalities in making a climate change adaptation plan a guidance document was published by the Danish Nature Agency (Miljøministeriet Naturstyrelsen 2013). The guideline requires the adaption plans to include risk mapping and a description of the municipalities efforts towards climate change adaptation. The specific scope of the efforts is not regulated. As climate change adaptation is connected to the EU flood and water framework directives climate change adaption plans have to be in line with the directives. Two triggers can be identified which resulted in these regulative institutional changes. On 2nd July 2011 as cloudburst event in Copenhagen caused damage up to 6 billion Danish Krones. This enormous damage lead locally to the creation of a cloudburst management plan in Copenhagen (City of Copenhagen 2012) and nationally to the agreement of KL and the government to have obligatory climate change adaptation plans in the municipalities(Miljøministeriet Naturstyrelsen 2013). Secondly also a political trigger through the change of Danish government in 2011 can be seen as a trigger for these new regulations (Wejs 2013). This fits to

fast institutional changes in the regulative pillar as described in Section 2.3. Institutional change in the normative and cultural-cognitive pillar is slower. As seen later in the results and discussion sections the implementation of the mandatory climate change adaptation plans in everyday planning is way slower through normative and cultural-cognitive barriers.

CHAPTER III - RESULTS

This chapter applies to the fifths and sixth stage (data collection and data processing) of Singleton & Straits (2010). It reveals the results of the data collection and puts them into relation with the three sub research questions.

3.1 Climate Change Adaptation Status

Climate change adaptation is addressed through different municipal instruments in Aalborg Municipality. These are described in the following in order to answer the first sub research question: *How is climate change adaptation implemented in Aalborg municipality?*

3.1.1 Climate Strategy

Aalborg Municipality has been addressing climate change already before climate change adaptation became mandatory in 2013. A Climate Strategy in 2012-2015 was developed in order to ensure that climate policies related to urban development, energy, environment and nature, as well as traffic are centrally located in municipal planning. The strategy addresses both climate change mitigation and adaptation. As this thesis is focused on climate change adaptation the mitigation part of the climate strategy is not further elaborated. The climate change adaption strategy developed strategies for different focuses with their aspired goals. These are backed up by guidelines, new initiatives and needed investigations (see Figure 6).

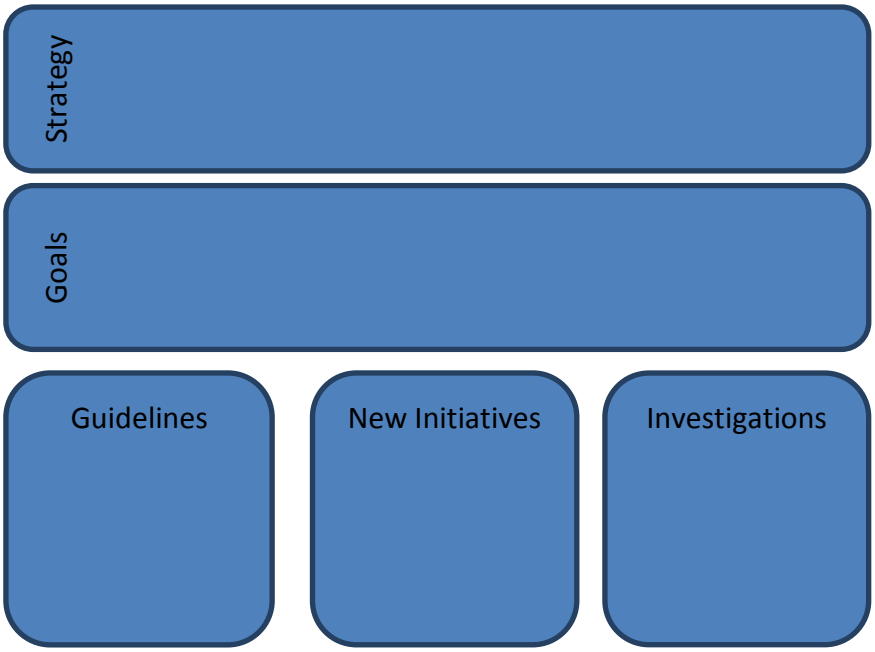
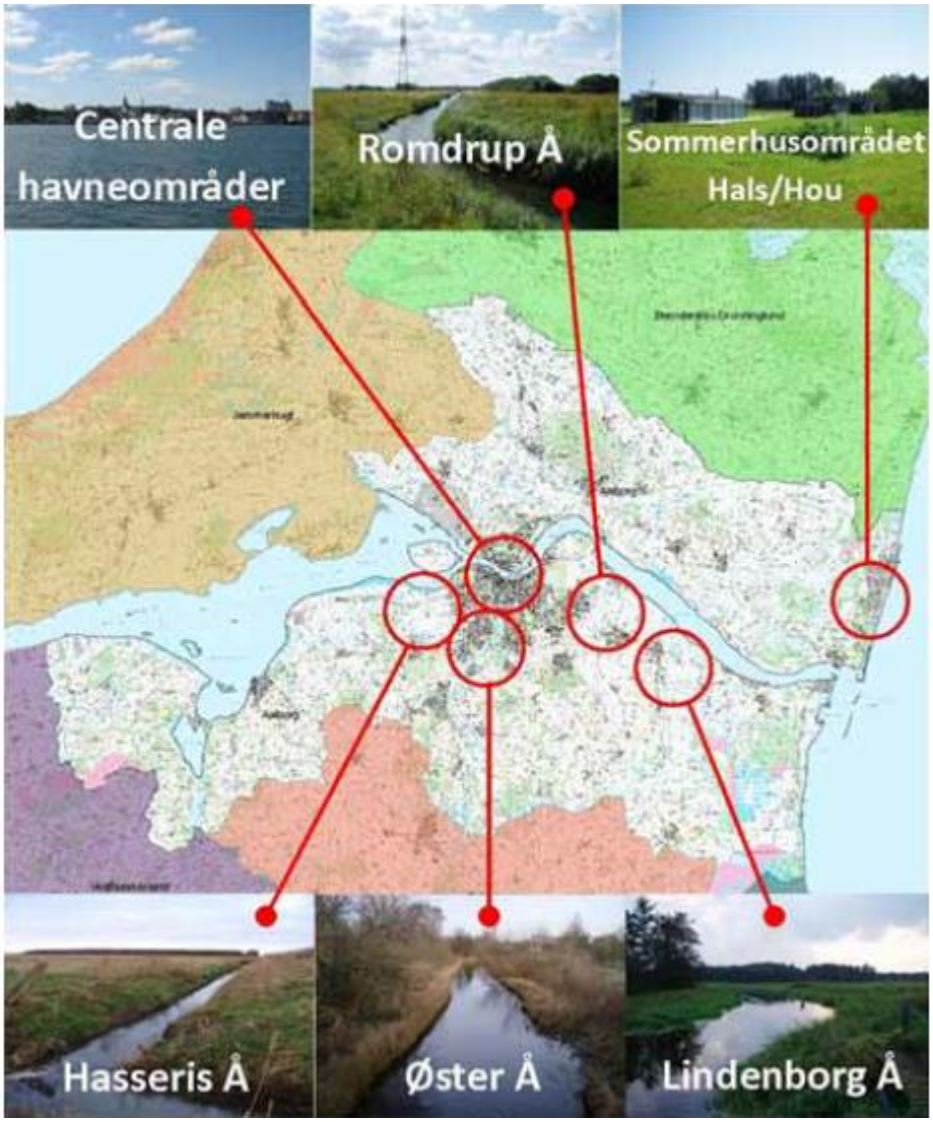


Figure 6: Approach of Climate Strategy in Aalborg (Aalborg Kommune 2011, p.5)

The strategy focuses primarily on flooding and the managing of water. Strategies are developed for managing coastal water and water in streams both in urban areas and open countryside. The strategy

identifies six focus areas to apply its strategies on. Map 1 shows the geographical location of the focus areas. These cover coastal, urban, industrial and agricultural areas. Their developed strategies are meant to be used as references for other similar areas (Lervad Thomsen 2016b). Besides the waterfront in the center of Aalborg (Central havneområder) and the summer house area (Sommerhusområdet) on the Kattegat coast, four out of the six focus areas are streams. Whereas the watershed of Romdrup Å is located inside the municipal borders of Aalborg Kommune, the streams Hasseris Å, Øster Å and Lindenborg Å share their watershed with the neighboring municipality Rebild in the South.



Map 1: Focus areas in Aalborgs Climate Strategy 2012-2015 (Aalborg Kommune 2011, p.9)

All together 26 guidelines, 19 new initiatives and 19 investigations are part of the strategy. Two departments are in charge to carry out the strategy: The Environmental and Energy Department (Miljø- og Energiforvaltning) and the Department of Urban and Spatial Planning (By- og Landskabsforvaltningen). In 2014 almost half of the guidelines were completed. Regarding new initiatives and investigations only around one quarter were completed.

Table 7: Climate Strategy Status 2014

	Total Amount	Completed	Partially Completed	Major efforts needed for completion
Guidelines	26	12	13	1
New Initiatives	19	5	7	7
Investigations	19	6	10	3

Although climate change adaption has been addressed in Aalborg municipality by the climate strategy since around five years, dealing with a strategy and its targets is always easier than having the strategy implemented. The regulation for mandatory climate change adaption plans was a driver to tackle the challenge of transforming strategies into action (Lervad Thomsen 2016b). By incorporating climate change adaptation into the municipal and local plans, climate change adaptation became a mandatory part of municipal planning.

3.1.2 Climate Change Adaptation Plan

The national regulation doesn't prescribe how the climate change adaption plans should be implemented in municipal planning. In Aalborg Municipality the climate change adaption plan, is added as a separate section to the municipal plan. Additionally the plan cross-references to climate change adaption guidelines in specific sections of the municipal plan like urban renewal and development, city life, parks and open spaces, the open countryside or Infrastructure and traffic. As proposed by the national government risk maps were developed by joining value maps with flood maps. The flood maps include flooding from sea-level rise, cloudbursts and streams. Additions to the municipal plan are prioritization tools. In order to set targets and measures for concrete adaptation projects specific action plans were planned to be established by 2014 addressing the six focus areas from the Climate Strategy. Because of lack of financial means for further investigation and analyses of the areas the action plans haven't been developed yet. Nevertheless climate change adaptation is implemented in ongoing projects like the opening of the channelized Øster Å stream in central Aalborg. Part of the project is the development of the former freight rail area (godsbaneareal). As the area is in a flood prone low lying area buildings are designed in a flood protected or in a way that flooding is acceptable. Further climate change adaptation is incorporated in the area by cloudburst management with SUDS. Because of a high groundwater level local drainage of rainwater is not possible. SUDS like green roofs are implemented to support evaporation. Further rain beds which are used as parks and sport fields in dry conditions are established in order to store and delay rainwater during heavy rainfall (Fødevareministeriet 2015).

In order to integrate climate change adaption into local plans, a map was developed with areas where flood risk is expected to increase by 5% by 2050. This map is part of a new section in the guidelines of urban renewal and development added in the course of the national regulation. New local plans or changes of existing local plans in the risk areas have to take flood risk into account and include measures to cope with climate change adaptation. Proposed measures are:

- separate sewage systems
- Sustainable urban drainage systems
- Reducing ground sealing
- Minimum base height for site preparations
- Location of building zones in relation to the natural surface runoff
- Opening of settlements so that it supports the natural surface runoff.
- Rising quay edges, landscape design and dikes.
- Permanent groundwater drainage.

In order to adapt the sewage system to extreme rainfall climate change adaption is connected to waste water plan (described later in more detail). The focus lies on separate sewage systems supported by sustainable urban drainage systems where possible. To cope with climate change impacts in streams, climate change adaption is also included in the water action plan in order to be in line with the European water framework directive.(Aalborg Kommune 2014)

3.1.4 Climate change adaptation in waste water plan

Aalborg Municipality is replacing its current waste water plan 2008-19 by the waste water plan 2016-2027. The proposal of the waste water plan includes climate change adaptation as a specific focus area. Climate change adaptation is addressed in the proposal by separate sewage, spatial planning, local drainage of rainwater and management of cloudbursts. Introducing separate sewage systems is part of the municipal strategy to have all sewage systems separated by 2100. Regarding spatial planning the proposal addresses the issues of sewage and drainage systems in low lying areas identified by the risk map with areas where climate change adaption has to be included in new and revised local plans. In connection with separate sewage and spatial planning comprehensive plans for the river basins ("Helhedsplaner for Vandløbsoplande") in the municipality will be developed in cooperation with the utility company Aalborg Kloak A/S. Climate change adaptation is part of these comprehensive plans. In the coming years comprehensive plans will be carried out for the river basins of Øster Å, Romdrup Å and Hasseris Å (Lervad Thomsen 2016a; Bøgh Vinther 2016a). With expected increase of precipitation more implementation of SUDS is the objective of the new water plan in order to relieve the sewage systems. A "LAR[2] catalog" will be included into the plan where suitable areas for SUDS are mapped and possible methods are described with its characteristics in order to support the implementation of effective SUDS. In order to manage cloudbursts a mapping of optimization opportunities was undertaken in cooperation with citizens' observations and information from damage service companies. Evolved strategies from the mapping are increasing the capacity of the sewers, distribute rainwater to sewers with existing capacities, delaying rain water and managing rain water locally with SUDS. (Aalborg Kommune 2016)

3.1.5 Climate change in water action plan

The EU Water Framework Directive (European Comission 2000) is implemented in Danish law since 2003 with the goal to reach good ecological and chemical status in the Danish waterbodies by 2015. After the

[2] LAR stands for Lokal Anvendelse af Regnvand (Local handling of rainwater). This thesis uses the equivalent term Sustainable Urban Drainage System (SUDS)

Municipal reform in 2007 the former water plans on county level became national water plans. Municipalities have to implement water action plans in order to have the national water plans implemented.(Aalborg Kommune 2015)

Climate change adaption is connected to the water action plans in the way that adaptation measures have to be in line with the EU Water Framework Directive. The adaption part of the Climate Strategy includes several guidelines connected to the water action plan of Aalborg Municipality. SUDS to handle rainwater in the city have to be in line with the water action plans in the way that pollution from run off rainwater has to be managed. The same applies to introducing separate sewage systems. The establishment of wetland in order to reduce the leaching of Nitrogen and Phosphor is part of the Aalborg water action plan. Also restoration of streams is included in the water action plan. Both of these measures go in line with the Climate Strategy to delay water by using river valleys as storage of water.

3.1.6 Importance of climate change adaptation

When asked about the importance of climate change adaptation in their work, all replies from the survey stated climate change adaptation as important or very important. Although climate change adaptation has been addressed already before it became mandatory by law, the legislation raised the importance of climate change adaptation in Aalborg Municipality as stated by 60% of the survey replies. Nevertheless it was stated that budget and human resources are missing to intensify the work on climate change adaptation. As a possible reason, the lack of major flooding events in the past was mentioned. A major flooding event would put climate change adaptation into focus and force politicians to provide budget and resources (Lervad Thomsen 2016b).

3.2 Potential impacts across municipal borders

The second sub research question asked *How do climate change impacts connect Aalborg municipality to its neighboring municipality Rebild?* To answer this question this section analyzes climate cahneg impacts in a shared watershed and applies those to the geographical setting of Aalborg and Rebild Municipality.

Municipalities have their administrative borders. Although administrative borders often follow natural settings like water courses or mountain ridges, environmental impacts can occur across administrative borders. Transboundary environmental impacts arise especially in shared watersheds. With ongoing climate change impacts like increasing precipitation and more frequent extreme weather events are shared by co-riparians in a watershed. At the same time climate change adaptation measures result in impacts throughout the watersheds (Milman et al. 2013). Figure 7 illustrates cross-bordering climate change impacts in a watershed shared by two municipalities.

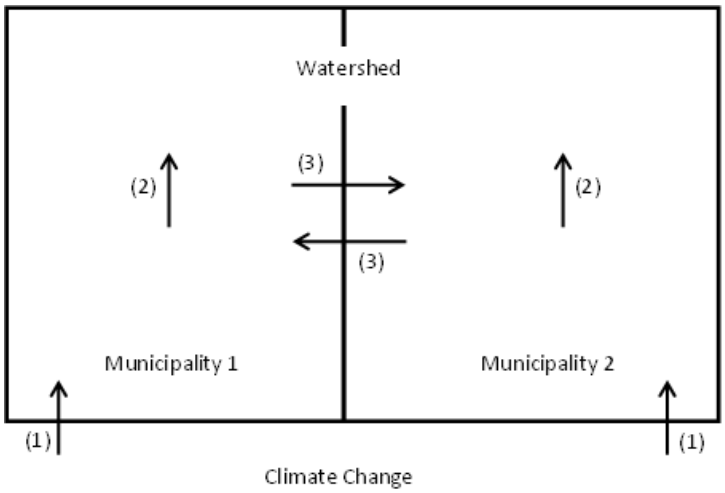


Figure 7: Cross-municipal climate change impacts in a shared watershed (Based on (Lintz 2015))

The arrows (1) indicate climate change impacts like increased precipitation or extreme weather events as cloudbursts affecting both municipalities. Both municipalities have to deal with these impacts in their area. Local effects are for example flooding from the sewage system exceeding its capacity (2). The arrows (3) indicate impacts crossing municipal borders caused by local measures in the municipalities. Figure 8 illustrates the impacts of climate and anthropogenic change to watersheds in more detail (Arnell 2002) Climate change affects waterbodies of a watershed directly with increasing precipitation and more frequent extreme rainfalls. Additionally local measures in form of land cover changes, changes in use of water and changes in sewage systems are impacting the water of a watershed. These measures can be the result of climate change adaptation but also developments not related to climate change. The consequences of the changes in the watershed are illustrated in the bottom of Figure 8. As seen in Figure 7 the impacts shown in Figure 8 are crossing municipal borders. Table 8 lists possible climate change adaptation measures and their local and downstream effects.

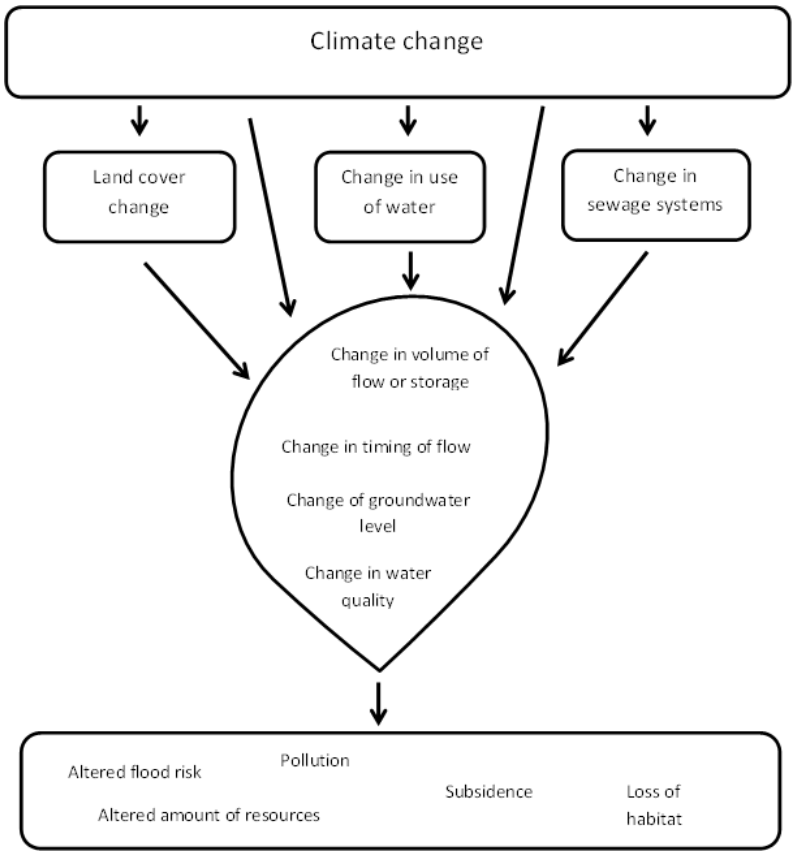


Figure 8: Climate change impacts to a watershed (Based on Arnell 2002, p.213))

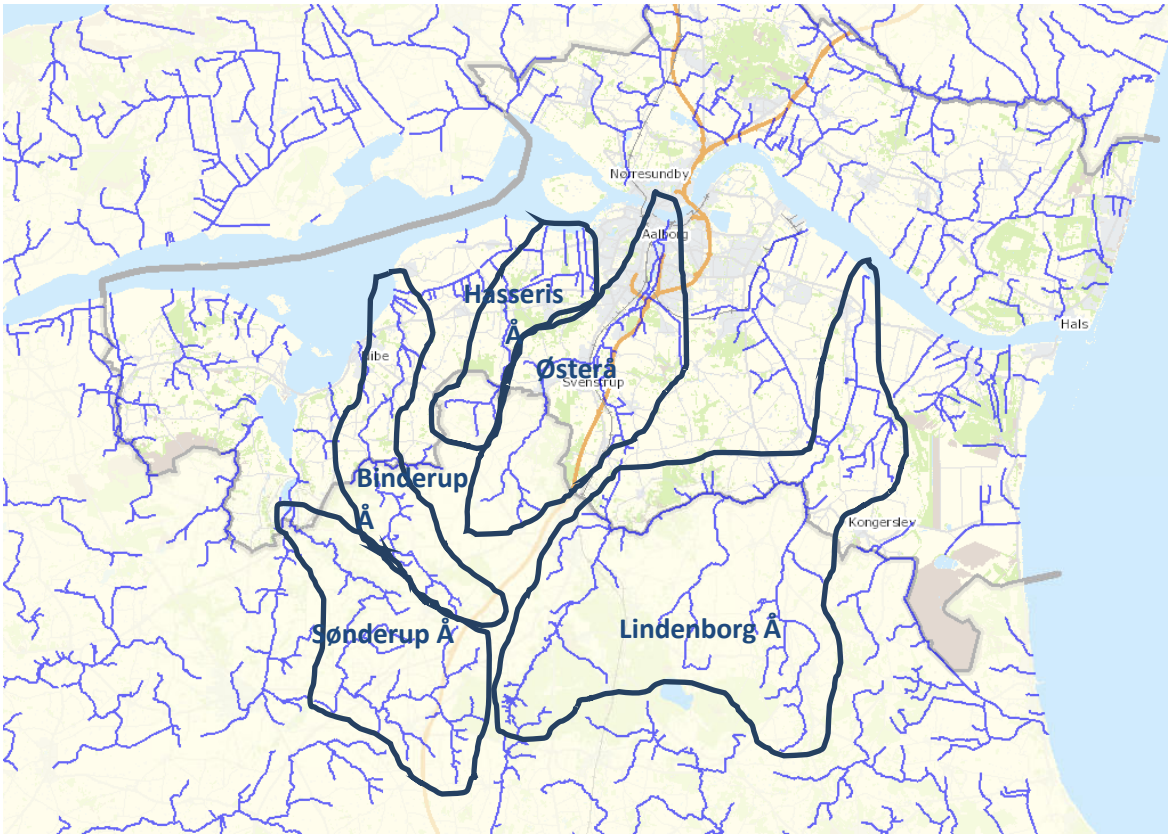
Table 8: Local and downstream effects of climate change adaptation in a shared watershed

Climate change impacts	**Measure**	**Local effects**	**Watershed effects**
Increased precipitation	Drainage of agriculture land	Subsidence of land → groundlevel closer to stream water level → higher flooding risk from streams	Subsidence of land → groundlevel closer to stream water level → higher flooding risk from streams
More intense rainfalls	Local drainage systems	Less local flooding from sewage system Rising groundwater level	Flow decreases downstream
	Separate sewage system without detention pool	No sewage flooding in houses	Flow increases downstream
	Separate sewage system with detention pool	No sewage flooding in houses. recreational space	Flow decreases downstream
	Sealing of permeable surfaces	More runoff	Flow increases downstream
	Restoration of streams	Controlled flood plains	Flow decreases downstream

3.2.1 Shared streams by Aalborg and Rebild Municipality

Aalborg Municipality is located North and South of the Limfjord. On the east it borders the Kattegat Sea. The neighboring municipalities are besides Rebild in the south Bronderslev in the north, Jammerbugt in the northwest and Vesthimmerland in the southwest. The largest urban area is the city of Aalborg on the southern shore of the Limfjord together with Nørresundby on the opposite northern shore. Also the main industrial areas are located on the Limfjord in the outskirts of Aalborg. The rest of the municipality is mainly agriculture land with small towns and villages. Large parts of the agricultural land are drained wetlands.

Aalborg and its neighboring municipality Rebild are connected by several streams which watershed is shared by both municipalities. Map 2 identifies five stream watersheds crossing the border of Aalborg and Rebild Municipality. All five streams originate in Rebild Municipality and flow into the Limfjord in Aalborg Municipality. Rebild municipality borders Aalborg in the south. The center of the municipality shares a large forest area where several streams originate. The largest part of the municipal area is agricultural land. Besides the larger towns Støvring and Skørping urban areas are mostly small towns and villages.



Map 2: Shared watersheds between Aalborg and Rebild Municipality

The Østerå flowing through the city of Aalborg and discharging there into Limfjord originates itself in open lands inside of Aalborg Municipality. It flows through the city of Aalborg first in the wide open river valley Østerådalen before it is channelized in the center of Aalborg until it discharges into the Limfjord. There are ongoing projects to open the Østerå in the center of Aalborg. The largest tributary, the Guldbækken has its origin in Rebild Municipality southwest of Støvring. It passes Støvring from the west, where it flows through the restored lake Julestrup Sø. Parts of Støvring are in the watershed of the Guldbækken. By name these are the business areas Julestrup- and Porsborgparken. Water from these areas flows into the Julestrup Sø. Besides passing Støvring and the small village of Guldbæk, Guldbækken flows through Rebild Municipality mainly in forest and farm land. It enters Aalborg Municipality in the village of Gothåb from where it flows through the urban area of Svenstrup before it joins with the Østerå in the open land between Svenstrup and Dall in Aalborg municipality.

From the streams connecting Aalborg and Rebild municipalities Lindenborg Å has the largest watershed in general and also its part in Rebild Municipality is larger than from the other shared watersheds. It originates in farmlands south of the Rolds Skov forest through which it continues to flow. Outside of Støvring the stream Mastrup Bæk discharges into Lindenborg Å. Mastrup Bæk flows through the center of Støvring and most parts of the city are in the watershed of it. These include also the new developing areas Støvring Ådale and Høje Støvring. Behind Støvring Lindenborg Å flows in agriculture land and forms the border between Aalborg and Rebild municipalities. Before the stream flows into Aalborg Municipality two tributaries from the south of Rebild flow in: Skibsted-Lyngby Å and Tustrub Bæk. These two have their watershed in mostly agriculture land with small villages. In Aalborg Municipality the stream flows through agriculture land passing small villages and discharges into the Limfjord outside of Storvorde.

Hasseris Å shares only a small part of its watershed with Rebild municipality. The stream originates south of Øster Hornum. Also Øster Hornum is the only settlement in the watershed in Rebild municipality. There are new developments planned to have the village grow. In Aalborg municipality it passes the small village of Tostrup before flowing into the Limfjord close to the Hasseris neighborhood of Aalborg.

Binderup Å origins outside of village Suldrup, which is also the main settlement in the part of its watershed belonging to Rebild municipality. It passes a few more villages before it enters Aalborg municipality where it flows into the Limfjord outside the town of Nibe.

Sønderup Å is the most western stream flowing from Rebild into Aalborg Municipality. It has like Lindenborg Å its origin in the Rold Skov forest but flows from there to the west. Another branch originates close to the town Haverslev. In its continuation Sønderup Å follows the border to Vesthimmerland Municipaliy before it flow into Aalborg Municipality were it shortly after discharges into the lake Halkær Bredning which is connected to the Limfjord.

3.2.2 Cross-border impact perception in Aalborg municipality

Aalborg's Climate Strategy 2012-2015 proposes the investigation of possible "climate partnerships" with neighboring municipalities as many of Aalborg's streams originate in neighboring municipalities. When asked about Aalborg's connection to neighboring municipalities related to climate change impacts, the answers were partly contradictory. A strong connection is seen related to streams, as well for flooding issues as for water quality. On the other hand in a planning perspective cross-border impacts are seen as weak because most of the streams flow in agriculture land and the focus of planning lies more on urban areas (Schultz 2016). Even more contradictory are cross-border climate change impacts perceived related to sea level rise in the Limfjord. 53% see a strong or very strong connection whereas 33% perceive the connection weak. A stronger perception is more in the planning department, whereas the weak perception of cross-border impacts through sea level rise is at the sewage utility company. Rising groundwater level and drainage of agriculture land are perceived with weaker cross-border impacts. Nevertheless they are seen as a major threat inside Aalborg Municipality (Schultz 2016).

3.2.3 Impacts across municipal borders by water management

As stated earlier, besides climatic changes, also changes in water management result in impacts throughout the watershed (Figure 8). Rebild municipality calculated changes in water volume and flow for outlets discharging storm water in the streams of the municipality. One cause of the changes are changes in the sewage system. One example is transforming combined sewage system which discharged rainwater together with waste water into wastewater treatment plants into separate sewage systems where storm water is discharged into streams. With the combined sewage system streams received storm water directly only in the case when the capacity of waste water treatment plants is exceeded and combined waste and storm water is discharged by overflows. These changes are leading to an increase of water volume and flow in the streams. Another example leading to changes in storm water flow are added detention pools to rain water outlets from separate sewage systems. These store and delay storm water resulting in decreased volume and flow in the streams. Both the described examples are local climate change adaptation measurements affecting the watershed further downstream. Besides changes in the sewage system water flow and volume in rain water outlets are also affected by changes of the surface in the catchment area of the storm water outlets. New developments sealing permeable surfaces increase the run off into the streams.

Table 9 and Table 10 added up all planned changes of rain water outlets from the watershed of the five streams connecting Aalborg and Rebild Municipality planned in the current waste water plan of Rebild Municipality in the timeframe from 2014 to 2017. In all five streams the annual volume of storm water discharged is planned to increase (Table 9). The highest increase in volume is planned for the Østerå watershed.

Table 9: Changes in rainwater outlets: Annual volume (Rebild Kommune 2014c)

Stream going into Aalborg Municipality	Annual volume 2014	Planed annual volume 2017	Change of annual volume	Change of annual volume
	[m³]	[m³]	[m³]	[%]
Binderup Å	79.071	106.282	27.211	34%
Hasseris Å	83.012	94.798	11.786	14%
Lindenborg Å	811.382	1.023.669	212.287	26%
Østerå	88.484	212.588	124.104	140%
Sønderup Å	108.751	202.211	93.460	86%
Sum	**1.170.700**	**1.639.548**	**468.848**	

The planned changes of outflows during rain events with a one year return period are much smaller than the planned changes in annual volume as seen in Table 10. Compared to the 140% increase of annual volume outflow from storm water outflows during 1 year rainfall events is planned to increase only by 15%. The reason for this is the large delay and storage of water in the detention lake Julestrup Sø. Storm water outflow received by Lindenborg Å and Sønderup Å is planned to be decreased. This is also caused by planned detention pools included in separate sewage systems.

Table 10: Changes in rainwater outlets: 1year rainfall event (Rebild Kommune 2014c)

Stream going into Aalborg Municipality	Current 1y rainfall event outflow 2014	Planned 1y rainfall event outflow 2017	Change of 1y rainfall event outflow	Change of 1 year rainfall outflow [%]
	[L/s]	[L/s]	[L/s]	[%]
Binderup Å	1.708	1.911	203	12%
Hasseris Å	320	320	0	0%
Lindenborg Å	2.386	656	-1730	-73%
Østerå	310	355	45	15%
Sønderup Å	2.111	906	-1205	-57%
Sum	**6.835**	**4.148**	**-2.687**	

3.2.4 Impacts across municipal borders by urban developments

As seen in Figure 8 land use change has impacts to the water downstream the watershed. In Rebild Municipality several areas are being new developed which are located in the watersheds of the streams shared with Aalborg Municipality. Three large developments are located in Støvring, the largest in Rebild Municipality. East of the railway the new urban area Støvring Ådale is being developed. As stated in the municipal plan 2013 (Rebild Kommune 2013) the new area is an expansion of housing and public services.

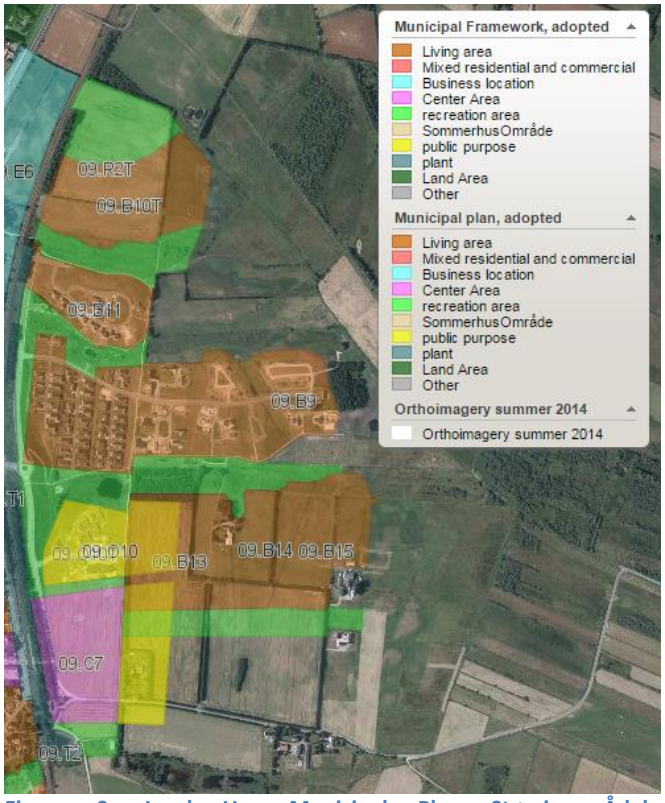


Figure 9: Land Use Municipal Plan Støvring Ådale (Geodatastyrelsen & Erhvervssyrelsen n.d.)

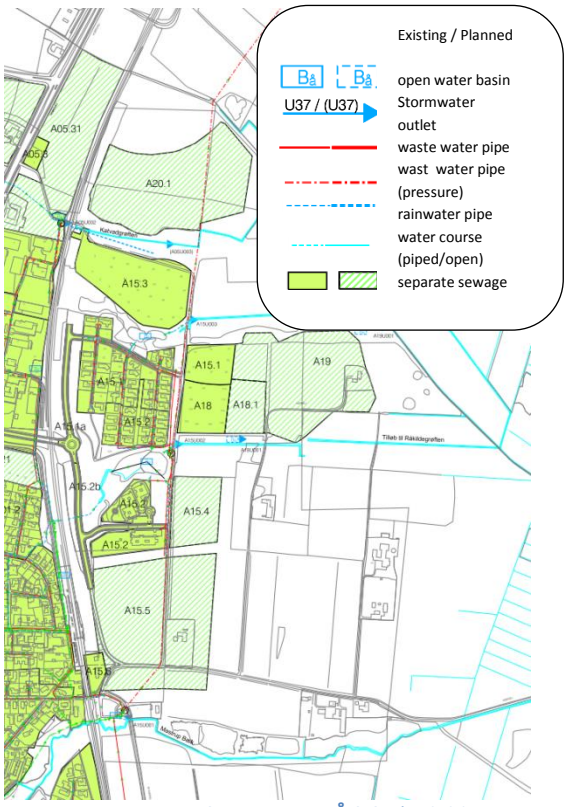


Figure 10: Sewage Plan Støvring Ådale (Rebild Kommune 2015)

Figure 9 shows the land use framework for Støvring Ådale as defined in the current Municipal Plan 2013. The brown colored residential areas are mostly 1-2 story one family houses. The areas 09.B9 and 09.B11 are mostly built. The areas 09.B10T, 09.B13, 09.B14 and 09.B15 are being prepared for developments as well the new pink colored center area 09.C7. In the yellow colored public area 09.O10 an elderly home and a childcare center are opened. The area of Støvring Ådale is located in the watershed of the Lindenborg Å. The assessment in the wastewater plan 2014-2017 revealed the area as not suitable for SUDS. As seen in Figure 10 the area is already connected to or planned as separate sewage systems. This means that all runoff from sealed surfaces flows into the watercourses. As rainwater from streets has to be cleaned and in order to store and delay the run off several open detention basins are installed or planned in the area. These measures are one of the reasons why there is no increase in projected in outflow into the watercourses of the Lindenborg Å watershed (Table 10). Nevertheless the new developments contribute to the increase in the annual volume of run-off being discharged into the Lindenborg Å in Rebild Municipality (Table 9).

Figure 11: Outline Development Plan Høje Støvring (Rebild Kommune 2014a)

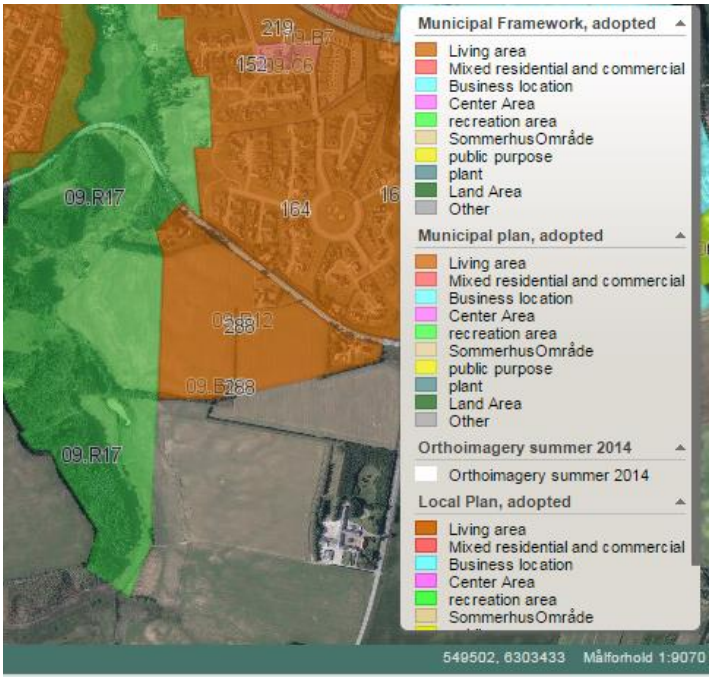


Figure 12: Land Use Municipal Plan Høje Støvring (Geodatastyrelsen & Erhvervssyrelsen n.d.)

In the South of Støvring the new residential area Høje Støvring has started to be developed. Figure 11 shows the whole area as planned in the Outline Development Plan. Figure 12 shows the area for which a local plan has been created (Rebild Kommune 2014b). The area has not been connected to the sewage system. Rainwater is planned to be percolated locally as the soil is suitable for local infiltration. Although there are drinking water extractions nearby local infiltration is possible. Special focus has to be set on rainwater from the road as it has to be treated before. Through the local handling of rain water, impacts to a change of the nearby streams Mastrup Bæk are not expected.

The third large development project in Støvring is located in the west of the town. Figure 13 shows the areas Julestrup- and Porsborgparken as business areas as defined in their local plans. Whereas Julestrupparken has already business developments built Porsborgparken will be new developed. As business areas go along with a large sealing of permeable surfaces through the buildings and parking lots a large amount of run-off will be created. As seen in Figure 14 the areas are developed or planned with separate sewage. Rainwater is collected in three open detention basins before it is discharged into the lake Julestrup Sø. As the Guldbækken stream flows through the lake and finally discharges into the Østerå stream the annual stormwater running into Aalborg is increasing in a high amount (Table 9).

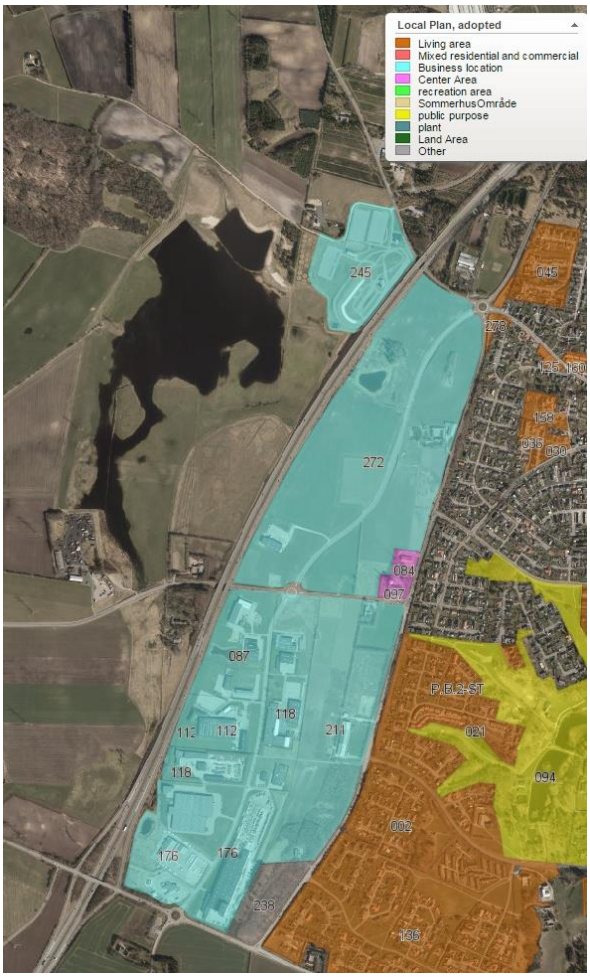


Figure 13: Land use Local Plan Julestrup-/Porsborgparken (Geodatastyrelsen & Erhvervssyrelsen n.d.)

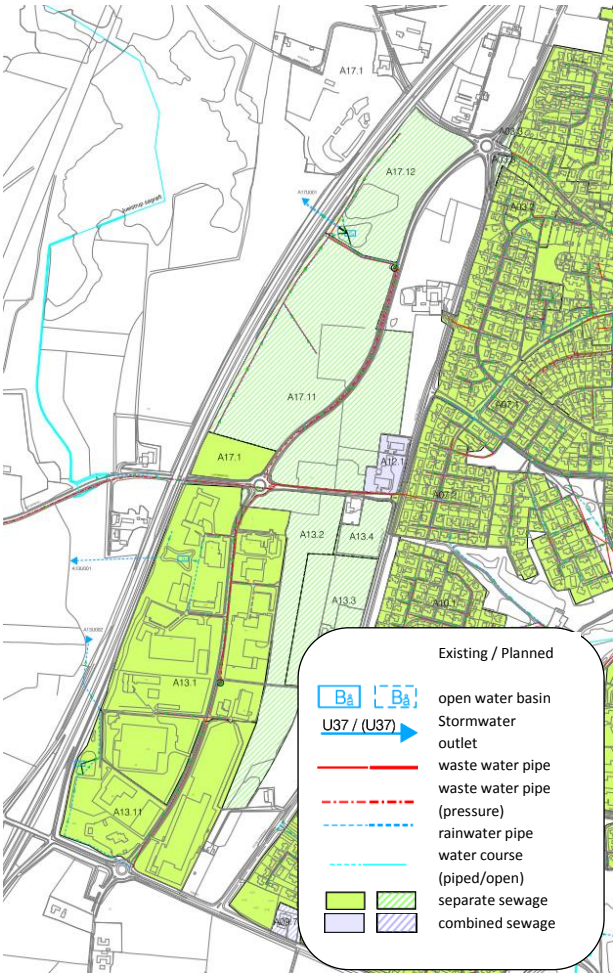


Figure 14: Sewage Plan Julestrup-/Porsborgparken (Rebild Kommune 2015)

3.2.5 Impacts across municipal borders by stream restoration

Rebild municipality has planned 26 stream restoration projects for which funds from the Danish Nature Agency were granted. The main goal of the projects is to improve the ecological status of and the habitat for fish in the watercourses. Nevertheless these measures change the flow properties of the streams, impacting also Aalborg Municipality downstream.

3.2.6 Impacts across municipal borders in the future climate

The described connections between Aalborg and Rebild Municipality have only minor impacts across the municipal borders. With the predicted changes of the climate, though, these now minor impacts of upstream developments are predestinated to increase especially with increasing precipitation and more frequent extreme rainfalls.

3.3 Collaboration on climate change adaptation

The third sub research question askes: *How can collaboration between Aalborg and Rebild Municipality be incorporated in climate change adaptation?* To answer this question first collaboration inside of

Aalborg Municipality is described. Further collaborations between Aalborg and other municipalities are analyzed. Also the result of the analysis of climate change adaption and collaboration in Rebild municipality as well as examples other inter-municipal climate change adaptation collaborations are shown in the following sections. Prospects of climate change adaptation collaboration between Aalborg and Rebild are pointed out later in the discussion (Section 4.1.2) based on these results.

3.3.1 Internal collaborations in Aalborg municipality

Aalborg municipality is organized in different departments and sectors. Nevertheless municipal tasks relate to several departments and raise the need of inter-municipal collaboration. The difficulties and barriers which arise by implementing cross-sectoral climate change issues into a strong sectoral organization are addressed by Wejs (2013 and Zamzam & Frederiksen (2013). With this background the extent and importance of cross-sectoral or cross-departmental collaboration in Aalborg municipality is investigated. The focus lies on collaborations between departments and utility companies which are connected to climate change adaptation. These are the Environmental and Energy Department (Miljø- og Energiforvaltningen), the Planning and Landscape Department (By- og Landskabsforvaltningen) and the sewage utility company Aalborg Kloak A/S. Internal collaboration between those is investigated in general and directly in relation to climate change adaptation. The large majority of the participants of the survey see a strong or very strong internal collaboration in general. All participants state that they collaborated with other departments in some way. Also specifically related to climate change adaptation internal collaboration is seen by the majority as “strong” followed by “very strong”. When asked how the collaborative culture changed in the last years the vast majority perceived an increase in collaboration. Related to internal collaboration in general answers from the planning department point out the importance of internal collaboration when creating any kind of plan. Directly related to climate change adaptation internal collaboration was pushed by the legislation of mandatory climate change adaption plans. For incorporating climate change adaptation into the municipal plan, a stronger collaboration between the environmental and planning department evolved (Lervad Thomsen 2016b). An example is the risk map showing areas where climate change adaptation has to be included in new local plans. Another example is the implementation of sustainable urban drainage systems (SUDS). The environmental department creating the SUDS catalog has to work together with the sewage utility company to coordinate where rainwater is treated locally with SUDS and where it is discharged by separate sewage. Again the planning department has to be involved to include SUDS in the local plans. The new waste water plan where the SUDS catalog is part of has climate change adaptation as one of its three focus areas. Also this plan is created in close collaboration between the environmental department and the sewage utility company.

3.3.2 Collaboration between Aalborg and other municipalities

Aalborg Municipality is working together with other municipality in different ways. Its collaboration between different municipalities is happening to a lesser extent than internal collaboration, though. In general topics inter-municipal collaboration is seen by the majority as strong. Related to climate change adaptation the inter-municipal collaboration is perceived by the majority as weaker. Nevertheless the importance of collaboration on climate change adaptation is seen. One reply states: “*Working with climate adaption projects is often a complex process with different stakeholders, who have different interests, but climate adaption projects also has a great potential to create good synergies! (Landscape*

architect, Planning Department Aalborg Municipality, Survey). Aalborg Municipality is collaborating with other municipalities mainly through different kinds of networks. The main purpose is to share knowledge and experiences with others working in the same field. So called Erfa groups play an important role in knowledge sharing. They were mentioned by interviewees and survey participants in this thesis as well in the thesis of Zamzam & Frederiksen (2013). In these groups specialists with the same work or interest meet regularly (Gyldendal 2015). Contacts from the Erfa groups are also mentioned as informal paths to ask for support. Another reply in the survey mentioned networks through the National Advocacy Organization of Danish Municipalities (KL[3]) for inter-municipal collaboration. In the field of sewage and water supply, the utility companies of Aalborg are part of DANVA[4] the non-profit interest organization of Danish water companies. One of DANVA's policies covers climate change mitigation and adaptation in the water sector (DANVA 2012).

Further Aalborg Municipality is a member of the Limfjord Council (Limfjordsrådet) (LIMFJORDSRÅDETS SEKRETARIAT n.d.). The Limfjord Council is a forum of 18 municipalities located in the Limfjord watershed. It has the target to improve the fjords environmental status in cooperation with all municipalities in the watershed. A special focus lies on the implementation of the EU Water Framework Directive (European Comission 2000) and Natura 2000 (European Comission 2016). Its political forum consist of 1-2 representatives from the members city councils. The political forum is supported by a group of senior officials (Embedsmandsgruppen) from each member municipality. Both groups meet several times per year. Represented and coordinated is the Limfjord Council by a joint secretary consisting of nine persons located in Aalborg Municipality. Climate change adaptation is not a part of the council's work. In 2014 though the senior official group decided to establish a working group on climate change and to develop a climate risk management plan (LIMFJORDSRÅDETS SEKRETARIAT 2014). This was an initiative of Aalborg Municipality. Because of missing resources the working on climate change in the Limfjord Council hasn't started yet (Lervad Thomsen 2016b). In a meeting with the regional part of KL in the Northern Denmark region (KKR Nordjylland) in February 2016 the Limfjord Council decided to include climate into its strategy. As climate impacts are seen to cross municipal borders the Limfjord Council wants to support the cooperation in "Helhedsplaner" (LIMFJORDSRÅDETS SEKRETARIAT 2016).

In the survey it was asked to state the importance of inter-municipal collaboration related to the different municipal plans which have a connection to climate change adaptation. Inter-municipal collaboration is the most important in water action plans. All replies state "important" or "very important" This result is not surprising as these plans are already include collaboration by addressing whole watersheds. The same strong importance is seen for the comprehensive plans of streams (Helhedsplaner) although they are not established yet. Inter-municipal collaboration on climate change adaptation is also seen important for waste water plans. Nevertheless there are contradictory perceptions. Four out of the 15 participants stated waste water plans as unimportant. All of these replies are made by employees of the utility company or employees who work directly with the sewage system. On the other side 4 out of the 6 replies stating "very important" were made by the planning department. Also the replies for the municipal plan are contradictory. Whereas 8 replies stated "important" and 2

[3] Kommunernes Landsforening (KL)
[4] Dansk Vand- og Spildevandsforening (DANVA)

"very important" also 5 replies stated "unimportant" All of these 5 replies are from the utility company. The climate change adaptation plan itself is also seen in majority important for inter-municipal collaboration. Only 2 replies stated here "unimportant". The lowest importance for inter-municipal collaboration on climate change adaption is seen for local plans. Only 3 out of the 15 replies stated "important" or "very important".

3.3.3 Context of collaboration with Rebild Municipality

3.3.3.1 Climate Change Adaption Status in Rebild Municipality

Rebild Municipality started working on climate change adaption when municipal climate change adaption plans became mandatory in 2013. In 2014 the climate change adaption plan was added as a supplement to the current municipal plan 2013. Before climate change adaption was not addressed. Because of a short time to create the plan and a lack of human resources the plan was mostly prepared by external consultants (Riber Knudsen 2016).Climate change impacts addressed in the plan are increasing precipitation and more frequent heavy rainfalls as well groundwater rise. In order to identify areas of risk and map them in a risk map, flood and value maps were compiled. Also local knowledge was included in the risk map. Two kinds of flood maps were prepared. One simulated the height accumulated water in depressions after rain events with 5, 10, 20, 50 and 100 year return periods. Another map compared the sewage capacity with accumulation of rainwater during heavy rainfalls. By combining the flood maps with a value maps 29 risk areas were identified, which are primarily in urban areas. Strategies for the risk areas are diverting, delaying and infiltrating rain water. The wastewater plan 2014-2017 (Rebild Kommune 2014c) includes the objective to use SUDS to support the sewage system in heavy rainfall. Therefore the suitability to infiltrate rainwater was assessed for the municipality. Because of high groundwater levels drainage rainwater is mostly not suitable in Rebild.

Since the climate change adaption plan was prepared climate change hasn't been addressed in depth in the municipality. Action plans to implement strategies in the risk areas have not been implemented yet. Missing resources have kept the focus on climate change adaption away. Another reason mentioned by the interviewed official from Rebild Municipality is that there was no major flood event in the recent past which would put risks of climate change into focus. A major flood event would create normative pressure to the municipality to address climate change adaption more. Nevertheless, also without an action plan climate change is addressed when issues arise. The building of a new cultural house and its parking lots created impermeable surfaces to the extent that the runoff into the nearby stream would exceed its capacity. Therefore some of the water had to be handled locally.

3.3.3.2 Collaborative Culture in Rebild Municipality

Climate change adaptation connects several departments and utility companies in Rebild municipality. The responsibility of climate change adaption is set in the Nature and Environmental Department. Further the planning department and the building department are involved when climate change adaptation is part of new developments. Further connections between departments exist in the preparation of the waste water plan. The plan is prepared by the Nature and Environmental Department in cooperation with the water and waste water utility company. The quote *"When Rebild Kommune*

[(Municipality)] is building something. We have a small unit that makes the plans and makes things with architects, a building function. Then we have my center and we handle environmental issues and then we have the planning department. They make the planning to make room for the builders … So in the ideal world would do this corporation very early in the planning process but we don't…" (Riber Knudsen 2016) shows that the need of close internal collaboration is seen in the municipality but that internal collaboration is not happening in the needed extent. In order to improve internal collaboration the municipality used external consultancy to bring the different departments closer together. The reasons for the lack of collaboration are seen in the deeply anchored culture of working in separate departments. In relation to Scott's institutional pillars, it can be followed that there are cultural-cognitive barriers for internal collaboration on the other hand the understanding of the need for collaboration can be seen as a normative motivation.

When asking about collaborations with other municipalities, the Limfjord Council was mentioned first. Also collaborations with neighboring municipalities in projects about wetlands removing nitrogen were mentioned. These collaborations are part of the water plans in order to adhere to the EU water framework directive. The staff of the Nature and Environmental Department takes part in different groups and exchange forums to share information and experiences. Further Rebild municipality cooperates in a network called KTC[5] in which the heads from the environmental departments from all Danish municipalities take part (Kommunalteknisk Chefforening n.d.). Another way Rebild municipality is planning to share and gain experiences and knowledge is by exchanging experts with other municipalities. Climate change adaptation hasn't been an issue in these networks. Nevertheless Rebild municipality sees collaboration on climate change adaption as an important goal. Especially the Limfjord Council is seen as an applicable structure for collaboration as it is already an institution connecting the municipalities in water related issues.

3.3.4 Existing climate change adaptation collaborations between neighboring municipalities

There are examples of already existing inter-municipal collaborations in climate change adaptation in Denmark. In the central Denmark region the Storå stream flows through the municipalities Ikast-Brande, Herning and Holstebro. The largest part of the watershed lies with 60% in Herning Municipality. Ikast Brande where the stream originates shares 15% and Holstebro where the stream discharges into the Nissum Fjord shares 25% of the watershed. The highest flooding risks are in the city of Holstebro where the stream flows directly through. In order to coordinate climate change adaptation along the Storå the three municipalities together with their utility companies established the Storå Cooperation Forum (Storå Samarbejdsforum) with the goal to adapt to climate change in a coherent way. The forum also has the objective to create a joint climate adaptation plan for the Storå watershed based on the adaptation plans of the three municipalities. The climate change adaptation plans of Holstebro and Herning state the natural connection of the municipalities by the Storå as the motivation to cooperate in climate change adaptation. (Holstebro Kommune 2014; Herning Kommune 2014)

[5] Kommunalteknisk Chefforening (KTC)

Another Danish example of inter-municipal collaboration on climate change adaptation is along the Usserød Å in the Northern Zealand region. In a project supported by the EU LIFE program the three municipalities Fredensborg, Hørsholm and Rudersdal are working together in climate change adaptation along the Usserød Å. The project targets three results. First a permanent organization across the three municipalities dealing with climate change adaptation has to be established. Second a toolbox has to be created with common measuring and warning systems. Finally specific adaptation projects will be built. Examples are new established wetlands which function as floodplains. The timeframe of the projects is from 2012 until 2016. (Fredensborg Kommune et al. n.d.)

CHAPTER IV - ANALYSIS AND OUTLOOK

In this chapter the seventh stage of analysis and interpretation (Singleton & Straits 2010) is applied. The collected data is analyzed and discussed to answer the research questions by relating it to the theoretical framework. Further the chapter concludes with an outlook.

4.1 Discussion and conclusion

4.1.1 Relations to institutional theory

The responsibility for climate change adaptation in Denmark is set on the local scale. Municipalities are in charge of preparing climate change adaptation plans and implementing them in their planning. Although climate change adaptation plans are obligatory, the importance of climate change adaptation in municipal work has space to increase. In relation to Scott's institutional pillars the main driver for institutional change to include climate change adaptation in municipal planning is the legal obligation, evolving in the regulative pillar (Table 11). This regulative driver has also a normative part, though. The national law was enacted also with the background of the extensive flooding after strong cloudbursts in Copenhagen in 2011 (Miljøministeriet Naturstyrelsen 2013). These events created a moral obligation to react to climate change, as events like this are expected to happen more frequently. With this moral obligation the regulative national law is connected to the normative pillar. At the same time the implementation of climate change adaptation exceeding the obligated plan doesn't reach its potential as this moral obligation is not strong in Aalborg and Rebild municipalities. No major flooding events have happened in the recent past. Officials from both municipalities mentioned that a major flood event would focus attention on climate change adaptation and morally force politics to provide money and human resources for stronger climate change adaptation. Also inter-municipal collaboration could be a normative driver for the implementation of climate change adaptation. The experiences and knowledge of climate change adaptation in other municipalities could be a moral trigger to also strengthen the implementation of climate change adaptation. Aalborg municipality addressed climate change adaptation already before it became obligatory. The same counts for including climate change adaption in development projects although specific action plans have not been created yet. These actions can be seen as drivers for a cultural-cognitive change in the municipality towards a higher importance of climate change adaptation.

Table 11: Institutional Change for implementation of climate change adaptation

Institutional Change for implementation of climate change adaptation	Drivers	Barriers
Regulative	Legal obligation	
Normative	Experiences of other municipalities which are farer with the implementation by inter-municipal collaboration	No local severe flooding happened in the recent past
Cultural Cognitive	Climate Strategy started before climate change adaptation became mandatory (Aalborg Municipality) Introducing climate change adaptation in projects also without existing action plan (Aalborg Municipality) Improving internal collaboration	Lack of internal collaboration

As climate change adaptation has an interdisciplinary status, several departments have to work with it. This leads to a need of close collaboration between different departments. Depending on the extent of internal collaboration, it can be a driver or barrier as well for the implementation as for inter-municipal collaboration (Table 11 and Table 13). The results of this thesis show that although municipal culture is strongly sector-based, internal collaboration is increasing. As a driver for increasing internal collaboration the legislation of mandatory climate change adaptation plans is identified (Table 12). For example the collaboration between the environmental department and planning department increased by incorporating climate change adaptation into the municipal plan. As a driver for cultural cognitive change it can be seen that departments were also collaborating already before the mandatory climate change adaptation plan. The case of Rebild municipality shows also the normative understanding that internal collaboration should be improved, by the effort to get external support for improving internal collaboration (Table 12).

Table 12: Institutional Change for internal collaboration on climate change adaptation

Institutional Change for internal collaboration on climate change adaptation	Drivers	Barriers
Regulative	Internal collaboration pushed through the need to connect climate change adaptation in municipal plans	
Normative	External consultancy for improving internal collaboration	Missing human and financial resources
Cultural Cognitive	Voluntary internal collaboration already before the mandatory climate change adaptation plan connected departments New staff	Sector based organization

As seen in the case study of Aalborg, impacts from climate change don't stay in municipal borders. Especially impacts related to water have effects throughout a watershed, calling for inter-municipal collaboration. In contrast to Sweden, where municipalities are obliged to make their master plans in collaboration with their neighbors, there is no legal regulation of inter-municipal collaboration in Denmark. A legal obligation to collaborate in municipal planning as in Sweden would trigger regulative institutional change also for collaboration in climate change adaptation. Nevertheless also without legal obligations, Aalborg Municipality is part of organizations and networks like the Limfjord Council. Adding climate change adaptation into these networks and organizations can be a trigger for inter-municipal collaboration in it. Being part of them creates more normative drivers for inter-municipal collaboration as there are binding expectations to take part in these networks and organizations. As major flooding events are drivers for implementing climate change adaptation inside the municipality, this counts also for inter-municipal collaboration. In example of the municipalities of Ikast-Brande, Herning and Holstebro collaboration on climate change adaptations evolved from frequent flooding events in Holsterbo. The example of Fredensborg, Hørsholm and Rudersdal also showed the flood risks as a trigger for collaboration, but also the possibility of funding from the EU LIFE projects can be seen as a normative trigger in the way that existing incentives should be used. On the individual scale a culture of collaboration is identified in Aalborg Municipality. Municipal employees have their formal and informal contacts and networks to ask for support and help. Formal networks are different Erfa groups. As informal networks personal contacts were mentioned. These can evolve from formal networks. Therefore drivers for inter-municipal collaboration are less related to the regulative institutional pillar but more to the normative and cultural-cognitive pillar. The mentioned networks are mostly focused on a specific sector or discipline. As climate change adaptation relates to several factors these networks can also be barriers for collaboration on climate change adaptation. Regarding the perception of cross-border climate change impacts a cultural focus on urban areas in the planning perspective is revealed as a cultural-cognitive barrier of inter-municipal collaboration as many streams connecting municipalities

flow in agricultural land. In general there is a weak culture of inter-municipal collaboration in the planning department.(Schultz 2016, Survey)
As the major barrier for improving collaboration in general missing budgets were mentioned followed by the lack of human resources and organizational structures. Regarding the first two barriers, regulative or normative institutional changes could provide the missing resources as described above. Organizational structures are rooted by the cultural-cognitive institutional pillar, but do also create rules and norms in the organization which relates to the normative pillar. Therefore also changes in the culture need to happen. These changes could be initiated by individual actions and initiatives. Cultural changes in collaboration were identified also through changes in staff (Table 12 and Table 13) (Bøgh Vinther 2016b).

Table 13: Institutional Change for inter-municipal collaboration on climate change adaptation

Institutional Change for inter-municipal collaboration on climate change adaptation	**Drivers**	**Barriers**
Regulative	Legal obligation of municipal collaboration (Sweden)	
Normative	Binding expectations in organizations like Limfjord Council Financial incentives	Missing human and financial resources No local severe flooding happened in the recent past
Cultural Cognitive	Private informal collaboration Participation in networks Increasing culture of internal collaboration New staff	Lack of internal collaboration Networks are sector specific Local focus of urban planning, collaboration seen more important in agricultural aspects

4.1.2 Prospects of collaborative climate change adaptation of Aalborg with neighboring municipalities

The Climate Strategy 2012-2015 states an interest in Aalborg Municipality of investigating potential collaborations in climate change adaptation with neighboring municipalities. As seen in the results of this thesis this collaboration is not happening yet. Nevertheless the connection between neighboring municipalities is recognized in Aalborg Municipality. Also the further analysis of connections between Aalborg and Rebild municipality reveal border crossing impacts through shared watersheds. Opinions which don't see the importance of climate change adaptation across municipal borders could be based on the fact that impacts caused by developments in neighboring municipalities are only minor in the current climate with the lack of intense rainfalls causing severe impacts.

As cultural cognitive institutions have a high resistance to change, the collaborative culture in the municipalities can be seen as the foundation for inter-municipal climate change adaptation. With the results of this thesis an increase in collaborative culture is identified in Aalborg as well in Rebild

municipality. Based on this foundation, changes in regulative or normative institution could lead to inter-municipal climate change adaptation. A strong trigger for regulative and normative institutional changes is identified in severe weather events. In the regulative pillar this has already happened after the cloudbursts in Copenhagen. Normatively severe impacts from local extreme weather events would create a moral obligation to focus more on climate change adaptation also in Aalborg and Rebild and reducing the main barriers of collaboration identified as lack of financial and human resources. Statements in the survey for the question asking what could encourage collaboration with other municipalities are backing these triggers by naming legislation and resource allocation. Further the results identified a strong participation in networks where knowledge and experiences are shared. Experiences from other municipalities already collaborating in climate change adaptation could also trigger the collaboration between Aalborg and its neighbors like Rebild Municipality.

As illustrated in the theoretical framework (Figure 3) municipalities are set in an organizational field. Collaborations between municipalities could be realized directly between the municipalities or through a third party functioning as a carrier for collaboration. Table 14 lists networks and organizations Aalborg Municipality is participating in with its actors and possible tools for inter-municipal collaboration on climate change adaptation.

Table 14: Potential carriers for inter-municipal collaboration on climate change adaptation

Carrier	Agencies	Tools
Limfjord Council	City council members Senior officials	Helhedsplaner Water action plans
DANVA	Utility companies	Waste water plans
Erfa groups	Specialists	Shared knowledge/experiences
KTC networks	Head of departments	Shared knowledge/experiences

Aalborg Municipality's strongest connection in climate change impacts with neighboring municipalities was identified by water bodies like shared streams and the Limfjord. Therefore the Limfjord Council, in which all municipalities in the Limfjord watershed are members, has a high potential to be a carrier for collaboration on climate change adaptation. The initiative of Aalborg Municipality to establish a working group about climate change in the Limfjord Council as well as the addition of "climate" to its strategy in 2016 emphasizes its potential. Nevertheless the importance of climate change adaptation has to increase inside the member municipalities to provide financial and human resources for the working group. Also the organization of many municipalities in the Limfjord Council could be a stronger way to be heard more by the national government for support in climate change adaptation than by municipalities themselves (Interview: Jens Bøgh Vinther). Already the participation of only a few municipalities could be a normative driver to join the working group to collaborate on climate change adaptation. In the Limfjord Council municipalities are already working cooperatively with water action plans implementing the EU Water Framework Directive. For comprehensive plans for streams (Helhedsplaner), as planned in Aalborg Municipality for three of its streams to start with, inter-municipal collaboration is seen important by the Limfjord Council. Besides ensuring good ecological and chemical status of the streams,

the inclusion of climate change adaptation as well as the connection to the waste water plans makes these Helhedsplaner a strong tool for inter-municipal collaboration on climate change adaptation. Together with the water action plans they are seen in the survey as the most important plans to include collaboration. As Helhedsplaner focus on the watershed of specific streams, existing structures of water action plans could be applied.

Climate change adaptation is already part of the policies of the non-profit interest organization of Danish water companies DANVA. As it represents all Danish water utility companies it could be also a carrier for inter-municipal climate change adaptation. Possible barriers though can be seen as the network is based on only the waste water sector whereas climate change adaptation is connected throughout municipal sectors. In the listed Erfa groups the sharing of knowledge and experiences could be used to identify common issues in climate change adaptation and therefore create synergies. The regular meetings of heads of environmental departments in the KTC network could be used to identify common projects in climate change adaption.

4.2 Perspectives

Climate change connecting municipalities is focused in this thesis on streams in shared watersheds, impacted by increasing precipitation and more frequent intense rainfall. Also climate change impacts to other waterbodies can cross administrative borders. In the case of Aalborg municipality the coast of the Kattegat Sea and the Limfjord are shared with other municipalities. Adaptation measures like closing the Limfjord would impact all municipalities bordering the Limfjord. In order to protect coastlines adaptation measurements can also have impacts along the coastlines. Further research could be done to assess municipal collaboration regarding these impacts. Climate change adaptation is also closely connected to risk management. Especially when looking at shared streams more research could be done for example in collaborative warning systems.

The case study in this thesis is set in a context with a high potential for effective climate change adaptation. The Notre Dame Global Adaptation Index (ND-GAIN), developed previously by the Global Adaptation Institute in Washington, D.C and now by the University of Notre Dame, ranks Denmark as one of the countries with the highest readiness to adapt to climate change (Notre Dame Global Adaptation Index 2014). Readiness is defined as the extent to which countries are able to leverage investments into climate change adaption. The readiness is assessed by economic, social and governance indicators. Governance readiness evolves from institutional factors. As this thesis puts collaboration on climate change adaptation in an institutional context especially the high score of Denmark in the governance indicators[6] is noticeable. The thesis shows what is possible in this high readiness context. The conclusion could be applied in similar contexts but can also be used to learn for the future in areas with increasing readiness. Further research could be undertaken in order to compare prospects of collaboration on climate change adaptation between different areas with different readiness in governance.

[6] ND-GAIN governance indicators come the World Governance Indicators (WGI) (The World Bank Group 2015)

5. References

Aalborg Kommune, 2016. Forslag til Spildevandsplan 2016-2027. Available at: http://aalborg.viewer.dkplan.niras.dk/DKplan/dkplan.aspx?pageId=107 [Accessed May 10, 2016].

Aalborg Kommune, 2011. *Klimastrategi 2012-2015 Tilpasning*, Available at: http://www.e-pages.dk/aalborgkommune/915/.

Aalborg Kommune, 2014. Tillæg H.029 Klimatilpasningsplan. Available at: http://soap.plansystem.dk/pdfarchive/12_2747196_1400659610760.pdf [Accessed May 10, 2016].

Aalborg Kommune, 2015. Vandhandleplan for Aalborg Kommune. , pp.1–32. Available at: http://www.aalborg.dk/media/3591255/vandhandleplan-2015-vedtager-oktober-2015-2.pdf.

Aarhus Kommune, 2014. CLIMATE ADAPTATION PLAN 2014 – ADAP TING TO MORE WATER ADDENDUM NO 1 TO MUNICIPAL PLAN 2013. , (1), pp.1–40. Available at: https://www.aarhus.dk/~/media/Dokumenter/Teknik-og-Miljoe/Natur-og-Miljoe/Vand/Oversvoemmelse/Planer-og-projekter/Climate-adaptation-plan-2014-pdf-str-small.pdf.

Anguelovski, I. & Carmin, J., 2011. Something borrowed, everything new: Innovation and institutionalization in urban climate governance. *Current Opinion in Environmental Sustainability*, 3(3), pp.169–175.

Arnell, N., 2002. Hydrology and Global Environmental Change. *Harlow: Pearson Education*.

Arts, B. & Van Tatenhove, J., 2006. Political modernisation. *Institutional Dynamics in Environmental Governance*, pp.21–43.

Bøgh Vinther, J., 2016a. *E-Mail, Jens Bøgh Vinther to Samuel Schlecht, 27.04.2016*.

Bøgh Vinther, J., 2016b. *Interview with Jens Bøgh Vinther, Environmental and Energy Department (Miljø- og Energiforvaltningen), Aalborg Kommune, conducted by Samuel Schlecht, 20.04.2016*.

van Buuren, A., van Vliet, M. & Termeer, C., 2015. The governance of adaptation to climate change and the need for actionable knowledge: the challenges of climate change adaptation and the promise of action research. In *Action research for climate change adaptation: Developing and applying knowledge for governance*. Routledge, pp. 1–18.

Cashmore, M. & Wejs, A., 2014. Constructing legitimacy for climate change planning: A study of local government in Denmark. *Global Environmental Change*, 24(1), pp.203–212. Available at: http://dx.doi.org/10.1016/j.gloenvcha.2013.09.019.

Charlesworth, S.M., 2010. A review of the adaptation and mitigation of global climate change using sustainable drainage in cities. *Journal of Water and Climate Change*, 1(3), pp.165–180.

City of Copenhagen, 2012. Cloudburst Management Plan 2012. , pp.1–28. Available at: http://unix4.com/download.php?id=17212.

City of Copenhagen, 2011. Copenhagen Climate Adaptation Plan. , p.100. Available at: http://en.klimatilpasning.dk/media/568851/copenhagen_adaption_plan.pdf.

Danish Energy Agency, 2008. *Danish strategy for adaptation to a changing climate*, Available at: http://www.kemin.dk/Documents/Klima- og Energipolitik/klimatilpasningsstrategi_UK_web.pdf.

Danish Ministry of the Environment, 2007. *The Planning Act in Denmark Consolidated Act No. 813 of 21 June 2007*, Available at: http://www.naturstyrelsen.dk/NR/rdonlyres/07000CC6-C7F2-4DBE-B23A-018DF195E022/50763/planlovenpengelsk2007.pdf.

Danish Technological Institute, Rensning af regnvand-LAR in Danmark. Available at: http://www.laridanmark.dk/rensning-af-regnvand/31262 [Accessed May 19, 2016].

DANVA, 2012. Om DANVA. Available at: http://www.danva.dk/DANVA/Om-DANVA.aspx [Accessed May 25, 2016].

DiMaggio, P. & Powell, W.W., 1983. The iron cage revisited: Collective rationality and institutional isomorphism in organizational fields. *American Sociological Review*, 48(2), pp.147–160.

European Comission, 2000. Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy. *Official Journal of the European Union*, L237, pp.1–73.

European Comission, 2016. Natura 2000. Available at: http://ec.europa.eu/environment/nature/natura2000/index_en.htm [Accessed June 1, 2016].

European Environment Agency, 2015. *Overview of climate change adaptation platforms in Europe*, Available at: http://www.eea.europa.eu/publications/overview-of-climate-change-adaptation/at_download/file.

European Union, 2016. Climate-ADAPT. Available at: http://climate-adapt.eea.europa.eu/ [Accessed May 7, 2016].

Fødevareministeriet, M., 2015. Skybrudssikret byomdannelse i Aalborg. Available at: http://www.klimatilpasning.dk/cases-overview/skybrudssikret-byomdannelse-i-aalborg.aspx#category-status [Accessed May 11, 2016].

Fredensborg Kommune, Hørsholm Kommune & Rudersdal Kommune, Usserød Å. Available at: http://www.usseroed-aa.dk/forside [Accessed May 26, 2016].

Geodatastyrelsen & Erhvervssyrelsen, Kommuneplan PlansystemDK. Available at: http://kort.plansystem.dk/spatialmap?page=loading&page=vis-kommuneplan&profile=plandk2&planid=1426407 [Accessed May 19, 2016a].

Geodatastyrelsen & Erhvervssyrelsen, Localplan PlansystemDK. Available at: http://kort.plansystem.dk/spatialmap?page=loading&page=vis-lokalplan&profile=plandk2&planid=181328 [Accessed May 19, 2016b].

Giddens, A., 1979. *Central problems in social theory: Action, structure, and contradiction in social analysis*, Univ of California Press.

Giddens, A., 1984. *The constitution of society: Outline of the theory of structuration*, Univ of California Press.

Gore, C.D., 2010. The Limits and Opportunities of Networks: Municipalities and Canadian Climate Change Policy. *Review of Policy Research*, 27(4), pp.415–432.

Goulden, M., Conway, D. & Persechino, A., 2009. Adaptation to climate change in international river basins in Africa: a review / Adaptation au changement climatique dans les bassins fluviaux internationaux en Afrique: une revue. *Hydrological Sciences Journal*, 54(5), pp.805–828.

Gyldendal, 2015. erfa-gruppe - Gyldendal, Den Store Danske. Available at: http://denstoredanske.dk/Natur_og_milj%C3%B8/Landbrug_og_havebrug/R%C3%A5dgivning_og_markfors%C3%B8g/erfa-gruppe [Accessed May 25, 2016].

Hedensted Lund, D. et al., 2012. Climate change adaptation in Denmark: enhancement through collaboration and meta-governance? *Local Environment*, 17(April 2012), pp.613–628.

Herning Kommune, 2014. Klimatilpasningsplan - Tillæg nr. 13 til Herning Kommuneplan 2013-2024. Available at: http://politik.herning.dk/dagsorden/Herning_Byraad/23-06-2014/Dagsorden(ID648)/Bilag/Punkt_213_Bilag_1_Forslag_til_klimatilpasningsplan_Herning_280514.pdf.

Holstebro Kommune, 2014. Klimatilpasningsplan for Holstebro Kommune 2014. Available at: http://www.holstebro.dk/Admin/Public/DWSDownload.aspx?File=/Files/Filer/Borger/Klima+Energi+og+forsyning/Klimatilpasningsplan+VEDTAGET.pdf.

InterAcademy Council, 2010. *Climate Change Assessments: Review of the Proceses and Procedures of the IPCC*, InterAcademy Council.

IPCC, 2014a. Annex II: Glossary [Mach, K.J., S. Planton and C. von Stechow (eds.)]. In R. K. Pachauri & L. A. Meyer, eds. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC, pp. 117–130.

IPCC, 2014b. Climate Change 2014: Synthesis Report. Summary for Policymakers. In R. K. Pachauri & L. A. Meyer, eds. *Climate Change 2014: Synthesis Report. Contribution of Working Groups I, II and III to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*. Geneva, Switzerland: IPCC, p. 151.

IPCC, 2007. Summary for Policymakers. In S. Solomon et al., eds. *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*. Cambridge University Press, New York.

IPCC, 2013. Summary for policymakers. In D. Qin et al., eds. *Climate change 2013: the physical science basis. Contribution of Working Group I to the fifth assessment report of the Intergovernmental Panel on Climate Change*. Cambridge, UK & New York, NY, USA: Cambridge University Press.

Jepperson, R.L., 1991. Institutions, institutional effects, and institutionalism. *The new institutionalism in organizational analysis*, 6, pp.143–163.

Keskitalo, E. & Carina, H., 2013. Introduction. Local organisation to address flood risks: possibilities for adaptation to climate change? In E. Keskitalo & H. Carina, eds. *Climate Change and Flood Risk Management: Adaptation and Extreme Events at the Local Level*. Edward Elgar Publishing, pp. 1–34. Available at: <Go to ISI>://WOS:000332675000001.

Kommunalteknisk Chefforening, About KTC. Available at: http://www.ktc.dk/om-ktc/about-ktc [Accessed June 1, 2016].

Leck, H. & Simon, D., 2012. Fostering Multiscalar Collaboration and Co-operation for Effective Governance of Climate Change Adaptation. *Urban Studies*, 50(May), pp.1221–1238.

Lehmann, M., 2008. *Conceptual Developments & Capacity Building in Environmental Networks: towards Public-Private-Academic Partnerships for Sustainable Development*, Videnbasen for Aalborg UniversitetVBN, Aalborg UniversitetAalborg University, Det Teknisk-Naturvidenskabelige FakultetThe Faculty of Engineering and Science, Institut for PlanlægningDepartment of Development and Planning.

Lervad Thomsen, S., 2016a. *E-Mail, Steffen Lervad Thomsen to Samuel Schlecht, 11.05.2016.*

Lervad Thomsen, S., 2016b. *Interview with Steffen Lervad Thomsen, Environmental and Energy Department (Miljø- og Energiforvaltningen), Aalborg Kommune, conducted by Samuel Schlecht, 05.04.2016.*

LIMFJORDSRÅDETS SEKRETARIAT, 2016. *Konklusioner fra moede med KKR Nordjylland*, Available at: http://www.limfjordsraadet.dk/media/44172/konklusioner-fra-moede-med-kkr-nordjylland.pdf.

LIMFJORDSRÅDETS SEKRETARIAT, Limfjordsrådet. Available at: http://www.limfjordsraadet.dk/ [Accessed May 24, 2016].

LIMFJORDSRÅDETS SEKRETARIAT, 2014. *Referat Limfjordsrådet Embedsmandsgruppen 14.11.2014*, Available at: http://www.limfjordsraadet.dk/media/1628/14-11-2014-referat-af-moede-i-embedsmandsgruppen.pdf.

Lintz, G., 2015. A Conceptual Framework for Analysing Inter-municipal Cooperation on the Environment. *Regional Studies*, 3404(May), pp.1–15. Available at: http://www.tandfonline.com/doi/full/10.1080/00343404.2015.1020776.

Lundqvist, L.J., 2015. Planning for Climate Change Adaptation in a Multi-level Context: The Gothenburg Metropolitan Area. *European Planning Studies*, 4313(February), pp.1–20. Available at: http://www.tandfonline.com/doi/abs/10.1080/09654313.2015.1056774.

Matthews, T., 2013. Institutional Perspectives on Operationalising Climate Adaptation through Planning. *Planning Theory & Practice*, 14(2), pp.1–13. Available at: http://www.tandfonline.com/doi/abs/10.1080/14649357.2013.781208.

Mayors Adapt, 2016. Mayors Adapt. Available at: http://mayors-adapt.eu/ [Accessed May 7, 2016].

Miljø- og Fødevareministeriet, 2014. Miljøminister Ida Auken har uddelt midler til klimasamarbejde. Available at: http://www.klimatilpasning.dk/kommuner/tilskud-til-klimatilpasning/klimasamarbejdspulje-paa-2,7-milioner-kroner.aspx [Accessed March 29, 2016].

Miljøministeriet Naturstyrelsen, 2013. Klimatilpasningsplaner og klimalokalplaner, Vejledning. Available at: https://www.google.dk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwicrv7Mp5PNAhUDYZoKHfOgDa0QFggoMAA&url=http://www.klimatilpasning.dk/media/598918/klimatilpasningsvejledning_web.pdf&usg=AFQjCNHX-iemOycQ3M19nTiKIvIacGz2OQ&sig2=H5mv_v.

Milman, A. et al., 2013. Assessment of institutional capacity to adapt to climate change in transboundary river basins. *Climatic Change*, 121(4), pp.755–770.

Næss, L.O. et al., 2005. Institutional adaptation to climate change: Flood responses at the municipal level in Norway. *Global Environmental Change*, 15(2), pp.125–138.

Nickel, D. et al., 2014. German experience in managing stormwater with green infrastructure. *Journal of Environmental Planning and Management*, 57(3), pp.403–423.

Nielsen, M.L., 2014. *Regnvandshåndtering i Aalborg Kommune: Tilgange til Lokal Afledning af Regnvand (LAR) i et institutionelt perspektiv*. Aalborg University.

Notre Dame Global Adaptation Index, 2014. Denmark/ND-GAIN Index. Available at: http://index.gain.org/country/denmark [Accessed May 10, 2016].

Olesen, M. et al., 2014. Fremtidige klimaforandringer i Danmark. In *Danmarks Klimacenter rapport*. Danmarks Meteorologiske Institut, p. 35. Available at: www.dmi.dk/klimaforandringer.

Østergård, N. & Witt, H., 2007. *Spatial Planning In Denmark*, Copenhagen: Danish Ministry Of The Environment. Available at: http://naturstyrelsen.dk/media/nst/Attachments/Planning_260907_NY.pdf.

Ostrom, E., 2009. *Understanding institutional diversity*, Princeton university press.

Perry, L.G. et al., 2015. Incorporating climate change projections into riparian restoration planning and design. *Ecohydrology*, 8(5), pp.863–879. Available at: http://dx.doi.org/10.1002/eco.1645\nhttp://doi.wiley.com/10.1002/eco.1645.

Randall, M.T. et al., 2013. Assessing urban groundwater table response to climate change and increased stormwater infiltration. *Geological Survey of Denmark and Greenland Bulletin*, (28), pp.33–36.

Rebild Kommune, 2014a. *Dispositionsplan for Byudvikling Støvrings Høje Støvring*, Available at: https://www.google.de/url?sa=t&rct=j&q=&esrc=s&source=web&cd=1&cad=rja&uact=8&ved=0ahUKEwi11cXWwebMAhUFHxoKHRr6BR8QFggoMAA&url=http://rebild.dk/sites/default/files/wysiwyg_media_files/dispositionsplan_hoeje_stoevring_-_december_0.pdf&usg=AFQjCNGf5d8q6yGuV.

Rebild Kommune, 2013. *Kommuneplan 2013*, Available at: http://soap.plansystem.dk/pdfarchive/11_1426407_APPROVED_1372934588105.pdf.

Rebild Kommune, 2015. *Kort nr. 32 Støvring, Spildevandsplan 2014 - 2017*, Available at: http://rebild.dk/sites/default/files/wysiwyg_media_files/316e256f-27da-4a3d-9f94-1adc16d3afa1.pdf.

Rebild Kommune, 2014b. Lokalplan nr. 288. Available at: http://soap.plansystem.dk/pdfarchive/20_2988347_1433416162086.pdf.

Rebild Kommune, 2014c. *Spildevandsplan 2014 – 2017*, Available at: http://rebild.dk/sites/default/files/wysiwyg_media_files/spildevandsplan_inkl_bilag.pdf.

Riber Knudsen, C., 2016. *Interview with Claus Riber Knudsen, Head of Nature and Environmental Department (Center Natur og Miljø), Rebild Kommune, conducted by Samuel Schlecht, 28.04.2016*.

Roland, G., 2004. Understanding institutional change: Fast-moving and slow-moving institutions. *Studies in Comparative International Development SCID*, 38(4), pp.109–131. Available at: http://www.springerlink.com/index/10.1007/BF02686330\nhttp://emlab.berkeley.edu/~groland/pubs/gr3.pdf.

Schultz, J., 2016. *Interview with Jesper Schultz, Department of Urban and Spatial Planning (By- og Landskabsforvaltningen), Aalborg Kommune, conducted by Samuel Schlecht, 18.04.2016*,

Scott, W.R., 2001. *Institutions and organizations*, Sage Publications. Available at: https://books.google.dk/books?id=qSxHAAAAMAAJ.

Singleton, R.A. & Straits, B.C., 2010. Approaches to social research.

Suchman, M.C., 1995. Managing Legitimacy: Strategic and Institutional Approaches. *Academy of Management Review*, 20(3), pp.571–610. Available at: http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.108.2768&rep=rep1&type=pdf.

Swart, R. & Raes, F., 2007. Making integration of adaptation and mitigation work: mainstreaming into sustainable development policies? *Climate Policy*, 7(4), pp.288–303.

Tennekes, J. et al., 2013. Out of the Comfort Zone: Institutional Context and the Scope for Legitimate Climate Adaptation Policy. *Journal of Environmental Policy & Planning*, 16(2), pp.241–259.

The Danish Nature Agency, 2014. *Analyse af IPCC delrapport 2 – Effekter, klimatilpasning og sårbarhed, med særligt fokus på Danmark*, Copenhagen. Available at: http://www.klimatilpasning.dk/media/871395/analyse_af_ipcc_delrapport_2__effekter_klimatilpasning_og_s_rbarhed_final.pdf.

The Danish Nature Agency, 2016a. Precipitation. Available at: http://www.klimatilpasning.dk/kort/nedboer.aspx [Accessed May 2, 2016].

The Danish Nature Agency, 2016b. Temperature. Available at: http://www.klimatilpasning.dk/kort/temperatur.aspx [Accessed May 25, 2016].

The World Bank Group, 2015. WGI 2015 Interactive. Available at: http://info.worldbank.org/governance/wgi/index.aspx#home [Accessed May 10, 2016].

UNEP, 2010. UN Atlas of the oceans. Available at: http://www.oceansatlas.org/servlet/CDSServlet?status=ND0xODc3JjY9ZW4mMzM9KiYzNz1rb3M~ [Accessed May 6, 2016].

United Nations, 2015. Adoption of the Paris Agreement, Proposal by the President, Draft decision. In *Conference of the Parties, Twenty-first session*. p. 32. Available at: http://unfccc.int/resource/docs/2015/cop21/eng/l09r01.pdf.

Vejle Kommune, 2014. Klimatilpasningsplan for Vejle Kommune. , p.113. Available at: http://www.vejle.dk/lib/file.aspx?fileID=92469.

Wejs, A., 2013. *Climate for change? Integrating Climate Change into Cities' Planning Practices*. Aalnborg University. Available at: http://westminsterresearch.wmin.ac.uk/6749/.

Yin, R.K., 2009. *Case Study Research : Design and Methods* 4th ed. R. K. Yin, ed., Thousand Oaks, Calif. : Sage.

Zamzam, B.K. & Frederiksen, M., 2013. *Waters with borders - The Horizontal Collaboration on Climate Change Adaptation in Danish Municipalities*. Aalborg University.

Zhou, Q., 2014. A Review of Sustainable Urban Drainage Systems Considering the Climate Change and Urbanization Impacts. *Water*, 6(4), pp.976–992. Available at: http://www.mdpi.com/2073-4441/6/4/976/htm.