Information needs in planning for adaptation to climate-induced floods

Rebecka Snefuglli Sondell

June 2018

NTNU
Norges teknisk-naturvitenskapelige universitet

Fakultet for arkitektur og design
Institutt for arkitetur og planlegging

MASTEROPPGAVE 2018

TILGJENGELIGHET: ÅPEN

FAGOMRÅDE:	DATO:	ANTALL SIDER:	VEDLEGG:
Fysisk planlegging	02/06/2018	83	2

TITTEL: Information needs in planning for adaptation to climate-induced floods
(Informasjonsbehov ved klimatilpasning til flom)

UTFØRT AV: Rebecka Snefuglli Sondell

EKSTRAKT:

Climate change has risen and one of the major global challenges in the coming decades and despite its global scale, many of the climatic effects will need to be mitigated locally. As a result, spatial planning has been identified as a key instrument for adaptation to climate change and the interest for climatic effects is growing in the field of planning. While the need for adaptation is widely recognised, few municipalities are actively addressing adaptation in the planning process. One explanation for this passive approach is suggested to be a lack of relevant information regarding climate change adaptation on a local level.

In an attempt to overcome this barrier, this master thesis seeks to explore the need for information resources when planning for adaptation to climate change. More specifically, it focuses on adaptation to climate-induced floods from sea level rise and urban runoff. The study is designed as a case study of two Norwegian municipalities, Trondheim and Stavanger, and is primarily based on qualitative interviews with planning practitioners in the two municipalities. The findings suggest that information resources play a facilitating, although not determining, role for climate change adaptation in the municipalities. It also confirms that improvements can be made to the content of the information resources available today. However, it is noted that organisational measures and capacity-building are necessary for the enhancement of adaptation in planning.

STIKKORD:
Klimatilpasning
Flom
Informasjonsbehov
Resurser

VEILEDER: Terje Skjeggedal
VEILEDER UTENFOR INSTITUTTET:
Daniela Baer og Nathalie Labonotte
UTFØRT FOR:
Klima 2050 / SINTEF

Postadresse
Institutt for arkitektur og planlegging
7491 Trondheim

Telefon +47 73 59 50 30
Org. nr. 974 767 880

Master oppgave info og ekstrakt

NORGES TEKNISK-NATURVITENSKAPELIGE UNIVERSITET
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ERKLÆRING

Jeg erklærer med dette at jeg har fulgt gjeldende instruks for utarbeidelse av masteroppgaven ved Fakultet for arkitektur og design, NTNU

Trondheim, 01/06/2018

Rebecca Snefjella Sandell

Chi va piano va sano e va lontano.

Preface

This thesis is an original work by Rebecka Snefuglli Sondell and it marks the completion of a master degree in Physical Planning at Norwegian University of Science and Technology (NTNU), Faculty of Architecture and Design, Department of Architecture and Planning. The author has previously completed a bachelor degree in Politics at the University of Edinburgh.

The master thesis is a part of Klima 2050, Centre for Research-based Innovation, which is run by SINTEF Byggforsk in Trondheim. Klima 2050 aims to reduce climatic risks in the built environment, specifically related to increasing precipitation and flood exposure.

Before moving on to the thesis itself, I would like to take the occasion to thank the people who in different ways have supported me throughout this work.

First, I would like to thank my supervisor, Terje Skjeggedal, and my co-supervisors Daniela Baer and Nathalie Labonotte for their academic and personal support during the past months.

Furthermore, I want to thank Edvard Sivertsen and Berit Time for being helpful and enthusiastic about my research both before and during the master thesis.

I would also like to thank Hampus for distracting me with endless cycling-sidetracks during our many coffee breaks that kept me motivated throughout this year.

I want to thank my lovely flatmates Justyna and Owen for bearing with me this semester. I know that a burnout depression, with a master thesis on top of that, does not make an ideal flatmate.

Finally, I wish to thank Line for helping me realise that the world does not end with a B.

Trondheim, 04/06/2018

Rebecka Snefuglli Sondell

Summary

Climate change has risen as one of the major global challenges in the coming decades and despite its global scale, many of the climatic effects will need to be mitigated locally. As a result, the interest in climate change and its consequences has increased also within the field of spatial planning, which is considered to be a key instrument for adaptation to climate change. Two of the primary climatic challenges in Norway are increasing precipitation and sea level rise, resulting in a higher flood exposure for many local communities. While the need to adapt to the new climatic conditions is largely acknowledged, few municipalities are actively planning for adaptation to climate change. One of the explanations given for the passive approach to adaptation is a lack of relevant information regarding climate change adaptation on a local level.

On this background, this thesis has sought to further investigate the claim that the availability and quality of the current information resources might explain the limited adaptation in the municipalities. The aim of this thesis has therefore been to assess the need for information resources in adaptation planning, focusing specifically on climate-induced floods from sea level rise and urban runoff. To find an answer to this, interviews have been conducted with public officials involved in the planning processes in the municipalities of Stavanger and Trondheim. The interview data has in addition been supported by secondary sources such as planning documents and official reports related to adaptation. The discussion starts off by looking at how flood risk is dealt with in municipal planning processes today, investigating both how and when adaptation is addressed throughout the planning process, and what consideration that is given to adaptation in the final plans and their implementation. Followingly, the use of and the expressed need for information resources is examined by focusing specifically on the need for data, tools and guidance material related to flood adaptation. Finally, taking a more theoretical approach, the question is asked whether information resources are at all a prerequisite for addressing climate change adaptation through planning.

The findings identify a gap between the intention to adapt and the actual rate of adaptation in the planning practice. Conflicting interests and insufficient information about the need to adapt are brought up as challenges that could explain why adaptation needs have not been

addressed according to the existing provisions. Information resources could play a role for mitigating these challenges. At the same time, the interview data suggests that awareness of the available data and the competence of the users might be just as important for enhancing adaptation, as the content of the information itself. Although capacity-building initiatives are taking place, there is still a significant need for better knowledge about adaptation among planning practitioners. Considering the findings from the interviews in relation to rational planning theory and the more recent strand of literature on planning for uncertainty confirms that information resources has an important role to play for planning, also in contexts of high uncertainty.

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List of abbreviations

DSB – Norwegian Directorate for Civil Protection [*Direktoratet for samfunnssikkerhet og beredskap*]

GAF – Green Area Factor [*Blågrønn faktor*]

GDP – Gross Domestic Product

GHG – Greenhouse gases

IPCC – Intergovernmental Panel on Climate Change

NOK – Norwegian Krone

NOU – Norwegian Official Report [*Norges offentlige utredninger*]

PBL – The Planning and Building Act [*Plan- og bygningsloven*]

RCP – Representative Consentration Pathway

SSB – Statistics Norway [*Statistisk sentralbyrå*]

TEK10 – Regulations on Technical Requirements for Building Works [*Byggteknisk forskrift*]

TEK17 – Regulations on Technical Requirements for Construction Works [*Byggteknisk forskrift*]

1 Introduction

Climate change is a challenge gaining increasing interest and concern within the field of urban planning. Many places will experience more extreme climates with more severe droughts; increasing precipitation; rising sea levels; landslides; air pollution or water scarcity (Field et al., 2014, p. 538). Despite the rising awareness of the potential consequences of climate change, the process of climate change adaptation remains slow. In Norway, the local municipalities were assigned the main responsibility for the adaptation process, with the White Paper [*Stortingsmelding*] on climate change adaptation (St. Meld. 33, 2013), nevertheless many municipalities remain passive actors in the adaptation process.

Previous research finds that one of the reasons for the slow adaptation process in local municipalities is the lack of relevant information. While there is a lot of information available about climate change and its potential effects, officials on municipal level report that they lack information that is locally relevant and useful in the local adaptation process (Carlo Aall et al., 2015; Dannevig and Aall, 2015; Hanger et al., 2013; Hanssen, Hofstad and H. Hisdal, 2015; Storbjörk, 2007; Tol, R. J. T. Klein and Nicholls, 2008). Guidance material, specifically targeting adaptation in the municipalities, is often dominated by general information about climate change and lacks descriptions of specific adaptation measures that could be implemented (Haugen, Almsås and Flyen, 2016, p. 5). A survey conducted among Norwegian municipalities showed that 9 out of 10 municipalities wish to have more information about the local effects of climate change (DSB, 2008, p. 32).

Recognising the mismatch between the available information resources for climate adaptation and the need for information, as perceived by actors in the municipal planning processes, this thesis seeks to explore what information that is needed in planning for climate change adaptation. More specifically, the study will focus on adaptation to climate-induced floods in Norway. By interviewing public officials involved in the planning process in the municipalities of Stavanger and Trondheim, this area of currently limited knowledge will be explored in further detail. The findings can hopefully inform the research agenda and thus contribute to the development of information resources that are better adapted to the planning practitioners' needs and in the long-term increase the resilience to negative effects of climate change.

2 Background

Water management with regard to flood risk will become a major climatic challenge in the years to come. The increased flood risk is a result of both sea level rise and increasing precipitation. The first two sections describes these two phenomena and how they contribute to flood risk, both generally and specifically for Norway. This is followed by an assessment of the possible magnitude of losses from future flood events. The fourth section gives a status update on the adaptation process in Norwegian municipalities and identifies the primary causes for the lack of action on climate change adaptation. Drawing on these findings, the following chapter identifies the theme for this thesis and defines corresponding research questions. The background chapter is largely based on an article that the author has previously written for SINTEF and the argumentation might therefore bear some resemblance.

2.1 Sea level rise

Sea level rise is a consequence of global warming, where the increasing temperature causes the water masses to expand in volume at the same as the addition of melt-water from glaciers is increasing (Field et al., 2014, p. 1139). Sea level refers to the average water table relative to land within defined temporal and geographical dimensions (Stocker, 2014, p. 1142). Global climate projections suggest that the sea level might rise with between 0,26 and 0,98 meters until the end of the century. Projections further into the future are more uncertain and vary largely with the different trajectories for greenhouse gas (GHG) emissions. Some estimates suggests that the most extreme scenarios could result in as much as a 3 meters increase relative to today's sea level (Stocker, 2014, p. 1140). There will also be regional variations in the relative sea level rise, where the geological setting determine its impact on the affected land areas (Stocker, 2014, p. 1194).

Sea level rise will have consequences for both natural and human systems in the coastal areas. Some of the direct effects of sea level rise are floods, loss of wetland, erosion, intrusion of saltwater in freshwater sources, reduced drainage capacity and higher water table of the groundwater (Field et al., 2014, p. 375). This will in its turn have a negative impact on society through damage of infrastructure; reduced water- and soil quality; loss of land and

resources; and loss of cultural values (Nicholls and R. J. Klein, 2005, pp. 208-209).

In Norway, the effect of sea level rise will be limited by the ongoing land rise, as a result of the last ice age, and the flood risk in the coastal areas is therefore relatively low (Simpson et al., 2015, p. 15). It is estimated that the sea level rise will amount to between -10 to 55 centimetres between the periods 1986-2005 and 2081-2100 (Simpson et al., 2015, p. 8). While the expected sea level rise in Norway is comparatively low and might not generate significant damage in itself, it will nonetheless result in a higher flood risk in cases of storm surge, when the sea temporarily reaches extreme height levels. Today's estimated level for storm surge with 200 years interval varies between 1,2 and 2,2 meters above the average sea level, depending on the geographical location. With the expected sea level rise, the extreme storm surge levels will also occur more frequently (Simpson et al., 2015, p. 9). The return level for the 200-year storm surge is estimated to be 0-104 centimetres higher than today by the end of the century (Simpson et al., 2015, p. 110).

2.2 Precipitation

One of the effects of climate change is a change in precipitation. This will vary both geographically and temporally, with some regions becoming dryer while others become wetter, and the contrast between the dry and wet seasons is likely to increase (Stocker, 2014, pp. 20-22). Norway is one of the countries that is expecting a wetter climate, with the annual precipitation increasing by 7-23 percent by 2100, based on the RCP8.5 GHG emissions trajectory. Moreover, cloudbursts are likely to occur both more frequently and with higher intensity (Hanssen-Bauer et al., 2009, pp. 11-12).

The risk of flood from precipitation is more difficult to foresee, due to the geographical and temporal variation in precipitation and the ability to infiltrate runoff water. It is generally acknowledged that urban areas, with a high coverage of non-permeable surfaces, are especially vulnerable to increases in precipitation and notably cloudbursts. This results in an increasing volume of urban runoff, meaning the "part of precipitation that does not evaporate and is not transpired, but flows through the ground or over the ground surface and returns to bodies of water" (Field et al., 2014, p. 1772), which the closed sewage system is often incapable of handling. While 10-20 percent of the annual rainfall becomes runoff

in rural areas, these numbers are on average 60-70 percent in urban areas, as a result of limited soil infiltration (Lensa Jotte, Gema Raspati and Kamal Azrague, 2017, p. 8). Extreme rainfall can result in flooding of closed storm sewers systems, as the capacity of the ageing pipes are not dimensioned for today's runoff volumes (Field et al., 2014, p. 556; Lensa Jotte, Gema Raspati and Kamal Azrague, 2017, p. 8). Floods in urban areas can result in damage of infrastructure; water contamination; increase the risk of water-born diseases; waterlogging; and loss of livelihood (Field et al., 2014, p. 555).

2.3 Flood risk and the benefits of adaptation

Prevention and adaptation to floods will have significant benefits in terms of reducing material and economic costs. Today, flood damage accounts for 25 percent of all economic losses from natural disasters globally (CRED, 2015, p. 38). With the increase in flood risk in face of climate change, this number can be expected to grow significantly. Already in 2005, it was estimated that resources to a value of 5 percent of the global GDP were located within the coastal risk zone for sea level rise, and it is assumed to increase to 9 percent of the global GDP by 2070 (Field et al., 2014, p. 383). Similarly, the damages losses from weather events, there among pluvial floods, have had an global annual growth rate of 1,4 percent since the 1980s (Aon Benfield, 2017, p. 8). With flood damage being largely under-reported, these numbers are presumably even higher in reality (CRED, 2015, p. 42). Adaptation will play a central role in reducing the negative impact of climate change, and more specifically flood events. It is estimated that adaptation measure could reduce the damage costs of sea level rise by as much as 90 percent in Europe, with the highest benefits in north-western Europe, where the highest damage costs are expected (Brown et al., 2011, p. 31). Similarly, Pappenberger et al. (2015, p. 287) suggest that investment in flood warning systems, for the purpose of preempting and preventing flood damage, can reach a cost-benefit ratio of 1:400. Hence there are strong economic incentives for climate change adaptation with regard to floods.

The interest for climate change adaptation appears to vary among the different sectors. In Norway, relatively little interest has been given to adaptation within the building sector, where climate challenges have been considered to a less degree than for example within

transport, despite the significant consequences also for the built environment (Carlo Aall et al., 2015, p. 122). Considering, firstly, that over 40 percent of the Norwegian population are living in the coastal area (O'Brien et al., 2006, p. 51), and secondly, the strong correlation between urbanisation and increasing urban runoff, it becomes clear that significant parts of the societal infrastructure may be exposed to flood risk. A report published by SINTEF shows that 110000 buildings in Norway are situated in the zone of <1 meter above sea level and will thus be exposed to future sea level rise. While the majority of these building are classified as garages, they also include "18000 holiday houses, 6000 smaller houses, 3000 industrial buildings, 3000 storage buildings, 2000 hotels and restaurant buildings and 1600 office- and commercial buildings" (Kvande et al., 2012, p. 9). Sea level rise could have negative consequences for this part of the built environment in terms of increased risk of water pressure, flooding and salt deterioration. In addition, accelerated erosion can result in unstable foundations and landslides (Kvande et al., 2012, p. 8). It might therefore be necessary to implement mitigating and adaptive measures. Examples include damp- and waterproofing; changes in usage; relocation or demolition; underpinning; and general preparedness for flood events (Kvande et al., 2012, p. 12).

Increasing runoff in urban areas can also create significant damage costs. The insurance payments for runoff damage and sewer backup from a single cloudburst in Asker and Bærum, Norway, amounted to more than 250 million NOK and a similar experience in Copenhagen cost 9 billion NOK (Hauge et al., 2017, p. 24). A synthesis of insurance payments from the Norwegian Natural Perils Pool [*Norsk Naturskadepool*] between 2008 and 2015 shows that 27 percent of the compensations are related to sewer backup and 41 percent from external intrusion of water into buildings (Hauge et al., 2017, p. 24). About 25 percent of the drainage system dates before the 1970s and has in many cases insufficient capacity to deal with the increasing runoff volumes of the growing urban areas in Norway (Hauge et al., 2017, p. 24). Yet, with today's annual renewal rate of 0,5 percent, it will take another 200 years until all the existing pipes have been changed (NOU 2015:16, 2015, p. 49). A survey among Norwegian municipalities indicates that in 60 percent of the municipalities, the drainage system will not have sufficient capacity to deal with urban runoff within 30 years (NOU 2015:16, 2015, p. 52).

While climate change has accelerated and intensified the natural processes that cause floods,

it is only one of the drivers contributing to the flood risk. In addition, demographic trends, such as population growth and increasing inequalities, as well as the design and location of societal infrastructure equally contribute to the exposure to climatic risks (Aon Benfield, 2017, p. 10; Mileti, 1999, p. 3). Urbanisation contributes to the increasing flood risk, both by the increase in runoff and by increasing the number of assets at risk (Wheater and Evans, 2009, s259). This claim is supported by a study of flood-related damage costs in Europe since the 1970s, which attributes the increase in flood damage costs to population growth and an overall increase in assets per capita, resulting in higher exposure of people and assets (Barredo, 2009, p. 102). Considering the structural aspect of flood risk, Wheater and Evans (2009, s259) identify spatial planning as a central tool to flood management.

2.4 Adaptation to flood risk in Norway

Despite the likelihood of an increase in flood events, the process of adapting to future flood risk remains slow. Although the local municipalities were assigned the main responsibility for the adaptation process, with the White Paper [*Stortingsmelding*] on climate change adaptation (St. Meld. 33, 2013), many municipalities remain passive actors in the adaptation process. The negative consequences of sea level rise are often underestimated and adaptation is in many cases expected to occur automatically (O'Brien et al., 2006, p. 50; Tol, R. J. T. Klein and Nicholls, 2008, p. 436). Risk assessments of sea level rise and the potential need for adaptive measures often do not reach the political agenda in the local governments (Stokke, 2014, p. 72; Dannevig, Rauken and Hovelsrud, 2012, p. 598). Issues regarding urban runoff appear to be a more frequent topic on the local political agenda. About 70 percent of the municipalities report to have required risk assessments with regard to urban runoff during development projects in recent years (NOU 2015:16, 2015, p. 52). However, assessment of flood risk is far from formalised in the procedure, considering that only about 30 percent of the municipalities include such requirements in the general routine (NOU 2015:16, 2015, p. 52).

Previous research has identified numerous causes for the absence of climate change adaptation in the municipalities. Especially relevant in a Norwegian context appear to be a lack of centralised governance and national guidelines for adaptation (Dannevig and Aall, 2015,

p. 168; Hanssen, Hofstad and H. Hisdal, 2015, p. 65); a compensation system for flood damage that undermines the incentives for adaptation (Botzen, Aerts and Bergh, 2009, p. 2274; O'Brien et al., 2006, p. 51); and lack of locally relevant information about the impact of climate change (Carlo Aall et al., 2015; Dannevig and Aall, 2015; Hanger et al., 2013; Hanssen, Hofstad and H. Hisdal, 2015; Storbjörk, 2007; Tol, R. J. T. Klein and Nicholls, 2008). This thesis will focus on the latter of these three factors, in an attempt to contribute to improving the access to relevant information about flood risk adaptation.

Previous studies indicate that the problem is not so much the lack of data and information, but rather that the accessible information rarely is relevant in the local context (Carlo Aall et al., 2015; Dannevig and Aall, 2015; Hanger et al., 2013; Hanssen, Hofstad and H. Hisdal, 2015; Storbjörk, 2007; Tol, R. J. T. Klein and Nicholls, 2008; Hallegatte, 2009). A survey conducted among Norwegian municipalities showed that 9 out of 10 municipalities wish to have more information about the local effects of climate change (DSB, 2008, p. 32). Similarly, a Swedish study found that close to 50 percent of the municipalities do not have sufficient access to flood risk maps and guidelines for urban development (Helena Dunberg and Emelie Gullberg, 2011, p. 15). This uncertainty about the local consequences of climate change is captured by Storbjörk (2007, p. 463): "What flood risks one is actually trying to adapt to and what risk levels are seen as reasonable are far from evident". Carlo Aall et al. (2015, p. 121) also identified the lack of resources as major barrier to the implementation of adaptive measures in Norway. This comes both from lack of priorities for adaptation and the lack of incentives for making adaptation a prioritised policy area.

The science-practice interaction is central to understanding the mismatch between the practitioners' information need and the scientific agenda. The way in which science is communicated to local practitioners will influence how the information is incorporated in policy-making and if the communication fails, large amounts of valuable knowledge will remain largely untouched by policy-makers and practitioners (Vogel et al., 2007, p. 352; Hanger et al., 2013, p. 3). Problematic science-practice interaction can be explained by a lack of understanding of the practitioners' needs; lack of trust; ineffective communication; language barriers; imbalance between credibility and salience; and different criteria for 'legitimate' knowledge (Vogel et al., 2007). It is not only the research community that fails to communicate science in a way that is useful to practitioners, but practitioners are also not sufficiently

communicating their needs for information and tools (Hanger et al., 2013, p. 16).

Based on this background, one can conclude that there is a growing need for addressing climate change adaptation in spatial planning, considering the negative material and economical effects that could become reality if action is not taken. At the same time, it is shown that that focus on adaptation is still low in most municipalities, which, research suggests, could be explained by a lack of relevant information resources. This hypothesis will be explored further in this thesis, in order to better understand and undermine barriers in the local adaptation process.

3 Research questions

The previous section has identified a mismatch between the existing information resources and the local planning practitioners' need for information as an obstacle to incorporating climate change adaptation in municipal planning processes. In an attempt to overcome this barrier, this thesis explores the need for information resources, as perceived by planning practitioners on municipal level, when planning for climate change adaptation. More specifically, it focuses on adaptation to climate-induced flood risk from sea level rise and urban runoff. The findings will then be discussed in relation to relevant planning theory, in order to assess the necessity of information resources for a pro-active approach to flood adaptation in planning.

In order to achieve this, the following research questions will be answered:

- How is flood risk dealt with in municipal planning processes today?
- What data, tools and guidance material are needed to improve flood adaptation in municipal planning processes?
- What is the importance of information resources when planning for flood adaptation on a municipal level?

In this study, *information resources* will be defined as various forms of data and information that can be used to enhance development and secure defined interests. Focus will be put on the following three types of information resources: data, tools and guidance material. Here, data will be defined as "facts and statistics collected together for reference or analysis", and specifically for informing the planning process on issues related to flood adaptation (Stevenson, 2010). A tool will be defined as a systematic structuring of "an activity's content (information, data, etc.) and process (steps, actions, interactions, etc.)" (McEvoy et al., 2018, p. 319). Guidance material [*veiledere*] refers to "use-oriented publications (on the internet) that shortly give introduction and education in practical (and organizational) climate adaptation" (Haugen, Almsås and Flyen, 2016, p. 8).

4 Planning for climate change

The planning authority is one of the key actors in the implementation of climate change adaptation measures. The Norwegian Official Report on climate change adaptation states that a "planning system that takes climate change into account [...] [is] [...] the most important step our society can take in order to adapt to a changing climate" (NOU 2010:10, 2010, p. 17). The new planning guidelines on climate- and energy planning and climate change adaptation in the municipalities [*Statlige planretningslinjer for klima- og energiplanlegging og klimatilpasning i kommunene*], that are currently up for consultation, will further strengthen the obligation to take climatic factors into consideration in the planning process (Klima- og miljødepartementet, 2017). The following section will first give an overview of how the planning system works today, followed by a description of the legislation and policy framework that provide the basis for adaptation in planning. Finally, a briefly account will be made for the information resources available to practitioners when planning for adaptation.

4.1 The planning system

The Norwegian planning system is made up of a hierarchy of plans and planning authorities, representing the national, regional and municipal level, where the plans on an inferior level need to comply with the guidelines and provisions from superior planning authorities. National plans seek to protect national interests and set guidelines for regional and municipal plans (Planning and Building Act, 2008, § 3-5). Regional plans aim to guide the development in a region (Planning and Building Act, 2008, § 3-4). On municipal level, two plan types are produced: the municipal master plan, which seeks to coordinate the long-term activity and resource use in a municipality, and zoning plans that give provisions for use, design and protection of specific areas (Planning and Building Act, 2008, § 11-5; § 12-1). The two latter plan types include six main categories of land-use elements, those being buildings and installations; transport and communications installations and technical infrastructure; green structures; the Norwegian armed forces; agricultural, nature and outdoor recreation objectives and reindeer husbandry; use and conservation of the sea and river systems, with associated shore zones (Planning and Building Act, 2008, § 11-7; § 12-5).

The legal foundation for the municipal master plan is found in a set of legislation and regulations that define requirements for the planning process and the framework of plans. Here, the Planning and Building Act (2008) is a key source together with the National Expectations Regarding Regional and Municipal Planning (2015) [*Nasjonale forventninger til regional og lokal planlegging*], national planning guidelines [*nasjonale planretningslinjer*] and planning provisions [*nasjonale planbestemmelser*], regional planning strategies and regional plans. In addition, other sectoral laws, eg. the Nature Diversity Act (2009) [*Naturmangfoldsloven*], provide a framework for the master plan (Miljøverndepartementet, 2012, pp. 7-8).

Analysing and assessing the possible impact of new plans is an important part of the planning process. Environmental impact assessments [*Konsekvensutredninger*] are formally required for all regional and municipal master plans that give guidelines for future development and for zoning plans that could have a significant impact on the social and natural environment (Planning and Building Act, 2008, § 4-2). In addition, all development plans shall identify potential risks and vulnerabilities for the development in question in a risk- and vulnerability assessment [*Risiko- og sårbarhetsanalyse*]. The impact assessments are important tools for ensuring sustainable development of a climate resilient society and should describe the effects of climate change such as sea level rise, storm surge and floods (Planning and Building Act, 2008, § 21; DSB, 2014, p. 61).

4.2 Requirements for climate change adaptation in planning

The juridical and policy foundation for requirement of climate change adaptation in planning is derived from a range of sources. The Planning and Building Act, which is considered the key source of legislation in the planning process, does not explicitly cover climate change adaptation. However, there are paragraphs that are relevant for incorporating adaptation in the planning process. Firstly, it stresses that all plans shall "take the climate into account" (Planning and Building Act, 2008, § 3-1), which, according to notes from the legislative process, also implies securing the population from extreme weather events and sea level rise (Ot.prp.nr. 32, 2008, p. 180). Secondly, it defines when environmental impact assessments and risk- and vulnerability assessments are required in the plan (Planning and Building Act, 2008, § 4-2).

Similarly, the Act on Civil Protection [*sivilbeskyttelsesloven*] does not make any specific references to climate change adaptation, but more generally aims to protect society from the negative consequences of possible threats. The law requires that all municipalities conduct a risk- and vulnerability assessment mapping possible undesirable events, as well as their consequences and probability of occurrence. The risk- and vulnerability assessment shall be used to ensure civil protection in the development of plans (Act on Civil Protection, 2010, § 14). While the law does not specify the type of events that should be considered in the assessment, the guidance material from DSB (2017, p. 25) suggests storm surge, extreme precipitation, sea level rise and urban runoff as possible themes to include. For plans where environmental impact assessments are obligatory, these also require an assessment the plan's vulnerability to "climate change and nature hazards such as floods, land slides, storm surge and sea level rise" (Forskrift om konsekvensutredninger, 2017, § 19).

Although the regulations on technical requirements for building works (TEK10) [*Byggeteknisk forskrift*] are primarily a source in the building applications process, DSB (2016, p. 18) recommends that one already in the planning phase ensures that the new development meets the TEK10 safety standards. According to the TEK10 regulations, "structures which would suffer particularly severe consequences due to flooding shall not be sited in areas prone to flooding" (Byggteknisk forskrift, 2011, § 7-2), which will determine the location of important infrastructure such as hospitals and contingency units etc. (DSB, 2016, p. 18). The TEK10 regulations also requires mitigating measures for buildings that are situated in flood risk zones (Byggteknisk forskrift, 2011, § 7-2). DSB (2016, p. 26) recommends that the TEK10 safety standards should also be used as reference for flood protection of existing infrastructure.

On a national level, there are so far no legally binding planning provisions on climate change adaptation. However, the latest National Expectations Regarding Regional and Municipal Planning, which give direction to planning on national and subordinate level, underline the importance of considering the potential consequences from climate change in the planning process. The document sets the ambition that all municipalities and regions shall conduct risk and vulnerability assessments to allow for preventing and reducing negative effects from climatic changes today and in the future (National expectations regarding regional and municipal planning, 2015, p. 17).

National planning provisions are another sources of national directions for planning. The existing national planning provisions on climate and energy planning [*statlig planretninglinje for klima- og energiplanlegging i kommunene*] focus on mitigation of climate change and does not include adaptation as a theme (Klima- og miljødepartementet, 2009). However, an updated version that incorporates climate change adaptation into the existing national planning provision is now being drafted. The draft, that goes under the name national planning provision for climate and energy planning and climate change adaptation [*statlige planretningslinjer for klima- og energiplanlegging og klimatilpasning i kommunene*], puts a clear emphasis on climate change adaptation in planning. It requires a knowledge-based approach, where the administrative units shall consider possible climatic effects and how these might influence their particular field. More specific to planning, it further expects planning strategies to include climatic aspects when considering the need for updating existing plans. The social element of the municipal master plan [*kommuneplanens samfunnsdel*] shall assess the effects of climate change on the strategical longterm goals and all plans shall give sufficient consideration to runoff management, preferably through nature-based solutions (Klima- og miljødepartementet, 2017).

4.3 Knowledge and resources for climate adaptation

Knowledge is important for enhancing adaptation in planning and the amount of information on climate change and its effects has been growing in recent years. One of the key sources of information about adaptation in Norway is the website *www.klimatilpasning.no*, which was established by the Norwegian Ministry of Environment [*Miljøverndepartementet*, now *Klima- og miljødepartementet*] in 2009 (St. Meld. 33, 2013, p. 66). The portal provides information about climate change, together with tools and guidance material for how to include adaptation in planning processes and ensure the implementation of adaptive measures (Miljødirektoratet, 2018).

In addition to the *Klimatilpasning.no* website, a multitude of guidance material related to climate adaptation has also been developed, much that is related to spatial planning. A review of the existing guidance material for climate adaptation of building and infrastructure was published by SINTEF and identifies a total of 84 documents and websites (Haugen,

Almsås and Flyen, 2016, p. 32). The review shows that the guidance material is specifically targeting adaptation of buildings (22 %); storm water runoff, water quality and drainage (19 %); landslides (14 %); and flooding (9 %). In addition, 12 percent of the guidance material was related to spatial planning and zoning plans, and another 8 percent about holistic planning (Haugen, Almsås and Flyen, 2016, p. 32). Moreover, the review shows that many of the documents and websites studied provide information about climate change adaptation on a general level, but often lack detailed information about the practicalities of specific adaptive measures to be implemented (Haugen, Almsås and Flyen, 2016, p. 32).

While a multitude of information and guidance material exists, the need for information appears to be far from satisfied. The Official Norwegian Report NOU 2010:10 (2010, p. 200), on adaptation to climate change, suggests that there is a need for "more, better and more easily accessible knowledge" across a wide variety of sectors and parts of society (NOU 2010:10, 2010, p. 200). More specifically, the report recommends further mapping of natural hazard risks and the vulnerability to such hazards. Generally, there is need for a more centralised and nationwide approach to data collection. Today, much of the data that is used in planning for climate change is based on small-scale and geographically limited research initiatives, resulting in an incomplete patchwork of data. Moreover, national data sets with a common standard would facilitate access to data and comparison between regions. The NOU 2010:10 (2010) identified the need for a national digital terrain model; better mapping of pipelines and cable networks; a national database for climate-related damage to buildings and infrastructure; and the development of regional climate indices that could be used with regard to minimum requirements in the industry and construction sector (eg. dimensions for adaptive measures with regard to increasing precipitation) (NOU 2010:10, 2010, p. 214). The majority of existing information on climate adaptation primarily focuses on climate change as an isolated problem, not taking into consideration other societal change that might occur simultaneously. It is therefore asked for the development of down-scaled social projections, and, as a further step, combining them with climatic projections, which would provide useful data for more sustainable planning (NOU 2010:10, 2010, p. 213). The report also underlines the importance of tools and methods for handling the uncertainty of the consequences from climate change in planning. In this context, cost-benefit analyses and risk- and vulnerability assessments are brought forward as tools that could help prioritising adaptive measures (NOU 2010:10, 2010, p. 205).

5 Theory

This chapter provides a theoretical foundation for the thesis. In the first section, key concepts used in this study are defined and elaborated. Followingly, the subsequent section introduces the planning theories that will later be used as a theoretical framework for the discussion.

5.1 Key concepts

One of the most widely used definitions of climate change adaptation is the one provided by the fifth IPCC report, defining adaptation as:

> "The process of adjustment to actual and expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects." (Field et al., 2014, p. 1758)

Although recognising that the climatic causes for the increased flood risk could also have beneficial effects, such as the use of water as a recreational resource, this study will primarily focus on adaptation in terms of the reduction of negative consequences of climate change.

In order to limit the negative climatic effects, one must first identify the existing risks. In the context of climate change, risk is commonly understood as the product of complex interactions between societies, ecosystems and climate-induced hazards, rather than as a purely climatic phenomenon to which societies respond (Field et al., 2014, p. 1050). More precisely, risk is defined as "the potential for consequences where something of value is at stake and where the outcome is uncertain" (Field et al., 2014, p. 1048). Another way of illustrating risk is as the product of hazards, vulnerability and exposure (see Figure 1). Here hazard is defined a "climate-related physical event or trend or their physical impact" (Field et al., 2014, p. 1048). Exposure refers to the presence of things of value, such as populations, resources, infrastructure etc. in locations that could be negatively effected by a potential hazard. Finally, vulnerability refers to the "predisposition to be adversely affected" by a

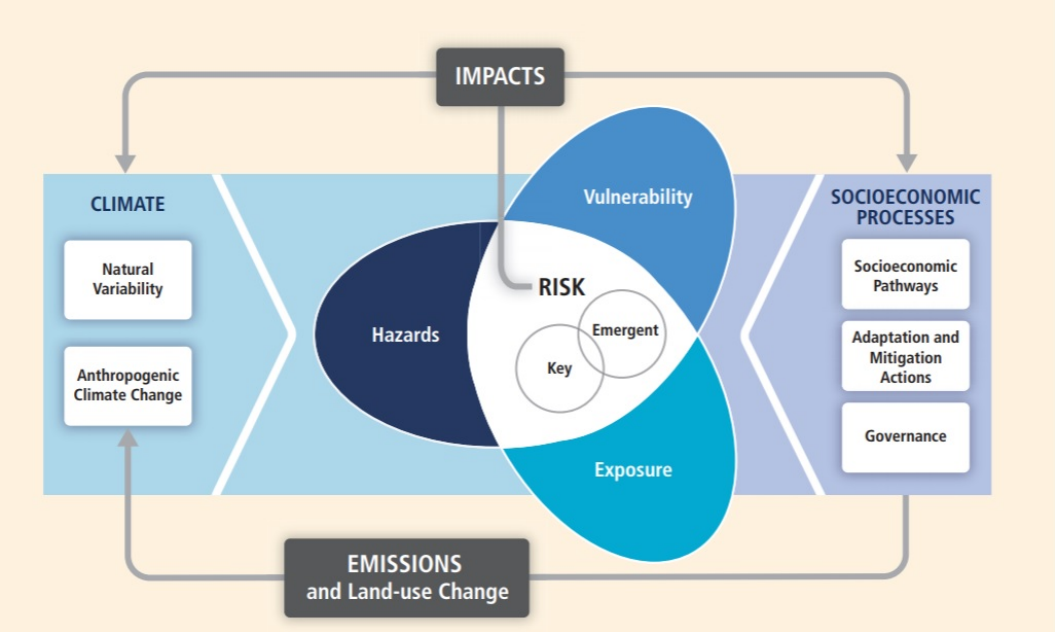

Figure 1: The diagram illustrates risk as an interaction between vulnerability, hazard and exposure, as well as how climatic and socio-economic processes influence each other. The illustration was originally published in the fifth IPCC report (Field et al., 2014, p. 1046).

hazard (Field et al., 2014, p. 1048).

Just as risk is the result of a complex interplay between exposure, extreme events and vulnerability, the adaptation task of reducing the risk has to target all the involved aspects. Wamsler, Brink and Rivera (2013, p. 79)'s study on urban resilience show that physical features as well as political, economic, environmental and socio-cultural risk aspects need to be targeted in the planning process, in order to achieve a successful adaptation. Information resources, which is the focus in this study, can be used to strengthen the awareness of the three risk components and thus, given that the risk factors are well understood, adaptive measures can be designed and implemented accordingly.

5.2 Planning for uncertainty

While there is a strong consensus on the need to adapt the society to climate change, the extent of the climatic consequences are yet to be known. Hence, planning for climate change adaptation will essentially be subject to a significant degree of uncertainty. Planning has always involved a certain level of uncertainty and the following section will explore how this is dealt with in different planning approaches. It starts off by looking at rational planning theory and Christensen (1985)'s categorisation of planning approaches. Thereafter, attention will be given to theories specifically dealing with planning for conditions of uncertainty.

Rational planning theory provides an archetype of the planning process and has had a strong influence on the planning profession (Christensen, 1985, p. 63). While it is far from the only planning theory, it nevertheless continues to have a significant influence on the planning practice and will therefore be considered here. Recognising that the normative and highly theoretical characteristics of the rational planning theory are rarely, if ever, found in their pure form in practice, several theorists have developed and contested this approach in theories that also have an impact on today's planning regime (see Lindblom (1959), Innes (1995), Healey (1996) etc.). Discussing all of these theories would however be a too extensive task for this study and they will therefore not be further considered here. As a result, the theoretical discussion on the implications for practice should not be considered a fully accurate representation of reality, but rather as an indication of the effect that inspiration from the rational planning theory could have on planning.

In rational planning theory, the ultimate goal for planning is to identify and implement the optimal solution to a given problem (Tarter and Hoy, 1998, pp. 212-213; Rosenhead, 1980, p. 210). However, this approach will in most cases falter on its assumption of access to clearly defined goals, perfect information and cognitive capacity to fully analyse the problem, which is essentially impossible to fulfil in reality (Tarter and Hoy, 1998, p. 213). The importance of prediction, certainty and comprehensive planning makes it especially unsuitable for conditions of high uncertainty that require flexibility (Rosenhead, 1980, p. 211). Rather, the application of this planning rationale often results in unsuitable goals as well as means for achieving them (Christensen, 1985, p. 63).

Different contexts require different approaches to planning. This is illustrated in Christensen (1985)'s classical categorisation of planning approaches. In this model (see Figure 2), approaches to planning are categorised according to the level of agreement on goals and means for achieving those. In conditions where both goals and means are clear, planning should take the shape of the rational model as presented above. When goals are agreed but the means of achieving them are unknown, planning should be characterised by pragmatism, experimentation and innovation. If means are known but a common goal is lacking, bargaining and mediation between conflicting interests will be central to the planning process. Finally, cases where both the goal and the means are unknown will require restoration of order and a shared understanding of the issue.

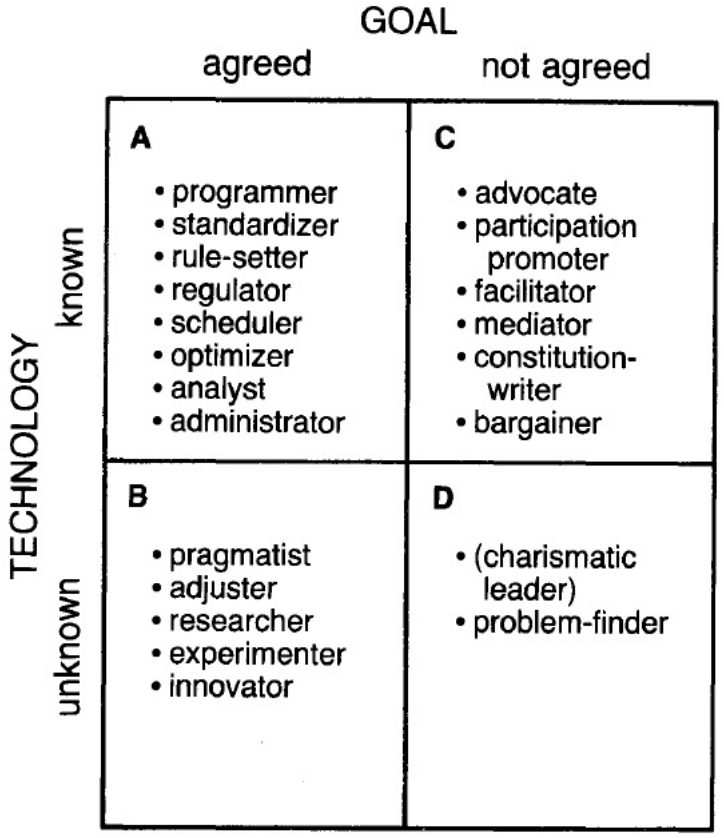

Figure 2: The model, originally published by Christensen (1985, p. 69), categorises planning approaches according to the level of agreement on goal and means.

In addition to these more generic planning theories, a recent strand of the planning discourse specifically addresses planning in conditions of uncertainty. A key feature of planning for uncertainty, and especially for climate change adaptation, is the importance of *resilience*. The term, which describes the robustness of a society, is defined as "the capacity of social, economic and environmental systems to cope with a hazardous event or trend or disturbance, responding or reorganising in ways that maintain their essential function, identity, and structure, while also maintaining the capacity for adaptation, learning and transformation" (Field et al., 2014, p. 1772). Davoudi et al. (2012, p. 309) distinguish between two main approaches that are found in the resilience literature. The ultimate goal in the conservative "survival" discourse is for society to return to its original state after a crisis. The more opportunistic approach views resilience as society "bouncing forwards" to a new and more sustainable state of existence. In support of the latter, Kelman et al. (2016, S137) underline the danger of aspiring for a return to a previous state of "normality" since this would be "a return to the conditions [...] which led to a disaster in the first place".

The goal of planning for uncertaincy also differs from that of the rational planning ideal. Several researchers within the field of uncertainty planning advocate so-called 'scenario-based planning approaches', where robustness across a wide range of alternative futures is favoured over optimisation of a solution for a particular scenario (Freestone, 2012, p. 23; Rosenhead, 1980, p. 214; Dessai et al., 2009, p. 75; Hallegatte, 2009, p. 242). While its application to adaptation is new to the planning practice, the approach itself is not a novelty and has been used in other contexts of long-term planning, such as water management (Hallegatte, 2009, p. 242). As opposed to planning approaches inspired by rational theory, the scenario-based approach is thus not dependent on precise prediction of future climate scenarios. Hallegatte (2009, pp. 244-246) presents five planning strategies that seek to increase the robustness of society:

- *No-regret strategies* – This strategy include actions that are beneficial also without climate change, such as barriers for sea level rise that would also protect from storm surge already today.
- *Reversible strategies* – These are strategies that lower the cost of incorrect climate predictions, by allowing for flexibility and reversibility of choices. One example would

be flood defences that can easily be upgraded according to future needs.

- *Safety margin strategies* – By significantly increasing the safety margins, this strategy drastically reduces the vulnerability. For example, designing infrastructure so that it can withstand practically any possible climate change scenario.

- *Soft strategies* – This type of strategy does not focus on technical measures, but rather the institutionalisation of new norms, such legislation or other requirements for adaptation in the planning process.

- *Reduced time horizon* – Considering that the uncertainty increases with time, this strategy reduces uncertainty by making more short-term investments.

The theories described above suggest that different conditions require different type of planning and that the planning approaches should be chosen accordingly. Moreover, it appears that the ability to deal with uncertainty in planning might differ depending on the type of planning approaches that is applied. The theories from this chapter will be brought into the discussion together with the interview results to answer the third research question, assessing the necessity for information resources when planning for adaptation.

6 Methodology

This case study applies a qualitative research approach, where in-depth interviews provide the primary source of data. The following chapter elaborates on the method and data that has been used and its implications for the final result of the thesis. First, the case study approach as a method is discussed, followed by a section describing the selection of cases in this particular study. Followingly, the data sources are described in more detail.

6.1 Case study

A case study is a research strategy, where a phenomenon is studied in its natural context where the boundaries between the context and the phenomenon are not well-defined. Moreover, case studies are usually conducted when the complexity of the context makes controlled experiments impossible (Yin, 1981, p. 59). The use of case studies has often been given a lower status than context-independent research. The approach has been accused of lacking generalisability and being unsuitable as a base for theory-building (Flyvbjerg, 2006, p. 221).

As a response, supporters of the case study approach argue that context-based knowledge is an essential addition to context-independent research, since it gives a more nuanced understanding of reality than rule-based theoretical approaches. This is necessary for the development of a more in-depth understanding of the phenomenon and thus represents a higher degree of expertise than the generalisable simplifications made by context-independent approaches (Flyvbjerg, 2006, p. 223). Flyvbjerg (2006, p. 223) argues that predictive theory is not possible in social sciences, making context-dependent knowledge the only alternative for understanding our surroundings. Moreover, Eisenhardt (1989, p. 548) argues that the case study approach is especially suited for and perhaps the only way of doing theory building in new research fields where previous research is lacking. Moreover, theory derived from case study research is often more verifiable, since the operationalisation and measurements were conducted already during the case study. The close ties to empirical data means that case-based theory is more likely to be empirically valid (Eisenhardt, 1989, p. 547).

The claims about limited generalisability also need further refinement. While not just any case study will be suitable for generalisation, a conscious selection of cases can make generalisation possible and sometime even more efficient than large N-methods. Notably, case studies can be useful for Karl Popper's *falsification* of scientific propositions (Flyvbjerg, 2006, p. 227). The type of case will determine what conclusions one can draw from the study. A *critical case* gives information about under what conditions a phenomenon is present. Here one should choose a context where the phenomenon is least likely to appear. If it is present in that context, one can assume that it will also be present in all other (more likely) contexts (Flyvbjerg, 2006, p. 230). In an *extreme case*, the phenomenon is observed in a rare context. Similarly to the critical case it allows for understanding the variance of a phenomenon (Seawright and Gerring, 2008, p. 301). *Paradigmatic cases* provide an archetype of the studied phenomenon and can function as a reference point for future research (Flyvbjerg, 2006, p. 232). It has also been claimed that case studies are more prone to subjective bias, since the use of qualitative methods allow for more arbitrary judgement and analysis (Flyvbjerg, 2006, p. 234). However, many studies show that, if any, case studies are more prone to falsification, rather than verification, of the hypothesis than other research approaches (Flyvbjerg, 2006, p. 237; Eisenhardt, 1989, p. 546).

Considering the exploratory nature of this particular study, the choice of the case study approach is, following Eisenack and Stecker (2012)'s argumentation, well-suited for gathering empirical data that can contribute to theory-building. Although generalisation and theory-building are not the primary goals of this study, it is reasonable to assume that the two cases studied represent critical cases in the Norwegian context, both being major cities that have relatively good access to resources and adaptive capacity more generally. It could therefore be expected that the findings on adaptation in Stavanger and Trondheim municipality represent the upper end of examples of climate change adaptation in Norway.

6.2 Selection of cases

This thesis is based on a case study of two Norwegian municipalities: Stavanger and Trondheim. The selection of these two municipalities is based on two main criteria. Firstly, climate change adaptation should already be on the local planning agenda. By focusing on municip-

alities that are actively planning for climate change and adaptation, it is assumed that the respondents have better insights into the existing information resources, their current use and what would be needed to improve the adaptation process further. Both municipalities already consider flood risk in terms of sea level rise and urban runoff in the current municipal master plans and the thematic environmental plan, by including measures such as flood risk zones and mitigation requirements (Stavanger kommune, 2015, pp. 83-84; Stavanger kommune, 2010, p. 27; Trondheim kommune, 2014, pp. 14-15; 27; Trondheim kommune, 2010, pp. 78-80) Both Stavanger and Trondheim have also participated in intermunicipal networks for climate change adaptation, such as *Framtidens byer* and *I-Front* (Gunnufsen and Solli, 2015; Jordbakke et al., 2017).

Secondly, the cases studied should have had some experience of previous flood events, since previous experience appear to have a strong influence on the pursuit of adaptation measures (Amundsen, Berglund and Westskog, 2010). Statistics of insurance payments for damage related to water intrusion show that both Stavanger and Trondheim are among the municipalities with the highest total flood damage cost in the last decade (ClimRes, 2018). Both municipalities are expected to see a significant increase in precipitation and sea level in the coming century, as a result of climate change, and Stavanger is already highly susceptible to storm surge (Simpson et al., 2015, pp. 116; 152; 154; Miljødirektoratet, 2015; Hanssen-Bauer et al., 2009, pp. 160; 166).

While Stavanger and Trondheim were not the only municipalities satisfying these criteria, they were also selected for the pragmatic reason that contacts were already established with both municipalities. Trondheim municipality is partner to the Klima 2050 project and the author had been in contact with Stavanger municipality during an earlier research project on climate change adaptation.

6.3 Interviews

The study is primarily based on twelve in-depth interviews (see Appendix A) with public officials at administrative units involved in planning processes in Trondheim and Stavanger municipality. Considering the lack of previous research about the information needs in the planning process with regard to adaptation, the study is intrinsically exploratory in charac-

ter. As a result, the interviews have followed a semi-structured interview design, with some main topics to ensure that key areas were covered (see the interview guide in Appendix B), while remaining open to other potentially important issues that might come up during the interviews. Similarly, it was not clear from the start who the most relevant informants would be, since the organisation of the adaption process varies among the municipalities. In both municipalities, the coordinator for climate change adaptation has provided contacts with relevant interview objects. Priority has been given to people who have experience of working with flood adaptation, since they were assumed to be able to give more informative input on the experienced information needs on adaptation based on their previous experience. In addition, *"snowball sampling"* was used to identify other relevant interview objects.

6.4 Literature

Academic literature, such as books and research journals, have been used to create a wider context, both empirical and theoretical, for this study. The literature review provided in the background section has helped form relevant research questions for the thesis. A close up on the academic discourse on planning for uncertainty and rational planning theory also provides an analytic framework for the discussion.

6.5 Documents

In addition to academic literature, a variety of official documents and planning documents have been used throughout the study. While recognising that measures related to climate change adaptation can be found in numerous planning documents, this thesis primarily focuses on the municipal master plans and the climate and energy/environmental plans in both municipalities, since these are identified by the municipalities as key sources in guiding the work on adaptation (Jordbakke et al., 2017). These sources provide information on the regulatory framework for climate change adaptation in planning and the current planning provisions regarding flood adaptation. Official reports and guidance material also give insights into the type of information resources that inform the planning processes today

and that are used to predict flood risk.

6.6 Data quality

This study is primarily based on qualitative data from the twelve in-depth interview, as described above. Given the limited number of cases as well as interviews, this study will not, and should not, pretend to make any generalisable conclusions. Rather, the interviews are used to shed light on the development and the information needs in the specific cases. Moreover, as a result of selection and interpretation bias regarding interview topics, the interest areas of the respondents as well as the data interpretation by the author, the interview data does not provide a complete depiction of the cases studied. The content must therefore be regarded as a collection of subjective narratives that in its totality may or may not give a correct representation on an objective reality. The findings should therefore not be considered as conclusions ready to be applied elsewhere, but rather as an invitation to further exploration of the field.

7 Results and Discussion

This chapter presents and discusses the findings of this study, primarily with basis in the interview material that has been gathered. First, a short background is given to the two cases studied, briefly describing the predicted local effects from climate change. The second section answers the first research question by examining how the municipalities deal with flood adaptation in planning today, both as it is implemented in plans and as it occurs in the planning process. The third part responds to the second research question as it reviews the need for information resources on adaptation, based on how it is perceived by the planning practitioners in the interviews. Finally, the third research question is addressed by discussing the findings in the previous section in relation to the theoretical framework established in chapter five.

7.1 Background on Stavanger and Trondheim

Stavanger is a coastal municipality in south-western Norway, incorporating the city of Stavanger and its immediate surroundings with a population of 130 000 inhabitants (SSB, 2018). Projections suggest that the region will see a 10 percent increase in the average annual precipitation until the end of the century (Miljødirektoratet, 2015). In addition, the number of days with extreme precipitation could more than double in the worst scenarios (Hanssen-Bauer et al., 2009, p. 168). The risk for floods will thus increase, especially in urban areas in form of increasing urban runoff (Miljødirektoratet, 2015). Stavanger is also vulnerable to the effects of rising sea levels. Already today, central parts of the city are at flood risk during storm surge events (COWI, 2017, p. 40) and the sea level is expected to rise by up to 80 centimetres by the end of the century (Simpson et al., 2015, p. 154). A recent cost-benefit analysis of future flood damage in Stavanger estimates the potential costs to 11 billion NOK by 2090, a cost that could be reduced to 3 billion if adaptive measures were implemented (COWI, 2017, p. 66).

Trondheim municipality is, with its 190 000 inhabitants the third biggest municipality in Norway based on population size (SSB, 2018). Historically, about 50 different flood events have been registered in Trondheim, primarily related to spring floods of the nearby rivers

and streams, but more recently also due to extreme weather events (Strømø, 2017). Climate projections suggest that the region will face both increasing precipitation and sea levels, resulting in higher flood risk. The total annual precipitation is expected to increase with 17 percent in the coming century in the worst scenario and the number of days with extreme precipitation could increase with up to 77 percent (Hanssen-Bauer et al., 2009, pp. 160; 166). While sea level rise has so far been compensated for by the regional effects of land rise, it is expected a sea level rise of 53 centimetres by the end of the century (Simpson et al., 2015, p. 152). This will increase the risk of flooding in the coastal areas especially when storm surges and wave effects are considered. However, in opposition to Stavanger, the possible consequences of sea level rise are not yet seen in Trondheim today.

7.2 Flood adaptation in planning today

In order to assess the need for information resources in adaptation planning, one first has to understand how adaptation is dealt with in planning today and how possible improvements could fit into the planning processes. This is the topic of the first research question, which will be answered in two parts in the following section. First, it starts off by examining how flood adaptation has been addressed in existing planning documents in Stavanger and Trondheim. While recognising that adaptive measures might be included, intentionally or not, in a wide variety of plans, this analysis is limited to the content of the municipal master plans and the climate- and energy/environmental plans, which have been identified as the most important planning documents for climate change adaptation. The second part then examines how adaptation is included in the planning processes in practice. This section is largely based on data from interviews with employees involved in planning processes in Trondheim and Stavanger. The result might therefore not give a complete depiction of the steps where adaptation is addressed in the planning process. However, it does arguably include the parts of the adaptation process that are familiar to the interviewees and, one could assume, also the most prevalent in use.

7.2.1 Flood adaptation in existing plans

Both Stavanger and Trondheim have already incorporated concerns about climate change adaptation in the current planning framework. In a review of the ongoing work on adaptation, published as a part of the *I-Front* network, Stavanger reports that the municipal master plan is the key planning document guiding the adaptation process (Jordbakke et al., 2017, p. 26). It sets as one of the general goals that Stavanger shall "adapt to the [climatic] changes that will come" (Stavanger kommune, 2015, p. 10). This ambition is most clearly reflected in the planning provisions regarding civil protection, which stipulate that "all buildings where the floor is lower than 3 meters above sea level must give consideration to flood risk" (Stavanger kommune, 2015, p. 83). It also addresses urban runoff by requiring that areas are reserved for runoff infrastructure, infiltration and vegetation (Stavanger kommune, 2015, p. 84). In addition, guidelines [*retningslinjer*] for the use of Green Area Factor (GAF) [*Blågrønn faktor*] were included in the municipal master plan from 2015. The guidelines suggest that a minimum GAF requirement (as defined in the municipal master plan) should be included in zoning plans (Stavanger kommune, 2015, p. 86).

In addition to the master plan, climate change adaptation is also dedicated its own chapter in the thematic climate and environmental plan from 2010. According to the plan, the municipality aspires to integrate climate change adaptation in the planning process and urban development more generally (Stavanger kommune, 2010, p. 27). It announces two key priority areas: the development of tools and methods that will facilitate the adaptation process; and strengthening knowledge about climate change adaptation and climatic effects in the region (Stavanger kommune, 2010, pp. 28-29). The proposed actions include: risk- and vulnerability assessments with focus on climatic effects; mapping climatic risks through the project *Klima-GIS*; development of an action plan; mapping previous climate-induced events; capacity-building; and initiating coordination of climate change adaptation in the region (Stavanger kommune, 2010, p. 29). In the draft of the climate and environmental plan that is now under revision, the plan specifies that a risk- and vulnerability assessment shall be conducted to identify the climatic effects that are likely to occur if the 2 degrees target from the Paris Agreement is not reached. The conclusions of this assessment will provide the basis for a climate change adaptation strategy that is the beginning of the development of a separate climate change adaptation plan (Stavanger kommune, 2018a, p. 50). In addition,

the focus on development of knowledge and tools is removed in the revised plan.

The current work on the master plan for the central part of Stavanger (see Figure 3) provides an example of how the abovementioned planning provisions for adaptation are applied to subordinate plans. Adaptation to sea level rise has been an important and somewhat conflicted issue in the development of the plan, since many of the historical buildings in the city centre are located on low ground in close proximity of the shore (Interview with employee at the planning unit in Stavanger, 13/04/2018). However, rather than referring to the +3 meter zone that requires consideration of adaptive measures to prevent flood according to the municipal master plan, the new plan for the city centre includes zones requiring special consideration [*hensynssoner*] in certain areas lower than 2 meters above sea level, where the need for flood barriers and other mitigating measures should be considered. The type of consideration required includes elevation of land surfaces; waterproofing of buildings; partially open flood barriers in the sea with the possibility for closure in case of flood; and continuous land-based flood barriers (Stavanger kommune, 2018b, pp. 20-21). At the same time, the requirements for open facades [*aktive fasader*] remain in some flood-exposed areas despite the challenge it poses to flood protection (Stavanger kommune, 2018b, p. 20). This reflects the challenge of compromising between conflicting interests in the plan, which in this particular case is the wish to create an interesting and pedestrian-friendly urban environment while at the same time ensuring sufficient flood protection (Interview with employee at the planning unit in Stavanger, 13/04/2018). The guidelines on GAF requirements in the plan are in accordance with the provisions in municipal master plan (Stavanger kommune, 2018b, p. 7).

Similar to Stavanger, Trondheim also refers to the municipal master plan as a key document for adaptation planning (Jordbakke et al., 2017, p. 26). The main elements related to flood adaptation are the planning provisions regarding runoff management and a defined risk zone for sea level rise. The plan requires purposeful coordination of land-use elements with regard to urban runoff, so that runoff water is primarily managed on the site and brought back to the local water sources (Trondheim kommune, 2014, p. 14). Further, it calls for mapping and preservation of existing floodways and specifically encourages the preservation of streams and the restoration of open waterways (Trondheim kommune, 2014, pp. 14-15). The area-specific regulation concerning sea level rise identifies a risk zone for sea level rise

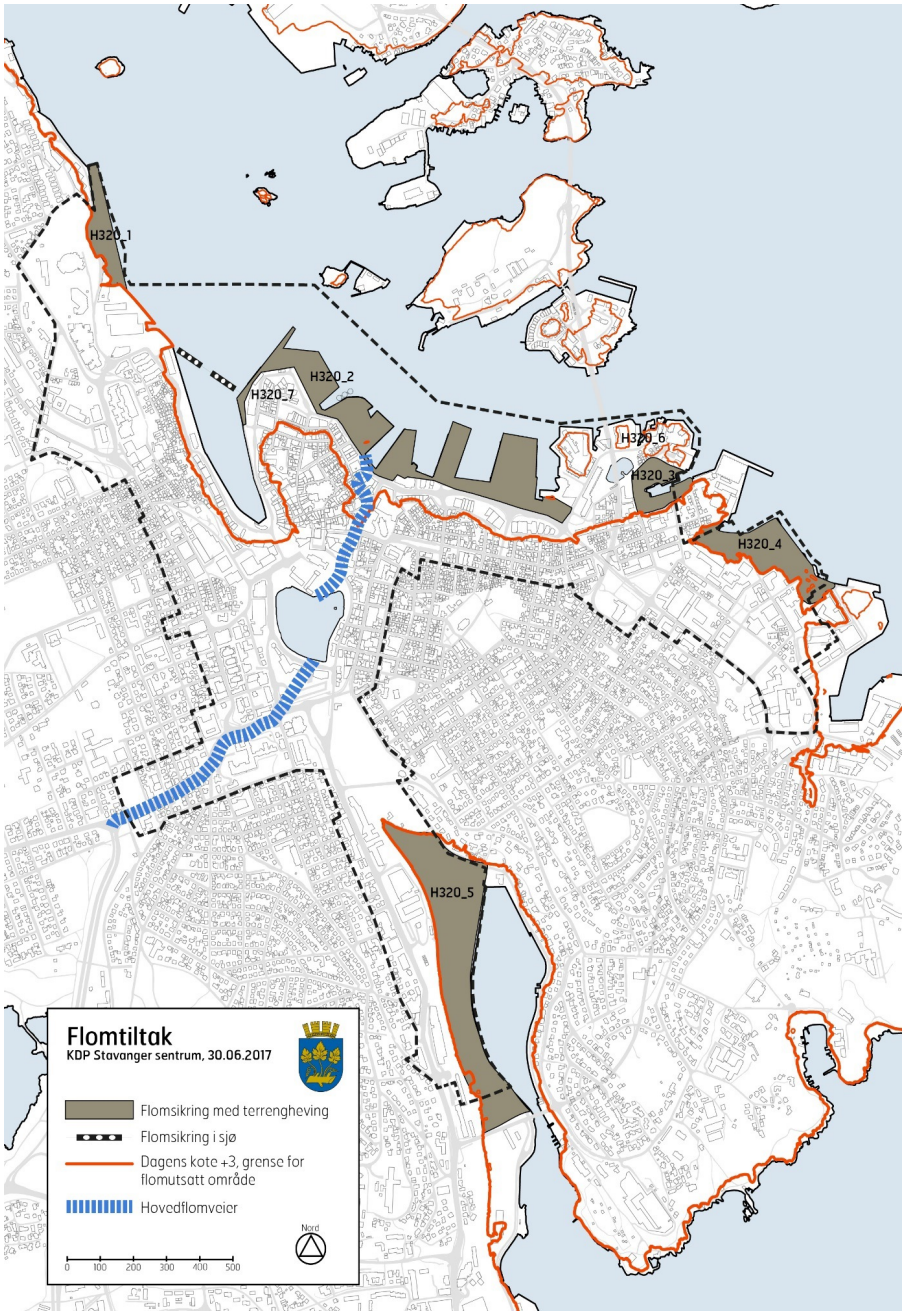

Figure 3: The map illustrates flood risk areas and adaptive measures as presented in the new plan for Stavanger city centre. The map was originally published by Stavanger kommune (2018b, p. 31).

where "mitigating measures shall always be considered" during planning or development within the zone (see Figure 4) (Trondheim kommune, 2014, p. 27).

Figure 4: The map shows the flood risk zone in central Trondheim, as defined in the planning provisions on sea level rise in the municipal master plan (Snefuglli Sondell et al., 2018, p. 16).

The energy- and climate plan is also mentioned as a key source for adaptation planning (Jordbakke et al., 2017, p. 26). The energy- and climate plan includes a chapter about climate adaptation, detailing the ambition to map future risks and improve the knowledge about the adaptation need, notably with regards to extreme precipitation, sea level rise and land slides (Trondheim kommune, 2010, pp. 78-79). The plan also presents the ambition to reopen the stream *Fredlybekken*, which is currently contained in closed pipes (Trondheim kommune, 2010, p. 79). Trondheim is planning to develop a new thematic plan for climate change adaptation, a task that was assigned to the internal climate change adaptation group but is yet to be finalised (Interview with employee at the environmental unit in Trondheim, 09/03/2018).

Figure 5: The map shows the area Grilstadfjæra and the risk zone for sea level rise (Snefuglli Sondell et al., 2018, p. 25).

A recent planning example in Trondheim, where adaptation to sea level rise was a relevant concern, is the development of the area Grilstadfjæra, northeast of Trondheim. The area is situated on land fill in connection to the local marina. Large parts of the area for planned development are within the risk zone for sea level rise, as defined in the municipal master plan (see Figure 5. According to the plan, the area will be developed for a mix of residential and commercial use. In the risk and vulnerability assessment, the risk of landslides and climate-induced precipitation and sea level rise come out as "yellow", indicating that risk-reducing measures should be considered. Assessments of the stability of the ground conditions find no risk for landslides and asserts that the land fill is sufficiently stable with regard to water currents, wave impact and erosion (Trondheim kommune, 2017). When it comes to precipitation, the plan indicates that runoff will not be problematic considering the proximity to the sea. Moreover, runoff water will be used for providing water to the park areas. With regard to sea level rise, the plan stipulates that new buildings have to be

placed at least 3.25 meter above sea level, which is below the 4.87 meter above sea level that defines the risk zone for sea level rise in the municipal master plan (Trondheim kommune, n.d.). At the same time, car parks are planned under ground level, despite recognising that this could be negatively affected by extreme precipitation and storm flood (Trondheim kommune, 2017). Apart from the above stated provisions, flood adaptation does not seem to have been a strong focus in the plan, judging from the plan documentation and the records from the political treatment of the plan. Instead the most discussed issue appear to be the allowed building heights and how they would affect the landscape and the sea view for the surrounding community (Trondheim kommune, 2017; Trondheim kommune, 2018). This is also confirmed by one planner in Trondheim, who states that no major adaptive measures were taken in this plan (Email correspondence, 09/04/2018). Whether this is a result of low risk or some other factors is not indicated.

Comparing the two cases, a couple of reflections can be made. Both municipalities address climate change adaptation, although through somewhat different measures, in the municipal master plan as well as in the thematic plans on climate and energy or environment. Seemingly, Stavanger has come further when it comes to formalising the use of blue-green solutions, with their inclusion of GAF provisions in the municipal master plan. Trondheim, on the other hand, has included a risk zone for sea level rise in the planning regulations, which has not been done in Stavanger. Looking specifically to the two examples of plan development two things can be noted. Firstly, the discussion regarding adaptation to sea level rise seems to have been much more prominent in the development of the plan for central Stavanger, compared to the planning process for Grilstadfjæra, where it does not come out as a central theme at all. Secondly, both show examples of deviation from the overarching guidelines regarding safety margins. In Stavanger, the general provision prohibiting constructions lower than 3 meter above sea level is reduced to 2 meter and they open up for more flexible flood barriers that will allow for access to the sea. The risk zone for sea level rise in the municipal master plan for Trondheim only requires the need for adaptive measures to be considered. In Grilstadfjæra buildings are allowed above 3.25 meters but does not specify any further consideration of adaptive measures for buildings that are situated between 3.25 and 4.87 meter above sea level. Rather, the inclusion of underground car parks, despite the overhanging flood risk, suggests that adaptation has been largely overseen. The interview data further suggests that the deviation is likely to be a result of a

compromise with conflicting interests in the plan. Overall, there seems to be a gap between the intention to adapt and the actual adaptation, where the former is more ambitious than the real implementation.

7.2.2 Adaptation in the planning process

The process is central to the planning practice and the quality of the planning process often has a strong influence on the outcome. The foundation for the adaptation to flood risk is laid early in the planning process. At the commencement of the plan, usually before the initiation meeting [*oppstartsmøte*], an interdisciplinary forum [*internt samråd*] is arranged among the involved units of the municipal administration. At the forum, the basic outline of the plan is presented and representatives from each unit give input on which themes within their field that will be important to highlight in the plan and how to ensure that sufficient mitigating measures are taken. "We get input on whether there is a floodway in the area or if there is limited capacity in the sewer system and also how these issues can be secured through the planning provisions", explains one of the planners in Trondheim (Interview, 12/04/2018).

While the forum sheds light on important issues to consider in the subsequent planning process, it does not necessarily provide a clear answer for what solutions that should be implemented. Firstly, the degree of importance of the proposed measures is sometimes unclear. The representatives from the different administrative units present obligatory as well as recommended measures for the plan. One of the informants from the water management unit in Trondheim notes that issues concerning urban runoff and sea level rise will result in obligatory measures (Interview, 26/03/2018). However, one of the planners in Stavanger report that it is sometimes difficult for the planning unit to know whether or not measures should be taken for problems that are identified in the reports from the interdisciplinary forum. "We had an example of a plan where the general plan on water management listed a number of challenges and how these could be solved, but concluded that there was no need for it to be included as provisions [in the plan]. Then we wonder why it is mentioned as problematic in the first place? How serious is it, considering that it is recommended to not do anything about it in the end" (Interview, 12/04/2018)? This suggest a potential

for improvements to the communication across the internal units, where clearer information about the gravity of the consequences might be part of a solution.

Secondly, the interests of the different administrative units are not always easy to reconcile, resulting in the need for compromise and prioritisation. "Sometimes there are contradictions between historical values, density [...] and natural values", says one planner in Trondheim during the interview. "You want to create an urban street environment and high density at the same time as it might be a very important green zone" (Interview, 09/04/2018). With the exception for concerns that are enforced through national legislation, there are no clear guidelines for how to prioritise in cases of conflicting interests. Rather, decisions are made on a case-to-case basis. But as noted by another planner in Trondheim, there is not *one* answer for how to prioritise among the diverging interests, it differs depending on the context (Interview, 12/04/2018). Hence, despite the challenges of conflicting interests, a general set of priorities would most likely be counterproductive. One could also expect that adaptation will get a stronger priority within planning once the National Planning Provisions for Climate and Energy Planning and Climate Change Adaptation come into force.

Followingly, the recommendations from the interdisciplinary forum will inform the plan, primarily by providing the basis for environmental impact assessments and risk- and vulnerability assessments. This is done either through the development of a planning program [*planprogram*] for larger plans, or, if no planning program is needed, the requirements for assessments will be given at the commencement meeting (Interview with employee at the planning unit in Trondheim, 09/04/2018). The planning program stipulates what relevant themes and issues that should be included in the environmental impact assessment. If new information that appears during the planning process suggests that additional assessments might be needed, these can then be subsequently added. It is on the other hand rare that any of the assessments recommended in the planning program are left out during the process (Interview with employee at the planning unit in Stavanger, 12/04/2018). One planner in Stavanger notes that the themes covered by the environmental impact assessments has been steadily growing over the years, resulting in more complex and extensive assessments (Interview, 12/04/2018). This arguably adds on to the already difficult act of prioritising between conflicting interests, as discussed above.

The planning program is then made available for public inspection [*høring*], during which external stakeholders get the opportunity to comment on the content and possibly come with objections. Two of the planners in Stavanger recall that this inspection process was how they first came in contact with adaptation to flood risk in planning. In both cases, the county governor [*Fylkesmannen*] filed an objection about the plan on the grounds that it did not sufficiently address flood risk in the area (Interview with employees at the planning unit in Stavanger, 13/04/2018; 10/04/2018). Similarly, although prior to the development of the planning program, the current master planning process for Stavanger city centre has received objections from the county governor for having too small safety margins with regard to storm surge and wave impact (Fylkesmannen i Rogaland, 2016). Hence, the public inspection can have an important role as a "double-check" on the planning process, and perhaps especially on recent issues, such as climate change adaptation, that are not yet fully institutionalised in the planning practice.

When a planning proposal has been developed, it is brought back to the interdisciplinary forum where the content is once more reviewed and commented by representatives from the different administrative units. According to the interviews, the comments and suggestions from the first round of discussions have in most cases been considered and incorporated in the plan by this point. Any neglected issues will otherwise be highlighted in this second forum meeting and recommendations for mitigating actions are given (Interview with employee at the water management unit in Trondheim, 26/03/2018). This is however the last opportunity for professional experts to influence the content of the plan and there is no evaluation on whether or not these recommendations are reflected in the finally adopted plan. "I actually don't know what happens to it after this, because we don't follow up on it afterwards. Then it's out of our hands", says one person from the water management unit in Trondheim (Interview, 26/03/2018). Several of the respondents agree that it could be useful to evaluate the implementation of recommended mitigating measures in the final plans. At the same time, limited resources and time constrains are mentioned as barriers that would make a closer follow-up unlikely.

In some cases, plans are also object to political treatment, where the construction council in the municipality considers and makes recommendations for the plan. One respondent in Stavanger notes that, in previous years, there have been occasions where blue-green

solutions have been removed from the planning proposal as a result of political treatment in order to reduce the implementation costs. "There were a few cases, at least 3-4 years ago, when there was not as much focus on this as it is today, where there were things that one would have wanted today, in terms of blue-green factor, that the politicians considered they could not afford", says the respondent while underlining that this could probably not have happened today thanks to the current planning provisions on adaptation. This type of economic argument seems to be more likely to occur in public plans that are financed by the municipality. "It is the municipality that sets the budget for the construction of a new school [...] and then there will be arguments with regard to the budget", says the informant who suggests that this is not the case when it comes to private planning initiatives, which makes it easier to implement the planning provisions in private plans (Interview with employee at the building inspection unit in Stavanger, 11/04/2018). This illustrates the importance of a political will for climate change adaptation, giving a strong mandate to include adaptive measures in the plans and ensuring their implementation.

Once the final plan is adopted, the building inspection office is responsible for ensuring that the implemented development projects are in line with the plan. One building inspection official in Stavanger notes that it is possible to get dispensation from the general building restriction in areas situated lower than 3 meters above sea level, on the condition that the project owner takes full legal responsibility of any future flood damage at the site. However, the respondent does not indicate to what extent such dispensations are given (Interview, 11/04/2018). One planner in Stavanger recalls that in the implementation of GAF, which was included as a requirement in the most recent municipal master plan, there have been cases where the final result has not reflected the GAF as required by the plan. "We have experienced that in a few places where they were meant to have a GAF, it is always included [in the construction plan], but when it is constructed it happens that big trees and other things that count [towards the GAF] are discarded under the construction process" (Interview, 12/04/2018).

The interviews suggest that one possible cause for counter-productive dispensations is uncertainty about the underlying intention of planning provisions. This is especially problematic for older plans where it is no longer possible to consult the planner who was responsible for the plan. "It is often they [the building inspection unit] do not understand the underlying

intention and it can seem meaningless", says one planner in Trondheim. "So it can happen that the building inspection unit does not know what to do in that situation, so they give the dispensation" (Interview, 09/04/2018). Considering that provisions on flood risk have been included in plans only recently, it can nevertheless be assumed that this is less of a challenge when it comes to the implementation of adaptation measures.

As shown in this section, there are several process-related challenges regarding climate change adaptation in planning. It appears to be a lack of control and evaluation of the actual implementation, both regarding the content in the plan and later its reinforcement. Giving priority to climate change adaptation in planning is also challenging due to an increasing number of competing and sometimes conflicting interest areas dealt with in the plans. While a reduction of issues on the planning agenda is not likely to be seen anytime soon, clearer information regarding possible consequences and the need for adaptive measures could facilitate prioritisation and result in better compromises. Similarly, evaluation of the final result, both in the plans and on the construction sites, would give a better overview of progress in adaptation.

7.3 Information needs in planning for flood adaptation

The main goal of the thesis has been to get a better understanding of the need for information resources when planning for flood adaptation. This is reflected in the second research question, which seeks to understand what data, tools and guidance material that are needed to improve flood adaptation in planning. Addressing this question, the following chapter will examine the use of information resources for flood adaptation in planning processes as well as the need for development of information resources in this field. Firstly, the general knowledge on flood adaptation will be discussed, identifying areas that would benefit from knowledge development. Followingly, the subsequent sections will explore the use and potential needs for information resources as experienced by planning practitioners in the two municipalities.

7.3.1 Knowledge-status on adaptation in the municipal administration

Awareness about the need to adapt, together with knowledge about available adaptive measures, are identified as two of the prerequisites for succeeding with planned adaptation (Füssel, 2007, p. 270). Thus, the absence of these factors could explain why climate change adaptation often has not come further in the municipalities. The interviews suggest that there is a general lack of knowledge and competence within the field of climate change adaptation. The competence on flood adaptation, especially concerning sea level rise, is often very limited in the municipal administrations. Several of the interview participants claim that the competence on climate change adaptation varies a lot from person to person and is primarily based on individual engagement and interest in these issues. "Not all 50 people who work at the planning office are fully updated on these issues. Even though the aim is that they will be", says one of the interview participants in Trondheim municipality (Interview with employee at the environmental unit in Trondheim, 09/03/2018). When asked to name the most important factor for strengthening climate change adaptation in planning, one of the planners brings up the need for a "general understanding of what climate change adaptation is", which suggest that even a basic understanding of the concept might in some cases be missing (Interview with employee at the planning unit in Stavanger, 12/04/2018).

The competence gap is most likely even larger in smaller municipalities with fewer resources set aside for climate change adaptation. This was the experience in Trondheim, where Trondheim municipality functions as a mentor on climate change adaptation for smaller municipalities in the region of *Trøndelag*, where previous to the initiative none of the smaller communities had addressed the need for adaptive measures (Interview with employee at the environmental unit in Trondheim, 09/03/2018).

Although the competence level might not be sufficient, it becomes clear that the focus on climate change and adaptation to flood risk has increased dramatically in both Stavanger and Trondheim municipality (Interview with employees at the planning units in Trondheim and Stavanger, and the building inspection unit in Stavanger, 12/04/2018; 12/04/2018; 11/04/2018) . "I have worked here for 25 years now and in the past 5 years it has become a growing focus on these issues", says one respondents in Stavanger (Interview with employee

at the building inspection unit in Stavanger, 11/04/2018). At the same time, another respondent notes that flood adaptation is not a central issue on the planning agenda. "In most plans, this is not the main focus, because there are many other things we need to take into consideration as well" (Interview with employee at the planning unit in Stavanger, 10/04/2018).

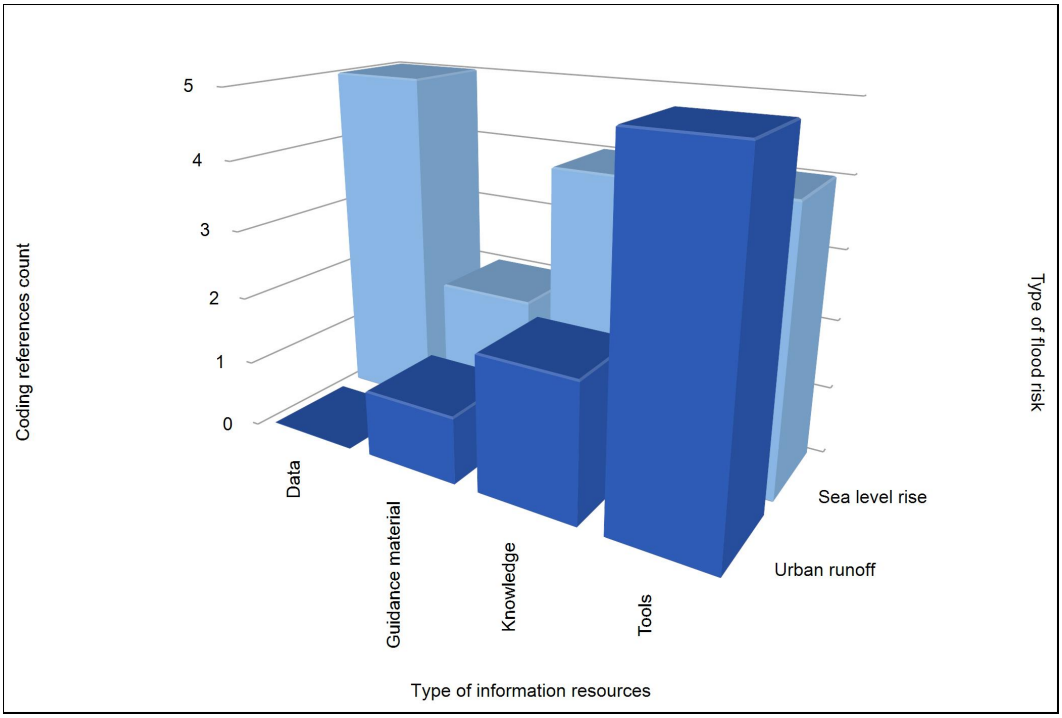

Figure 6: The graph shows the recurrence of the flood types in relation to the different types of information resources in the interview material, as coded in Nvivo by the author. It gives an idea the focal points for the two flood types considered.

The focus in the discussion on information resources with regard to flood adaptation also appears to differ depending on the type of flood risk concerned. As shown in Figure 6, the interview references to information resources in general, and more specifically on data, are predominantly concerning adaptation to sea level rise. There are no references in the interviews to the use of data when it comes to urban runoff. Only the discourse regarding tools is more frequent in speech about urban runoff than it is in discussions of sea level rise. No obvious explanation for this tendency has been found in the data material, so it is not possible to draw any general conclusions solemnly from this graph. However, it is

worth speculating on whether this could be the result of a) the unpredictable nature of the intensive precipitation that causes problems with urban runoff, hence reliable data might not be possible to acquire; or b) a relative lack of information resources on sea level rise resulting in a higher demand.

The interviews suggest that there have been some internal competence-building initiatives on climate change adaptation, such as seminars and thematic meetings. However, these have primarily been singular events. In addition, both Stavanger and Trondheim have established an intersectoral working group on climate change adaptation, in order to improve the communication between different fields and to ensure a more holistic approach to adaptive measures. Both municipalities are also members of various cooperation networks on climate change adaptation, which provide a platform for exchanging experiences and learning from others. However, for the exchange to be fruitful it is necessary to bring the knowledge into the local adaptation process. "The network is meant to provide competence and inspiration, but this has to be included in the documents back home, otherwise it makes no sense. It does not matter if you sit here [in the network] glowing with enthusiasm and interest if you do not bring it back home", says one of the respondents (Interview with employee at the environmental unit in Trondheim, 09/03/2018). Interview participants from Stavanger municipality appear to be content with how the intersectoral working group functions, especially since the membership was widened to include not only technical service units but also the planning and building inspection units. "But we are not done yet. There is still some potential for improvement", one person says, pointing to the need for some organisational changes and to strengthen the mandate of the group (Interview with employee at the contingency unit in Stavanger, 20/04/2018). The intersectoral working group in Trondheim also has potential for improvements. The group has struggled with lack of engagement and insufficient competence among the members. "We need some restructuring, otherwise we will not move forward", says one of the members of the group. "Not everyone has the time, they are not dedicated and competent enough" says one respondent (Interview with employee at the environmental unit in Trondheim, 09/03/2018).

As a result of limited competence and capacity within the municipal administration, analyses related to flood adaptation in the planning process are usually conducted by external consultants. However one planner underlines that there are not many experts in this field

also among private consultants (Interview with employee at the planning unit in Stavanger, 10/04/2018). “The numbers might increase if more municipalities begin demanding these [analyses]”, says the planner. While no further assessment of the knowledge status among private consultants has been conducted in this study, the result of these interviews suggest that the competence on adaptation to climate-induced floods is rather limited both in the public and the private sector.

To summarise, adaptation seems to be gaining ground within the planning field, but there is still some way to go. Although efforts to strengthen competence are made, there is still a need for greater knowledge and awareness on adaptation. The engagement varies largely, both among individuals and depending on the type of flood risk concerned, and existing working groups also have potential for improvements. It suggests adaptation planning is not fully institutionalised in the planning practice and is given attention on a more ad hoc basis.

7.3.2 Data

Access to data is important in climate change adaptation, both for identifying vulnerabilities and for designing sufficient adaptive measures. Geographic data is an important part of the information used to predict and prevent flood risk, often presented as flood risk maps that can be used to inform future plans. One of the key challenges related to geographic data appears to be the quality of the data sets. ”All units try to keep up to date on the best that there is. But sometimes we need more precise and more detailed data”, says one person who works with geographic data in Stavanger (Interview, 06/04/2018). Using inadequate data sets in flood risk analyses can result both in that vulnerable spots are missed and that the flood risk zones that require adaptive measures become unnecessarily large (Interview with employees at the geo-data units in Stavanger and Trondheim, 06/04/2018; 21/03/2018). This appears to be a problem notably when it comes to mapping waterways. ”It it like this with GIS analyses: ’shit in, shit out’. And this is also the weakness of our old flood way analysis. We see that it does not entirely match with reality [...]. The culverts and streams and such were not sufficiently mapped”, says another employee at the geo-data unit in Trondheim (Interview, 21/03/2018). The mapping of streams in data from *Felles*

Kartdatabase (FKB) has been based on whether or not the stream is visible on orthophoto. This approach becomes problematic in vegetated areas where visibility is low, resulting in arbitrary mapping or that the stream on the map simply ends in the middle of nowhere (Interview with employee at the geo-data unit in Trondheim, 21/03/2018).

Reflecting the needs listed in NOU 2010:10, laser scanning is mentioned as one of the main solutions for addressing the problems with data resolution. "With laser scanning, even in areas with spruce forest, there will be some laser rays reaching the ground, so you get a terrain model also where there is forest", explains one person at the geo-data unit in Trondheim (Interview, 21/03/2018). Therefore the ongoing nation-wide laser scanning of Norway is a much welcomed initiative. The project has run for a couple of years already and terrain models for large parts of the country are now openly available online. "Previously, the municipalities have had to finance and buy this service themselves, but the ongoing laser scanning is actually tax-financed", the respondent continues (Interview, 21/03/2018). Hence, in addition to improving the quality of the terrain models, the national laser scan improves the availability of data especially for smaller municipalities that might not have had the resources to conduct mapping projects of their own, thus laying the ground for better flood risk analyses.

Besides geographical data, respondents in both Stavanger and Trondheim municipality note the importance of historical data of flood events. "Things that have happened previously have a tendency to happen again", says one person at the geo-data unit in Trondheim (Interview, 21/03/2018). Past flood events are also described as a more reliable source of data for predicting future flood risks. "It is our strongest card in planning, that we prevent [flood risk] based on our previous experiences", says another respondent at the geo-data unit in Stavanger, while maintaining that scenario-based predictions of the future are also important despite their high uncertainty (Interview, 06/04/2018). Both municipalities have records of previous flood events, however the awareness and use of these records seem to be limited in some of the administrative units. "I have at least not been taught where to look for such information", says one person at the water management unit in Trondheim. "I know that those who have worked here for a long time know this by heart. But the question is what happens when they leave? Should we then learn it all again" (Interview, 26/03/2018)?

The interviews reveal that many of the actors in the planning process have limited or no awareness of the validity of the data material that is used as a base for flood adaptation. "It is a rather simple procedure when I look into the zoning plans", says one respondent at the water management unit in Trondheim. "We just look at the output of these [flood risk] models. But the question is, how well do these results represent reality? I actually don't know that" (Interview, 26/03/2018). Stavanger appears to be an exception to this, as one of few municipalities that actively seeks to validate the data that is used in the planning processes. In this particular case, the verification of data is primarily based on the engagement of one person at the contingency unit who uses external contacts, such as research institutes and national agencies, to verify the data. "I haven't heard about any other [municipalities] that do what I do", says the contingency official (Interview, 20/04/2018). "Many just skip this part and hope for the best." The underlying problem to the lack of data verification is the limited expertise within the municipalities. "It is very specific knowledge that we don't have. There is no one in the municipality [administration] who has expertise on wave impact and such things. And then we are a rather large municipality, so the smaller municipalities they don't have a chance to check these things", claims another informant in Stavanger (Interview with employee at the planning unit in Stavanger, 10/04/2018). As a result, many public officials have no choice but to trust the data provided by external sources.

The inability to verify data also results in an uncertainty about what data to use. "There were some discussions about what data that would be correct to use for a plan we were working on. You have some [data] from NVE [...] and then there was some work done in Bergen that was more recent but not approved by the ministry", explains one of the planners in Stavanger. "We thought we should nonetheless use those that had been approved on a national level [...] even though those numbers were starting to get a bit old" (Interview, 10/04/2018). Similarly, one of the respondents in Trondheim notes that the municipality's flood risk maps, which were made in 2011, are already outdated by newer data. "If you look at the maps on Trondheim municipality's [website] you will see the old sea level estimate from 2011, which says 40 cm sea level rise in Trondheim. However the new guidelines from the Norwegian Directorate for Civil Protection (DSB) [*Direktoratet for Samfunnssikkerhet og Beredskap*] say 70-80 cm, and even more recent research says that we can forget about these small numbers, it will be 100-150 cm" (Interview with employee at the environmental

unit in Trondheim, 09/03/2018). New flood risk maps are now on the way, but for the time being the plans are still based on the outdated maps. The time lag of acquiring and internalising the most recent data therefore slows down the adaptation process further.

These findings suggest that there is an ongoing and seemingly accelerating process for improving the quality and access to data used for flood adaptation planning. Yet it seems like the major challenges might not be related to the data itself but rather to the ability to make use of it. The interviews unveil weak points in the organisation of data and the competence of its users, suggesting that these could be possible areas for improvements that could optimise the use of data.

7.3.3 Tools

Data sets, such as the ones discussed above, provide important input data for tools that are used to inform the planning process. GIS-programmes are one of the key tools in flood adaptation and are used to create flood risk assessments as well as to identify the existing waterways and catchment areas. This tool is often used to generate static maps, however several respondent mention 3D-visualisations as one type of tool that could benefit from further exploration. "If you visualise it [flood risk] [...] in 3D or something similar it becomes understandable to everyone", claims one respondent in the geo-data unit in Stavanger (Interview, 06/04/2018).

To some extent, the needs for data and tools in the adaptation process guides the development of new functions in the existing simulation software. Feedback from users is in some cases communicated back to the provider, who can then incorporate more suitable functions in accordance with the current user needs. According to one person at the geo-data unit in Stavanger, it is easier to influence Norwegian software providers and especially if many municipalities experience similar problems. "If it is a large company that is based in Europe or the United States, then it is rather difficult to have an impact", says the respondent, who also underlines the importance of putting more pressure on the providers who are not necessarily aware of the challenges regarding flood adaptation (Interview, 06/04/2018).

Quantitative evaluations are also mentioned as important for bringing flood adaptation

higher up on the agenda. "Everything you quantify and measure gets prioritised", says one of the water management engineers in Trondheim (Interview, 12/04/2018). Although both municipalities have implemented regulations and guidelines to enhance flood adaptation through the planning process, neither of them conduct any evaluation of the final result of these measures. Evaluating the effect would allow for identifying both successful examples and problems that occur and thus make possible a more efficient adaptation process.

Not only is there an opportunity for measuring the effect in terms of risk reduction and implementation rate, but economic analyses of adaptive measures and flood scenarios could further inform decision-making and lead to more efficient adaptation. "Transforming it into [monetary value] will allow for comparing, when you are dealing with complex issues involving both 'apples and pears'", says one respondent at the water management unit in Trondheim (Interview, 12/04/2018). Yet the interest in conducting economic assessments is seemingly low. A cost-benefit analysis of flood damage was developed for Stavanger, in which a GIS-based analysis allows for estimating future costs of flood damage to infrastructure as well as possible costs and benefits from adaptive measures. "This is a tool that all municipalities could use if you familiarise yourself with it", says an informant from the contingency unit in Stavanger. "I haven't received many inquiries about it so far, so I suppose there is not so much focus on these matters" (Interview, 20/04/2018).

Another key tool used in the planning process today are the various construction standards, such as the local water management regulation [*VA-normen*] and regulations on technical requirements for construction work [*Byggteknisk forskrift*] (TEK17). However, when it comes to blue-green solutions, that are viewed as the preferable and more sustainable way of handling urban runoff, standards are largely absent. Choosing blue-green solutions therefore becomes a riskier investment. As long as you follow the existing construction standards, the consultants will not be responsible for potential flood damage, because they have acted in accordance with the approved practice. But since no such standards exist for blue-green solutions it is difficult to claim that sufficient measures were taken if damage were to occur. One water management engineer in Trondheim therefore asks for similar standards for construction and dimensions also for blue-green solutions. "I think it is essential for the implementation of blue-green solutions. Consultants and developers need to feel certain that the solutions they implement are sensible, and perhaps most importantly, that they

will not risk getting responsibility for damage that could happen in the future" (Interview, 12/04/2018).

Several of the interview participants claim that the tools that are available today are generally good (Interview with employees at the planning unit in Trondheim, and the geo-data and contingency units in Stavanger, 12/04/2018; 06/04/2018; 20/04/2018). When it comes to possible improvements the opinions are more divergent. One informant in Trondheim claims that there are rather many tools available already as it is, while another from Stavanger is surprised that not more tools have been developed and taken into use. The latter also notes that the main weakness is the quality of the input-data rather than the tools themselves (Interview with employees at the geo-data unit in Stavanger and the planning unit in Trondheim, 06/04/2018; 12/04/2018). In some cases tools exist, but simply are not used by the municipalities, such as the cost-benefit analysis of Stavanger, that was mentioned above.

One possible explanation to the limited use of tools, as explained by one planner in Trondheim, is lack of awareness and competence about the tools that exist (Interview, 12/04/2018). There are toolboxes where relevant resources can be found, however these are not necessarily complete and are often one of many such resources collections. In addition, the employees experience that it is difficult to stay fully updated on developments in the field. "It is a very large organisation and many areas of responsibility and many people, so it is not always easy to keep update on everything that is new", continues the planner (Interview, 12/04/2018).

All in all, the interviews suggest that there is a potential for improvements, both regarding the use of existing tools and the development of new tools. The development of tools for visualisation, quantification and standardisation could provide better decision-making support. In addition, organisational and educative measures could probably enhance usage of the already available tools.

7.3.4 Guidance material

A large amount of guidance material on climate change adaptation has been published in recent years. A review of 84 different reports and websites addressing climate change adapt-

ation was published by SINTEF and identifies some general trends in the existing guidance material. Firstly, it often focuses primarily on general information about climate change, rather than detailed information about implementation of possible solutions. Secondly, much of the guidance material lacks a defined target group, which may reduce the effectiveness of the communication. Moreover, none of the guidance material in the review focus on decision-making processes and coordination between different sectors in the adaptation process (Haugen, Almsås and Flyen, 2016, pp. 5-6).

The findings of the abovementioned report are also reflected in the interview material for this study. The guidance material that is available does not reflect the need of the users. One respondent describes difficulties in finding more technical information in the guidance material and another asks for more examples of how adaptive measures can be implemented in practice and information about the implementation process (Interview with employees at the planning units in Stavanger and Trondheim, 12/04/2018; 10/04/2018). It is also mentioned that the complexity of the issues is not always captured in the guidance material, with an example being the impact of waves on sea level rise (Interview with employee at the contingency unit in Stavanger, 20/04/2018). At the same time, it appears to be an overload of information that the users have difficulties navigating through. "If it is like you say that there are more than 80 reports out there, it is rather obvious that it will be difficult to keep track of it all", says one planner in Trondheim (Interview, 12/04/2018).

The absence of process-related guidelines is also brought up as an opportunity for improvement on adaptation. "There should be [...] guidance material for each phase [in the planning process]", says one informant. "Those who are responsible for the different phases in a project need to get clear guidelines describing that 'here you should watch out for this; and consult these actors and ask about such and such'. Then you can say that this is done; OK, move on to the next phase. [...] There is too much discussion about this [process] in general" (Interview with employee at the environmental unit in Trondheim, 09/03/2018).

There is also an imbalanced focus on the different topics covered in the guidance material. The interviews indicate that the available guidance material is more useful for dealing with urban runoff than it is for addressing sea level rise. This resonates with the thematic analysis presented by Hauge et al. (2017, p. 24), which shows that 19 percent of the guidelines

reviewed focus on urban runoff, compared to merely 1 percent that deal with sea level rise.

The often poorly defined target group is mentioned as another challenge with the current guidance material. "Who is it made for? Is it for someone with a PhD or are they written for grannies?" asks one informant at the environmental unit in Trondheim (Interview, 09/03/2018). The unclear target group is brought up as one explanation to the limited usage of the existing guidance material. However, when asked about who primarily uses the guidance material, the perception appears to be that the resources are actually used. "Maybe the environmental unit uses it. The building inspection office and the planning office probably also has to look into these matters. [...] Guidance material on climate change adaptation should also be something that the water management unit goes though", estimates one planner in Trondheim (Interview, 09/04/2018). Nevertheless, most of the interview participants primarily talk about others using the guidance material, and those that do have experience with it mainly recall deficiencies with the available resources.

Both the interviews and Haugen, Almsås and Flyen (2016)'s report confirm the previously established trend that the available information resources on adaptation do not correspond to the information needs in the municipalities. One measure for improving the usefulness of the guidance material would be to better coordinate the content with the needs as expressed by the users. Similar to the findings on data and tools, the use of the existing guidance material would also benefit from better organisation and awareness of the existing material and, perhaps foremost, a reduction in the number of reports and documents.

7.4 Is information necessary for adaptation?

As previous chapters have shown, information resources provide an important support and basis for decisions regarding climate change adaptation in the planning process. Earlier research suggest an information gap between the available information and the information needed in the local municipalities, a tendency that to some extent is supported by the interviews in this study. Hence, insufficient information resources could be one explanation to why many municipalities still have a long way to go when it comes to adaptation. This could easily lead to the conclusion that climate change adaptation should be enhanced through an improvement of information resources. However, before making any fast conclusions, it is

worth asking whether it is necessary to improve information resources in order to accelerate the adaptation process in planning. Will more and better information resources bring us towards a more resilient society or would other approaches to planning be more effective for this purpose?

In an attempt to answer the third research question, this last section will consider the findings from the interviews in a theoretical context. More specifically, the findings will be discussed first in relation to the traditional rational planning theory and Christensen (1985)'s classification of planning approaches, and then in the context of the more recent literature on planning for uncertainty, as presented in chapter five.

Rational planning theory has often been used as a model of an ideal planning process, although its critics make sure to underline that the model might not be so ideal in practice after all (Rosenhead, 1980; Balducci et al., 2011; Lindblom, 1959). This appears to be the case also when it comes to applying rational theory to adaptation planning. Rational planning theory, with its high demands on clearly defined goals and means, as well as on the human intellect, comes across as an unsuited ideal in an era of climate change with its intrinsically uncertain nature and impact. Firstly, given the uncertainty regarding climate change, it is not possible to achieve a perfectly informed decision when considering different solutions, as envisioned in the rational planning theory. Climate models lack the precision that is needed to make climate-proof plans, and real-time climate observations will only be possible decades later when it will be too late for proactive adaptation (Hallegatte, 2009, p. 242). Not only is the epistemological uncertainty a flaw in itself, but there is also a general misunderstanding that progress in climate science could narrow the range of predictions of alternative futures (Hallegatte, 2009, p. 242). Settling for a planning approach that requires reliable predictions of the future is therefore not a good option for achieving proactive adaptation in planning.

Yet this yearning for more certainty is clearly present also in the interview material of this study. Better data foundation, more standardisation and clearer directions about what scenario to adapt to is demanded by several of the interviewees both in Stavanger and Trondheim. It suggests that there is a wide-spread belief that more precise prediction are possible and that this is part of the solution for achieving adaptation. The focus on

strengthening certainty arguably reflects the impact of the rational planning ideal on the planning practice. At the same time, the interviews give no indication that the rational planning model with its desire for certainty is used as an excuse to delay the adaptation process. None of the informants imply that better climate projections are needed in order to start adapting. So rather than being a prerequisite, as proclaimed by rational planning theory, higher certainty appears to be perceived as a facilitating factor.

Secondly, rational planning theory's criteria of a clearly defined goal is only partly fulfilled in the context of climate change adaptation. While there is a general consensus on the need to adapt to climate change, this goal is often not defined in more precise terms (see Storbjörk (2007)). The question remains, what degree of adaptation can be considered sufficient? This challenge is reflected by some of the interviewees in this study, who describe an insecurity about what level of adaptation that will be needed. Given the geographical variations in climate impact, the goal for adaptation planning will necessarily differ depending on the exposure to risk, and the absence of a detailed universal goal might be part of the solution rather than an obstacle to it. Hence, rational planning theory's criteria of a clearly defined goal can neither be fulfilled nor is it always desirable in this context. It therefore seems like rational planning might not be an ideal model when planning for climate change adaptation.

The conclusion that rational planning is not compatible with the high uncertainties related to climate change adaptation brings up the next question: What type of planning would be more suitable in the context of climate change adaptation? Are there planning approaches that do not depend on certainty of information?

One clue to the answer can be found in Christensen (1985)'s classical categorisation of planning approaches. Considering the uncertainty that characterises climate change adaptation, as described above, Christensen (1985)'s model suggests that adaptation planning should focus on pragmatism, experimentation and innovation in cases where the goal is well defined, or alternatively on creating a shared understanding of the challenge if the goal is not defined. Notably the former resonates well with the demands for more knowledge on possible technical solutions and inspirational examples from successful cases elsewhere, as found in the interviews. The closest form of application of the pragmatic-experimental approach is found in Stavanger, with the current work on the plan for Stavanger city centre.

Rather than designing the flood protection system for a well-defined long-term future, it has been suggested to first consider the current projections of sea level rise for 2050, and instead reevaluate the need and possibly add height to the existing barriers if needed in the future (Interview with employee at the planning unit in Stavanger, 13/04/2018).

An alternative answer, although resonating with Christensen (1985)'s conclusions, can be found in the literature on planning for uncertainty. Recognition of the incapacity to achieve sufficient certainty regarding the future climate and its impact has also been the basis for this specific strand within the planning literature. Instead of designing a society in accordance with a certain vision of the future, researchers within this line of thought often propagate the use of scenario-based planning as described in chapter five (Freestone, 2012; Rosenhead, 1980; Dessai et al., 2009; Hallegatte, 2009). While scenario-based planning changes the requirements for the information basis in planning, it does not remove the need for information. Instead, it takes a different shape that might be more suitable for the data that can be produced today. According to Hallegatte (2009, p. 243) this approach will require information about possible future scenarios and their probabilities.

The focus on robustness across multiple scenarios goes hand-in-hand with the concept of resilience by reducing negative consequences for a number of alternative futures. Compared to adaptation for one specific scenario, scenario-based planning spreads the risk by planning in a way that might not optimise but nevertheless increases the robustness to climate change for several scenarios. This would, considering the uncertainty of climate forecasting, result in reduced uncertainty regarding the future risk. In the two cases studied, resilience is secured by using the most extreme climate change scenario, RCP 8.5, as a basis when planning for adaptation (Interview with employee at the contingency unit in Stavanger, 20/04/2018). This is in accordance with the national recommendations on climate change adaptation (DSB, 2016, p. 14). If assuming a linear increase in negative consequences, using the most extreme scenario guide adaptation would presumably also sufficiently mitigate risk in less extreme scenarios. To this extent one could say that the current planning practice in the two cases reflects scenario-based planning and particularly the so-called safety margin strategy as described by Hallegatte (2009). Yet some of the respondents express an uncertainty on whether today's safety margins are sufficient enough, in the event that the climate consequences would be worse than predicted (Interview with employees at the

planning unit in Stavanger, 10/04/2018; 13/04/2018). Rather than being an indication of insufficient safety margins, considering that the most sever case of climate change (RCP 8.5) is used as reference point, this might instead reveal a weakness in the theory of uncertainty planning. While it makes the information requirements in planning better suited to the uncertainty level, it does not escape the impact of uncertainty. The inability to achieve a comprehensive analysis based on perfect information, which is a reoccurring argument amongst the critics of rational planning theory, remains relevant also in the context of planning for uncertainty. If there is uncertainty about the possible range of climate scenarios, how could one then strengthen the robustness for all of possible scenarios?

From this one can conclude that rational planning theory is not a well-suited model for dealing with the highly uncertain context of adaptation planning. At the same time, the alternative planning approaches discussed here do not lower the requirements on information but rather demands a different type of data and information in order to adapt to climate change. Despite the withstanding need for information in adaptation planning, nothing in the interview material indicates that the lack of sufficient data would be used as an excused not to pursue adaptation in planning. The findings also suggest that approaches that claim to rely less on precise climate projections may nevertheless suffer the same weaknesses as rational planning when it comes to inability to make perfectly informed decisions. Hence, it appears that information resources do have an important, although not determining role to play for the progress on adaptation.

8 Conclusion

Looking at today's practice on adaptation, the answer to the first research question identifies a gap between the intention to adapt and the actual rate of adaptation. In both cases studied, flood adaptation is addressed with specific provisions in local plans, yet there are several examples of challenges regarding implementation. Recent developments in Trondheim and Stavanger show examples of deviation from flood-related provisions the municipal master plan, resulting in a lower safety-margin than recommended, and it also exemplifies how adaptation gets compromised on behalf of other conflicting interests. These tendencies are supported by the more general reflections on how adaptation is addressed in the planning process, where conflicting interests and insufficient information about the need for adaptive measures are brought up as key challenges. Information resources could play a role for dealing with these challenges. For example, evaluation of the implementation of adaptive measures could give a better overview of deviations from plans. Similarly, clearer information regarding the need for adaptive measures, perhaps in quantifiable terms, could facilitate the prioritisation among conflicting interests and ensure that sufficient measures are taken.

The second research question asks what data, tools and guidance material that are needed to enhance flood adaptation in planning. Here, the interviews suggest that the current insufficiency of information resources reflects deficiencies regarding availability just as much as the type of information provided. For all three information resources considered (data, tools and guidance material) lack of awareness about what information resources that are available appears to be a key barrier and a cause to the perception that information regarding climate change adaptation is insufficient. In addition, limited understanding of the validity of the data also makes it difficult to assess its relevance. Better organisation of the resources as well as strengthened competence among the users could optimise the use of the available information resources. The claims about insufficient information resources are however not groundless. The available GIS data would benefit from higher resolution, which is currently under development. There are also demands for tools for visualisation, quantification and standardisation, as well as guidance material focusing more on technical solutions and the process of adapting. Overall, it appears that focus on adaptation is increasing among

planning practitioners and capacity-building initiatives are already implemented. However, engagement in adaptation is still largely dependent on individual interest and there is need for more knowledge, awareness and competence on the issue among the practitioner.

While the findings in the sections above suggest that improved information resources are at least part of the solution to enhancing adaptation, the third research question asks to what extent information resources are a prerequisite for adaptation planning. This final section brings the conclusions from the two first research questions into a theoretical perspective in order to assess whether the prevailing planning approach could influence the need for information in planning. Looking first to the rational planning theory, as the archetype of the planning practice, it is concluded that this approach is unsuited for conditions of high uncertainty, such as when planning for climate change adaptation. A comparison to the literature on planning for uncertainty suggests that this approach does not remove the need for information resources in adaptation planning, but rather requires different type of information. While the need for information can seemingly not be bypassed, nothing in the interview data indicates that the absence of sufficient information would be used as an excuse not to pursue adaptation in planning.

Considering the claim in previous research, that the passive approach to climate change adaptation in local municipalities is partly a result of limited or irrelevant information resources, the findings in this study can provide a few useful pointers. On one hand, it identifies flaws in the adaptation process where improvements to information resources could help solve the problem. The result also indicates that there is indeed an expressed demand for information resources that are better adapted to the planning practitioners' needs. On the other hand, the findings suggest that limited use of the existing information resources is likely due to lack of awareness of the available resources and limited competence among the users. Hence the information content alone cannot be blamed for the slow adaptation process. Moreover, nothing in the interview data implies that adaptation is disregarded in planning as a result of insufficient information resources. It therefore appears that the quality of information resources might be a facilitating factor for climate change adaptation, but this study does not suggest that it has a determining impact on adaptation in planning.

Deriving from these conclusions, several topics might be of interest for further research.

Firstly, having established an opportunity for better adapting information resources to the needs of local planning practitioners, a more detailed mapping of these information needs will be required as well as research to develop the suggested information resources. Building on this, it would also be useful to examine how information needs are communicated between local practitioners and suppliers of information and investigate how one could to strengthen the relevance of the information resources that are produced. Uncertainty in planning is another aspect that would benefit from further research. Although planning for uncertainty has developed as a normative strand of literature, very little research describes how uncertainty in planning is dealt with in practice. A better understanding of this could facilitate the use of scenario-based planning approaches. From a practitioner's point of view, the development of process-oriented guidelines for adaptation could help formalising adaptation as a part the standard planning process. Considering that the cases in this study are major cities, it would be useful to expand the study to include municipalities of various size and geographical location. This would allow for identifying differences in information needs both across geographical regions and depending on municipality size.

This thesis has successfully brought light to an area of previously limited empirical research and the result has brought a more nuanced understanding of the impact of information resources on local adaptation processes. The conclusions made could facilitate the development of better usage and content of information resources related to planning for climate change adaptation. Moreover, it can inspire future research projects that will contribute to further strengthening resilience of the local communities.

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A Interviews

Interview with employee at the building inspection unit – Stavanger. [Telephone interview] Trondheim, 11/04/2018.

Interview with employee at the contingency unit – Stavanger. [Telephone interview] Trondheim, 20/04/2018.

Interview with employee at the environmental unit – Trondheim. [In person] Trondheim, 09/03/2018.

Interview with employee at the geo-data unit – Trondheim. [In person] Trondheim, 21/03/2018.

Interview with employee at the geo-data unit – Stavanger. [Telephone interview] Trondheim, 06/04/2018.

Interview with employee at the planning unit – Trondheim. [In person] Trondheim, 12/04/2018.

Interview with employee at the planning unit – Stavanger. [Telephone interview] Trondheim, 12/04/2018.

Interview with employee at the planning unit – Trondheim. [In person] Trondheim, 09/04/2018.

Interview with employee at the planning unit – Stavanger. [Telephone interview] Trondheim, 13/04/2018.

Interview with employee at the planning unit – Stavanger. [Telephone interview] Trondheim, 10/04/2018.

Interview with employee at the water management unit – Trondheim. [In person] Trondheim, 09/04/2018.

Interview with employee at the water management unit – Trondheim. [In person] Trondheim, 12/04/2018.

B Interview guide

Introduction:

- Present yourself.
- Aim of the study; present the themes of the interview; define key terms.
- Clarify the use of the interview material; anonymity; recording.
- Obtain consent to recording and use of interview material.

Background:

- Tell a bit about what your are working with?
- What is your role in the planning process?
- What is your previous experiences of working with climate change adaptation to flood risk?

How is climate change adaptation to flood risk addressed in the municipal planning processes today?

- Has the municipality previously experienced flood events?

  What was the cause of the previous events?

  What effect has previous events had on the society?

  Have previous flood experiences influenced the consideration of flood risk in the planning process?
- How big is the need for adaptation to flood risk in the municipality?
- What do you consider to be the most important factors for facilitating adaptation to flood risk through the planning process?

- How is adaptation to flood risk incorporated in the planning process today?

    What are the focus areas for climate change adaptation in planning?

    What type of adaptive measures are implemented today?

    What works well in the adaptation to flood risk today? Why?

    What does not work well in the adaptation to flood risk today? Why?

Are the available data/tools/knowledge sufficient for enabling climate change adaptation to flood in municipal planning?

- How do you experience the accessibility of data/tools/knowledge about climate change adaptation to floods?
- What data/tools/knowledge are used to facilitate climate change adaptation to flood in the planning process today? *(Specific websites/guidance material etc)*

    What works well? Why?

    What does not work well? Why?

    Relevance?

- How do you access data/tools/knowledge about climate change adaptation to flood in the planning process?

    Is it easy? Difficult?

    Accessibility?

- Is there any capacity building on climate change adaptation to flood?
- Who is responsible for meeting the needs for data/tools/knowledge on climate change adaptation to flood?
- Does the municipality produce its own data/tools/knowledge related to climate change adaption to flood?
- How are the needs for data/tools/knowledge communicated to those who produce these resources?

How could one better accommodate the needs for data/tools/knowledge about climate change adaptation to flood in the municipal planning process?

- Could any of the available data/tools/knowledge be improved to better facilitate climate change adaptation to flood in municipal planning?
- Are there any data/tools/knowledge that are lacking and that would improve the possibilities for climate change adaptation to flood?

  Content?

  Means of communication? Dissemination?

  Format?

  Capacity building?
- How would these data/tools/knowledge improve the prospects of climate change adaptation to flood?