How to make local context matter in national advice: Towards adaptive co-management in Norwegian climate adaptation.

Running head: Local context and adaptive co-management

Article type: Original article

Authors: Hege Westskog[a*], Grete K. Hovelsrud[a.c] and Göran Sundqvist[b]

[a] CICERO Centre for International Climate and Environmental Research - Oslo, P.B. 1129 Blindern, 0318 Oslo, Norway
[b]TIK Centre for Technology, Innovation and Culture, University of Oslo, P.B. box 1108 Blindern, 0317 Oslo, Norway
[c]Nord University, Faculty of Social Sciences, P.O.Box 1490, 8049 Bodø, Norway
[*]Corresponding author: Tel: +4722858759/50, Fax: +4722858751, E-mail: hege.westskog@cicero.oslo.no

Key words: adaptive co-management, multi-level governance, climate change adaptation, local context, Norway

How to make local context matter in national advice: Towards adaptive co-management in Norwegian climate adaptation.

1. Introduction

The latest report from the Intergovernmental Panel on Climate Change (IPCC) shows a 95 percent certainty that climate change is caused by human activities (IPCC 2013 WG I). However, climate impacts are complex, dynamic, non-linear, and there are uncertainties about future climate and the extent of upcoming impacts. In short: uncertainty is pervasive in climate change research (e.g. Dessai and Hulme, 2004). Uncertainty spans the range from climate models to societal vulnerability, adaptation needs, and the effects of mitigative and adaptive measures, often described as cascading uncertainties (Schneider et al. 2002).

The uncertainties about environmental and societal impacts from climate change are even more pronounced at the local level. The impacts vary along physiographic and topographic dimensions. The potential societal impacts also vary depending on a suite of sensitivities, such as available human and financial resources, access to relevant knowledge, and the particular exposure or hazards of a specific location. Added to the uncertainty about impacts are inherent and complex uncertainties in climate projections which increases as the resolution becomes finer. Nevertheless regional scale projections show clear trends of increasing temperatures and changing precipitation patterns, which in turn will require adaptation. Climate change is a fuzzy decision-making context with a more pronounced uncertainty than other policy areas as pointed out by Lempert et al. (2004, p. 2): “Climate change is associated with radically diverse decision contexts, geographic scales, and time scales. It comprises many different types of policy problems involving many different types of actors, and thus is not even theoretically optimizable”.

It is clear that climate adaptation is an emerging policy area across societal scale, and findings show that municipalities adapt to climate change even if national guidelines and advice are lacking (Dannevig et al. 2012, 2013). In many European nations, including Norway, municipalities have

been assigned the responsibility for local climate adaptation, but the resources and relevant background knowledge (e.g. maps and vulnerability assessments) are not available at the municipal, scale. These are only developed for the national and county levels. The authorities expect the knowledge and tools to be highly useful for municipal planning, assuming linearity from national scientific assessments to local implementation. Municipal officials underscore that they are used to planning under uncertainty, but that the currently weak national engagement on climate adaptation and lack of roles allocated to the different levels of government limit their ability to adapt proactively to climate change. Therefore, municipalities want their roles to be defined more clearly and ask for better national guidance and support (Amundsen et al. 2010, Dannevig et al. 2012, 2013).

National climate change adaptation has a strong tradition of being science-based with a top down standardized policy approach (e.g. Amundsen et al. 2010) while the nature of the problem, with cascading uncertainties, calls for a flexible management system in which adaptive measures are supported by state level institutions (Armitage et al. 2007, Olsson et al. 2004).

At a general level and in the short term, climate change impacts are likely to be less severe in Norway compared to elsewhere on the globe, and potentially economically positive for some sectors, such as agriculture (Kvalvik et al. 2011, Hovelsrud et al. 2011). On the other hand, the consequences for some municipalities could be significant and substantially affect the inhabitants because of the complex interlinkages between climate change impacts and societal conditions (e.g. West and Hovelsrud, 2010; Hovelsrud and Smit 2010). The reasons for the differences are multiple, complex, and closely related to the particular socio-economic (some have more administrative capacity than others), environmental conditions (some are more exposed to climate impacts than others), and the human and resource capacity (some have more dedicated officials than others) in a given municipality (e.g. Dannevig et al. 2012, Dannevig et al. 2013). This underscores the need to

51 understand the particular local contexts when studying policy development and adaptive responses
52 to climate change. One size does not fit all when it comes to local level climate adaptation.

53 Several studies show that the local context matters for effective policy formation and conclude that
54 this topic is largely overlooked both in national policy and in the literature on policy instruments
55 (e.g. Tørnblad et al. 2013). However, a few studies have addressed the need for adjusting national
56 policies to become locally relevant and efficient climate policy strategies (Moser and Ekstrom 2010,
57 Bulkeley and Betsill 2005, Gustavsson et al. 2009). In this paper we underscore that the significant
58 variation in contextual factors between municipalities is not sufficiently addressed and understood
59 by national and sectoral governmental authorities. The empirical evidence from our case
60 municipalities illustrates a mismatch between the need for a local contextual understanding of
61 climate change adaption and the dominant top-down standardized national policy approach. In this
62 paper, we investigate how the local context matters when developing local adaptation strategies and
63 we discuss the factors that constitute the local context for adaptation policies. Further, we identify
64 variation in the contextual factors for local adaptation, which calls for an adaptive co-management
65 strategy across the national, regional and local government levels. The main geographical focus is
66 Norway, but we zoom in on twelve municipalities in Vestfold County (see Figure 1).

67 The next section describes the context of climate change adaptation in Norway and in the case study
68 of the Norwegian County Administration Vestfold and its dozen municipalities. This is followed by
69 a theoretical section developing the adaptive co-management approach, a methods section and a
70 presentation of findings from case municipalities based on an analysis of four factors that constitute
71 the local context. Finally, we discuss the need for an adaptive co-management strategy based on our
72 findings before the results are summarised and concluded.

73

2. The context

2.1. Norwegian climate change adaptation policies[1].

Norway has two levels of sub-national government – regional or county government and municipalities respectively, both of which are governed by directly elected councils. A local administration headed by a chief executive officer in each municipality and county provides information for decisions to be taken by the councils and follows up policy decisions. In keeping with practices common to development of the Scandinavian welfare states (cf. Sellers & Lidström 2007), responsibility for implementing national policy decisions has to a large extent been decentralized to local authorities. Thus, municipalities are currently charged with responsibilities for primary and lower secondary education, primary health care, social services, municipal roads, water supply and sewage services, land use planning and local environmental issues. In addition to these mandatory responsibilities, municipalities also have residual discretionary authority and are free to engage in other tasks.

Norwegian national authorities have the responsibility to facilitate and oversee that national requirements, guidelines and intentions are followed by the municipalities (local level), while the municipalities are responsible for planning and implementing measures that safeguard the municipality and the residents, including handling the impacts of climate change. In carrying out this responsibility, the municipalities are to a great extent making their own judgements and design their own policy, within the national requirements and intentions: they decide if there is a need for local measures to mitigate climate change, type of measures to be implemented and how these instruments will be designed.

[1] The overview made in this section is based on Heiberg (2012) but includes updated information on the responsibilities from The Norwegian Environment Agency on climate change adaptation.

When it comes to climate change adaptation and preparedness, the national government develops requirements and provides guidelines for the local level. Through the Civil Protection Act (Lovdata 2016a), Norwegian municipalities are assigned the main responsibility for developing and implementing the necessary measures and to be prepared to secure its citizens against climate related events. Municipalities are required to map potential hazards and risks, to assess the likelihood of occurrences and how they will affect the municipality. Ideally, this is presented in a holistic Risk and Vulnerability Assessment (RVA), which forms the basis for a mandatory Preparedness Plan for the municipality. Private actors are responsible for planning and implementing necessary measures and for protecting their belongings from exposure to natural hazards, including climate related events, including assessing risks from flooding and landslides when planning building sites.

In addition, the RVA provides the basis for the municipalities' planning and infrastructure. Spatial planning within the municipal borders is the sole responsibility of the municipality and is strictly regulated by Norwegian national laws on civil and environmental protection against natural and societal hazards (Lovdata 2016b, Act on Natural Damage).

At the national level, several authorities are developing flood plans and maps of landslides relevant for the local level. Specifically, the Norwegian Water Resources and Energy Directorate (NVE) has an important role at the national level. NVE is responsible for preventing damage from flooding and landslides (Heiberg 2012) by mapping, informing, monitoring and alerting about areas at risk. NVE has regional offices throughout the country, which carry out the sectoral responsibilities of the Directorate. Our case municipalities in Vestfold County belong to the "Region South" of NVE, which is responsible for six counties, including 110 municipalities.

All national authorities are responsible for preventing and handling climate related hazards such as floods and landslides in their sector, currently with minimal cross-sectoral efforts. However, a

119 cross-sectoral approach to climate adaptation has been called for (NOU 2010; Meld. St 33, 2012-
120 2013) and recently the Norwegian Environment Agency has been given the responsibility for
121 advising other state level governmental authorities on climate change adaptation.

122 The County Governors comprise the national government at the county level and are responsible for
123 ensuring that national requirements and guidelines for climate adaptation are adhered to by the
124 municipalities. The County Governors have clear coordinating roles for overseeing that the
125 municipalities are prepared for climate-related events, with their own climate change expertise for
126 guiding the municipalities. The County Governor has a legislative right to object to housing and
127 building developments if risks and vulnerability assessments are lacking and if safety requirements
128 have not been addressed.

129 The interactions between the national level (with its requirements, guidelines and intentions for
130 climate change adaptation) and the responsibility of the local level to design relevant policy,
131 provides an interesting backdrop for studying the importance of the local context in national climate
132 adaptation policies, and for considering how local strategies can inform the development of national
133 and sectoral adaptation guidelines. First, given that municipalities are responsible for implementing
134 national climate adaptation policies it becomes important to understand whether and how
135 municipalities may influence such policy processes and measures. Second, since the national level
136 (including the County Governor) is responsible for overseeing municipalities, it is appropriate to
137 study the roles and interactions between these levels. We may expect national actors to be sensitive
138 to variations in local conditions and to be interested in feedback from local actors, but there is lack
139 of knowledge of how such interaction takes place in practice.

140 In summary: Norwegian municipalities are required by national regulations to develop RVAs that
141 incorporate climate change, and to prepare and develop adequate measures for responding to
142 potential climate events (Heiberg 2012). The national level controls and guides the municipalities'

143 work on climate change. The municipalities have a significant degree of freedom when designing
144 their policies, including climate adaptation.

145 **2.2 The case study area**
146 The twelve case municipalities are located in Vestfold County in southern Norway, which has 14
147 municipalities in total (see Figure 1). The study began with contact between Vestfold County
148 Governor and researchers (see methods) and was carried out as an iterative process between the
149 researchers, the Governor and the municipalities. The Vestfold County is one of Norway's smallest
150 counties geographically speaking in area, and with 238,748 inhabitants (2013 numbers) is one of the
151 most densely populated. Vestfold has many types of industries including a process industry, an oil
152 refinery and stone work, and is despite its size the largest vegetable producer in Norway. Soil,
153 climate and topography make Vestfold well suited for agriculture and forestry; 20% of the land is
154 farmed and 56% of the forest is productive (Vestfold Fylkeskommune 2016).

155 (Insert: Figure 1)

156 In Vestfold climate and weather related risks are directly connected to hazards from quick clay and
157 landslides. In addition, some areas are exposed to flooding and sea level rise combined with storm
158 surge. The challenges associated with key risk factors are not evenly distributed among the case
159 municipalities, but vary along a number of dimensions, including the amount of resources allocated
160 to addressing climate adaptation, who is responsible, and in which networks they participate. The
161 three types of inter-municipal networks in Vestfold of relevance to climate adaptation include the
162 county-wide Vestfold Preparedness Forum (Vestfold Beredskapsforum), the Vestfold Spatial
163 Planning Network (Vestfold Plannettverk) and a general inter-municipal network called 12K (12
164 municipalities). The 12K network is a municipal discussion forum for addressing current and often
165 shared challenges related to tasks and regulations. Two of the 14 municipalities (Svelvik and Sande)
166 chose to participate in the neighbouring county's general municipal network (the D5 network)
167 because of the geographic proximity. Table 1 below summarizes the organization of the adaptation

efforts and resources allocated in the case municipalities. It also outlines the different networks and efforts for cross-municipal collaboration on climate adaptation.

The resources used on climate adaptation (characterized as "few", "some", or "more") reflect the municipality's allocation of specific human resources to address preparedness/civil protection. If "few" human and financial resources are ear marked for climate adaptation it signifies that the responsibility for such tasks is added to a position that is already 100% dedicated. "Some" resources allocated signify that the responsibility is covered by less than a 50% position. "More" resources allocated signify that the municipality has a 50-100% position to cover these issues.

(Insert: Table 1)

3. Adaptive co-management

Adaptive co-management is a useful approach for understanding how the different levels of government interact in our case area. Olsson et al. (2004, p. 75) define adaptive co-management as "…flexible community based systems of resource management, tailored to specific places and situations, and supported by and working with various organizations at different scales". This approach to adaptive co-management is mainly applied to local level studies of natural resource management such as fisheries and wild life.

Inspired by Olsson et al. (2004) we apply the concept of adaptive co-management to our case study as a flexible system that considers the local context of municipalities in which adaptive measures are supported by different state level institutions such as the Vestfold County Governor and the NVE. Adaptive co-management is in this case relevant i) for developing national advice, guidelines and requirements important to the local level, and ii) for adapting national advice, guidelines and requirements to the local context in terms of particular challenges and opportunities facing each municipality. The latter is the main focus here. In our elaborations, adaptive co-management connotes an interdependence between the national and the local levels. We are specifically pointing

192 to the need for adaptive co-management when the relevance of climate change adaptation varies
193 significantly with local contexts and within the same county. This is at the heart of our argument;
194 adaptive co-management is an approach which captures the particular conditions in a particular
195 place (municipality), but allows for analysing the interplay with the broader and salient context (the
196 county and state).

197 An adaptive co-management approach recognizes that neither the state nor the municipality
198 contains the necessary roles and interests to address the challenges. Moreover, it includes local
199 knowledge and awareness in the decision-making process (Fitchett 2014). This kind of management
200 is based on collaboration between relevant actors in the management of complex and uncertain
201 challenges. Inspired by Armitage et al. (2007) and based on our findings we argue that management
202 problems associated with climate change impacts cannot be properly addressed through a top-down
203 approach. Climate change and climate adaptation is dynamic, non-linear and with a high degree of
204 uncertainty both with respect to projected changes and impacts. It creates a new kind of managerial
205 problems to which a centralized bureaucracy has a limited ability to respond (Gunderson and
206 Holling 2002, Berkes et al. 2003)[2].

207 Adaptation can be divided into reactive and proactive measures for reducing negative effects or take
208 advantage of positive consequences. Proactive adaptation refers to anticipated measures needed to
209 deal with future change, and reactive as a response to something that has occurred, for example the
210 aftermath of extreme events (Fankhauser et al. 1999, IPCC 2007). In most cases, adaptation is
211 reactive in terms of being a response to an extreme event that has happened and which requires
212 immediate action (Amundsen et al. 2010). Such after the fact responses to extreme events are not
213 sufficient in the long term; they are costly and may not minimize the risks properly, unless they are

[2] There are also other managerial problems that share many of the same characteristics as climate change adaptation when it comes to the degree of uncertainty and complexity. Eco-system management is one such example. See for instance Armitage et al. (2009) and Fitchett (2014).

214 included in proactive adaptation measures. Proactive adaptation is generally more desirable to
215 ensure preparedness and thereby minimize risks, but requires in-depth knowledge about potential
216 perturbations (Amundsen et al 2010). On the other hand that which may be needed for proactive
217 adaptation (e.g. relevant downscaled scenarios, robust planning tools) may be lacking which in turn
218 may hinder proper measures to be taken (see also Lempert et al. 2004). We argue that the process of
219 adaptive co-management, in creating space for the local context in national policy development,
220 may facilitate proactive adaptation.

221 Relevant adaptive co-management factors such as shared decisions making, participatory
222 approaches, and co-creation of knowledge are relevant for climate adaptation (Plummer and Baird
223 2013). Adaptive co-management co-decision processes between different levels of government
224 might enable cognitive learning (related to the acquisition of new or to restructuring existing
225 knowledge) and relational learning (referring to improved understanding of other mind-sets,
226 enhanced trust and ability to cooperate) in decision making for climate change adaptation (Baird et
227 al. 2014). Furthermore, adaptive co-management processes that involve local knowledge in the
228 decision making process provide an effective method to deal with change by incorporating local
229 input in management (Fidel et al. 2014).

230 Some scholars caution that power dynamics might challenge the outcome of adaptive co-
231 management processes (Watson 2013). The need to simplify and scale up local data to achieve a
232 manageable management regime might leave out certain affected groups or misrepresent them,
233 which can produce conflict. Others suggest that adaptive co-management processes might be
234 wishful thinking and difficult to achieve in practice (Bown et al. 2013). However, these cautions do
235 not preclude the benefits of adaptive co-management in finding ways to address climate change
236 risks and challenges. It may also be possible that the potential for conflict and exclusion is greater

237 when adaptive co-management takes place between interest groups and the government rather than
238 between different levels of government.

239 A number of scholars point to a need for integration across and between different scales of
240 management, sectors and among government departments, to efficiently respond to climate change
241 (Tompkins and Adger 2005, Bulkeley and Betsill 2005, Bulkeley 2005). Amundsen et al. (2010)
242 further assert that a multilevel governance framework is a way of advancing proactive adaptation
243 and overcoming barriers to adaptation. This literature implies that in order to ensure proactive
244 adaptation strategies locally it is essential for the national government to assign well defined roles
245 to municipalities by setting goals, creating regulations and financing adaptation processes for the
246 local governments to implement. Our empirical case study provides useful insights for further
247 developing the notion of a multilevel governance strategy for adapting to climate change. The study
248 shows how the local context matters for the development of local adaptation strategies, and that this
249 implies the need for a multilevel governance structure that is both adaptive and co-managing, with
250 room for co-decision processes and the option of changing these over time. Below we present two
251 central concepts that are relevant for analysing climate adaptation at the local level and for further
252 developing the adaptive co-management approach.

253 We align ourselves with the language of the IPCC and a framework developed for application to
254 local level case studies as outlined and discussed in Hovelsrud and Smit (2010) and references
255 therein, and in Ford and Smit (2004). When studying the need for adaptation in conjunction with
256 adaptive co-management it is important to distinguish between municipalities that are both exposed
257 and sensitive to hazards or perturbations and those that are only exposed but not sensitive (e.g.
258 Hovelsrud and Smit 2010). This has implication for assessing and designing measures from a
259 national level perspective: one size does not fit all, even within the same county. E*xposure-*
260 *sensitivity* refers to the manner and degree to which, in this case, a municipality is exposed and

sensitive to particular conditions, or natural hazards. “It reflects the likelihood of climatic conditions or natural hazards occurring in a particular place over time relative to the situational characteristics of places and people which make them sensitive to conditions or hazards” (Smit et al. 2010: 5) These risks could come from extreme weather events or natural hazards such as quick clay slides. Additionally, geographic characteristics, public policy, economic framework conditions, and social parameters determine whether a municipality is sensitive to exposures from risks and hazards. In this way, exposure-sensitivity speaks to the susceptibility to particular conditions creating risks or hazards. This is clearly illustrated by the case municipalities in relation to the risks of landslides associated with quick clay. Many municipalities (N10) are exposed to quick clay, but only a few (N3) are both exposed and sensitive to risks of landslides. Our assumption is that the exposure-sensitivity to risks and hazards will likely be reduced through deliberate adaptive co-management because of the potential for addressing the local conditions properly.

The concept of *adaptive capacity* is receiving increasing attention in the adaptation literature because it problematize the linear thinking that adaptation will happen if we only have enough knowledge (e.g. Preston et al. 2013; Moser and Ekstrom 2010). It is increasingly recognized that the ability to respond or adapt to perturbations hinges on the degree to which adaptive capacity is activated, utilized or enabled (e.g. Keskitalo et al. 2011; Hovelsrud et al. 2010). Adaptive capacity reflects an individual’s, industry’s or community’s ability to cope with, or adjust to, changing conditions. In this case it also reflects the municipality’s management of current and past stresses, their ability to anticipate and plan for future change, and resilience to perturbations. In the cases presented here the municipalities’ exposure-sensitivity and adaptive capacity to climate change is analysed in conjunction with adaptive co-management between the local and national levels. Our assumption is that the ability to adapt to risks and hazards will be strengthened through adaptive co-management, because of the inclusion of particular concerns and conditions. Whilst vulnerability is often analysed as an outcome or a function of exposure-sensitivity and adaptive capacity we do not

286 assess vulnerability per se in this paper (see Adger and Kelly 1999; Smit and Pilifosova 2001;
287 Turner et al. 2003a,b for a discussion of vulnerability in relation to exposure-sensitivity and
288 adaptive capacity).

289 ## 4. Methods

290 The methodological approach is inspired by transdisciplinary thinking on how knowledge can be
291 co-produced by researchers and governmental and municipal officials to solve specific and
292 identified problems (Elzinga 2008; Pohl 2011). Researchers and practitioners have collaborated
293 throughout the study in a three-step approach (planning process, data gathering, dialogue seminar).
294 In the first step, in 2012, the Vestfold County Governor invited researchers from the Centre for
295 International Climate and Environmental Research-Oslo and the Center for Technology, Innovation
296 and Culture, University of Oslo, to participate in and observe the process of planning a dialogue
297 seminar on local climate adaptation with participants from the municipalities, and the regional and
298 national governments. The aim of the dialogue was to improve climate adaptation in Vestfold
299 County. A reference group was established by the County Governor, involving the researchers, the
300 County Governor and the Vestfold County Council, Vestfold Energy and Environmental Forum, the
301 Norwegian Directorate for Civil Protection (DSB) and selected municipalities. The selection of
302 municipalities was based on previous involvement in work on climate adaptation including
303 municipalities with a relatively heavy engagement in the issue. The reference group held regular
304 meetings throughout the process and met with the municipalities to discuss both the outcome of the
305 dialogue seminar and new and improved measures for climate adaptation. The researchers
306 contributed with knowledge about local adaptation strategies and with competence on how to
307 produce, summarize, and transfer such knowledge between researchers, managers and decision-
308 makers.

309 In the second step the researchers conducted 26 interviews with representatives from 12 of the 14
310 municipalities. (Recruitment from two municipalities was unsuccessful.) The recruitment was

311 conducted by the County Governor and the target group was municipal personnel central to climate
312 adaptation efforts, in particular the Chief Municipal Executive (Rådmann) and officials responsible
313 for emergency planning and preparedness, and spatial planning. Not all municipalities were able to
314 participate with representatives from the three areas of responsibility either due to time constraints
315 or that the positions were vacant. In some municipalities, the person responsible for spatial
316 planning was also responsible for emergency planning and preparedness. In addition, interviews
317 were conducted with the County Governor (2) and DSB representatives (1) (see Table 2 below). A
318 guide for semi-structured interviews was developed in collaboration with the reference group. The
319 researchers developed a set of questions to be included in this guide, which was discussed by the
320 reference group. Questions were adjusted according to these discussions and a final interview guide
321 was developed to be used in the interviews. The interviews were recorded (except for the DSB),
322 and minutes were taken.

323 (Insert: Table 2)

324 Questions to municipal officials included status of climate adaptation work; how it was organized;
325 how they perceived their own knowledge about the issue; what competence, knowledge and
326 network they were involved in; and the possibilities to feed this to the national and regional
327 authorities that provide climate adaptation advice to municipalities. We asked how they
328 collaborated with other municipalities and actors and their views on the regional and national
329 governmental actors involved in adaptation. We asked specifically about what they perceived as
330 requirements from regional and governmental actors and what kind of support they needed. In
331 addition, the interviewees were queried about potential barriers they were confronted with when
332 addressing climate adaptation. The interviews with the County Governor and the DSB covered
333 topics such as how the guiding and overseeing of the municipal efforts on climate adaptation were
334 conducted and what it included (e.g. municipal experiences); their assessment of the resource needs

335 and barriers in today's climate adaptation policies; and possible future improvements in municipal
336 climate change adaptation.

337 The third step of the study was a follow-up dialogue seminar on climate adaptation with all 14
338 municipalities (including Tjøme and Sandefjord which did not partake in the interviews). The
339 municipalities were invited to the seminar by the County Governor. Prior to the seminar the
340 participants received a copy of the final report containing results from the interviews and feedback
341 from the reference group. The researchers participated in the one-day seminar and recorded the
342 discussions and dialogues on adaptation challenges and possible solutions pertaining to Vestfold.
343 The findings below are based on data collected from the three-step-process.

344 The process ended with a reference group meeting summing-up the results and discussing the co-
345 production process. We shared our experiences and specifically discussed how the research aims
346 had been changed during the process. The researchers had initially planned to carry out a qualitative
347 field experiment by interviewing the dialogue seminar participants before and after the seminar to
348 assess changes in their perspectives on municipal adaptation policies as a result of the seminar
349 participation. However, through the seminar planning process, it became clear that the Country
350 Governor considered it more fruitful to get a thorough understanding of the adaptation work in the
351 municipalities and use this information as a background for designing the dialogue seminar. This
352 illustrates the need for a flexible attitude towards what needs to be done, how it will be done and the
353 outcome of a co-production process. We further discuss the experiences gained in the co-production
354 process in section six where we address the need for having an adaptive co-management strategy in
355 climate adaptation.

356 ## 5. Findings

357 In this section, we present the empirical findings of how the local context matters for adaptation to
358 climate change and analyse the limits to adaptation created by broad and generic national guidelines
359 that lack contextual management strategies. Our study shows that local context matters with respect

360 to: i) Hazards and exposure-sensitivities, ii) Adaptive capacity in terms of human and economic
361 resources, iii) Adaptive capacity in terms of network and knowledge access and transfer, and iv)
362 Adaptive capacity in terms of co-benefits, focus and linkages to other municipal tasks. Table 3
363 summarizes the findings along these four dimensions and is found at the end of this section.

364 ***5.1 Hazards and exposure-sensitivities***

365 The case municipalities can be roughly divided into inland and coastal with respect to
366 physiographic characteristics and location. The physical location affects the nature of the natural
367 hazards and the risks to which the municipalities may or may not be exposed. Along the coast,
368 storm surge is an obvious hazard when combined with sea level rise and increased extreme weather
369 events, while inland, flood risks are related to rivers and waterways. Quick clay is an overall
370 physiographic characteristic both inland and at the coast. However, some of the municipalities, such
371 as Re and Hof are exposed, but not sensitive to hazards from quick clay because houses, buildings
372 and infrastructure are not located in areas with such risks, and they are neither exposed nor sensitive
373 to flood risks. In response to our questions about challenges related to weather and climate change,
374 the municipal officials in Re asked us to look out the window and see for ourselves: The main part
375 of the built area is on small hills situated above an agriculture landscape. A small stream runs
376 through the municipality, and in the event of extreme precipitation there is a small chance that there
377 will be *"some extra water on the agricultural land…"*. The case of Re municipality also provides a
378 good illustration of how current management practices unfold. Re municipality does not prioritize
379 climate adaptation and vulnerability assessments likely because of the perception of low exposure-
380 sensitive. However, they call for more dialogue with the County Governor in order to better define
381 their priorities given few available resources. But when the County Governor representatives are
382 visiting to control and guide the municipal activities they cannot answer questions about how to
383 prioritize between tasks that are mandatory (e.g. care for elderly and schooling) and climate change
384 adaptation needs and vulnerability assessments. The County Governor's office is not yet ready to

385 take the responsibility for prioritizing municipal goals, and indicate that they are not prepared to
386 give specific advice on how Re should handle climate change issues. This is because the Country
387 Governor is afraid, in retrospect, of being accused of giving wrong advice to the municipalities.
388 They also argue that they would not like to interfere with the municipalities' decisions and
389 judgements which they after all are entitled to make (see section 2).

390 Similarly, Hof municipality has experienced few worrying climate related incidents: *"we have*
391 *many small creeks and many dirt roads, but this does not cause any problems for us".* The two
392 municipalities do not perceive themselves as vulnerable to climate change.

393 Another exposure-sensitivity shared among most of the municipalities is under-dimensioned pipes
394 for draining surface water. While some municipalities such as Nøtterøy has adapted by finding
395 technical solutions to get rid of the surface water, others are still in need of upgrading the system. A
396 particular sensitivity in Lardal is the large number of outdated private water works and wells, which
397 under extreme precipitation are exposed to drainage of surface water with the risk of contamination.

398 Hazards associated with quick clay are currently related to existing housing and buildings
399 constructed on land that may be threatened by landslides. Risk of landslides will be exacerbated
400 with the projected increased precipitation. Some of the municipalities (Sande and Lardal), lack
401 maps outlining the sub-surface soil and geological conditions prone to landslides which implies lack
402 of relevant information to assess such conditions, and an uncertain exposure and sensitivity. Larvik
403 and Tønsberg are exposed and sensitive to flooding, because major industry and housing are
404 constructed along main waterways that flood during periods of heavy snow-melt and extreme
405 precipitation. With the projected precipitation increase this exposure-sensitivities will highly likely
406 require adaptive measures. Other smaller municipalities, such as Andebu, have constructed buffer
407 zones and protection of river banks against slipping, to protect against current levels of flooding in
408 smaller waterways. It is uncertain whether these measures will be sufficient to meet projected

409 increased water levels. Coastal municipalities (Nøtterøy, Svelvik, Horten and Holmestrand) have
410 identified storm surge as a current hazard to which they are exposed and sensitive. Increased storm
411 surge and extreme weather events combined with the effects of projected sea level rise
412 (approximately 40 cm by 2100,Norwegian Metrological Institute 2009) will increase these
413 challenges significantly. Hence, physiographic challenges as identified across the municipalities
414 range from none to high exposure-sensitivity to weather and climate change.

415 ***5.2 Adaptive Capacity: Human and economic resources***

416 A general feature of our case studies is that the smaller municipalities (population size) of our
417 sample (Re, Hof, Lardal, Andebu, Svelvik) have dedicated few human and economic resources to
418 deal with climate adaptation and civil protection (see Table 1 above). As stated by the interviewee
419 from Svelvik: "*It is a challenge to have sufficient human resources and expertise in all areas. We*
420 *are few and we don't always have enough time to evaluate and consider everything. We don't have*
421 *enough money and resources are limited*." Interestingly the tasks associated with climate adaptation
422 are assigned to people who are fully occupied with other tasks that are more pressing or mandatory
423 (education, care for elderly and health) (see also Dannevig et al. 2013). Tasks associated with
424 adaptation and civil protection against weather related events and hazards are closely linked to
425 spatial planning but are not necessarily subsumed under such activities in the smaller municipalities.
426 The larger municipalities (Larvik, Tønsberg, Horten, Nøtterøy) have earmarked economic resources
427 for dedicated positions to work with climate adaptation and civil protection. The medium-size
428 municipalities (Holmestrand and Sande) vary in the way they dedicate resources. In Holmestrand
429 the work on civil protection is allocated to a person who is already responsible for a number of
430 other tasks, while Sande has allocated some human resources to specifically deal with climate
431 adaptation.

The findings show a variation in the degree of coordination between sectors, independent of municipal size. Two types of coordination of climate adaptation emerge; between civil protection and spatial planning, and between the different sectors and spatial planning. Tønsberg coordinates well by including climate change when coordinating across the different municipal sectors with civil protection and planning. While Horten coordinates the work on adaptation and civil protection across sectors such as health and crisis administration, climate change is neither included in spatial planning nor between spatial planning and other sectors. Hence, these municipalities vary in the degree to which they dedicate resources to climate change adaptation, and in whether and how they coordinate with other sectors.

5.3 Adaptive Capacity: Networks, knowledge and transfer

As shown in Table 1, the municipalities vary in network participation and in how much they coordinate their planning efforts. All the case municipalities are involved in the countywide Preparedness Forum and the Spatial Planning Network for Vestfold. Most of the municipalities are involved in 12K (see section 4). Three of the municipalities (Re, Hof and Holmestrand) have a common municipal plan which includes the spatial plan, but have to date not included climate adaptation in their work. Sande and Svelvik collaborate on developing their RVA. The remaining municipalities (Tønsberg, Larvik, Lardal, Andebu, Stokke, Horten, Nøtterøy) have done little to coordinate their efforts.

The municipalities also vary with respect to knowledge access. In our study two aspects warrant attention: i) the municipalities do not have access to relevant knowledge due to a limited network and a lack of expertise on how to locate the knowledge, and ii) locally relevant knowledge about quick clay slides and flooding has not yet been developed by state level agencies (NVE) because such events are not life-threatening in these municipalities. The authorities prioritize the development of quick clay and flood maps where health and lives are threatened. For NVE to develop such maps, major mapping exercises are needed.

457 Lardal is a good example of both aspects; they lack the network needed for gathering information
458 and they lack the necessary maps on quick clay and flooding needed in their planning activities.
459 Tønsberg has a sufficient network and know where information can be found, but the maps they
460 need for planning purposes are not available. Some of the municipalities have clear ideas on the
461 kind of knowledge that is needed to support local climate adaptation. Some also have the capacity
462 to articulate how this knowledge should be tailored to the local context but this input is not taken
463 into account by national authorities. Nonetheless, most of the municipalities in Vestfold do not have
464 sufficient expertise to know what kind of information is needed to further develop adaptation
465 strategies.

466 ***5.4 Adaptive Capacity: Co-benefits, and linkages to other municipal tasks***

467 Andebu is one municipality that explicitly makes the link between public health and climate
468 change, partially because of one engaged municipal planner. This planner has expertise in public
469 health and is also responsible for planning in the municipality. She has been heavily involved in the
470 development of the climate and energy plan in which adaptation is included. Her engagement in
471 both issues has influenced her linking climate change adaptation in Andebu to public health. In
472 Larvik engaged officials integrate both climate mitigation and adaptation in one and the same
473 climate and energy plan. Such plans usually focus solely on climate mitigation. Horten is highly
474 engaged in civil protection and acknowledges that climate adaptation has become an important
475 aspect of such protection. Horten expressed a need for including climate adaptation in their plans
476 because of the co-benefits in linking civil protection and climate adaptation. The officials argue that
477 this will strengthen their image as a municipality well prepared for disaster.

478 Table 3 below summarizes the results.

479 (Insert Table 3).

6. The call for adaptive co-management

Climate change impacts unfold locally and how it is dealt with in municipalities depend on the local municipal context. Below we discuss the implications of our findings for the governance of climate change adaptation at the local level, and if and how adaptive co-management may improve climate change adaptation in the municipalities.

Table 3 shows that there is great variation between the twelve case municipalities with respect to physiographic challenges, available resources, networks, needs, knowledge and focus areas, illustrating that they experience different exposure-sensitivities which in turn result in different adaptation needs. A comparison shows that the municipalities differ in the extent to which they have resources to mobilize for adaptation to climate change. They also differ in expertise and capacity to both utilize and meet national guidelines and requirements. The national adaptation guidelines and requirements are general and overarching and local concerns and needs are not the main target. The guidelines and requirements are in turn interpreted in each municipal context, which may lead to differing ways of operationalization. The outcome may be either too little or too much adaptation. With too little adaptation, municipalities may respond or adjust to national guidelines inadequately due to lack of resources and relevant knowledge. They may not prepare for future climate adaptation in a proactive manner but instead adapt reactively which is likely to leave them more vulnerable (this may be the case for Holmestrand and Svelvik in the future). Too much adaptation, pertains to national adaptation guidelines and requirements demanding engagement in adaptation issues even when few exposure-sensitivities are identified in the municipality (to be expected for Re and Hof). Therefore, general national guidelines lacking contextual management strategies may result in both too much or too little engagement in adaptation. A changing climate will create new challenges for local communities and local governments. Climate change uncertainties and reactive adaptation practices together make a strong motivation for an alternative approach to governance that is flexible and adequate to address future climate risks and hazards.

505 The variation across local contexts demands an adaptation policy that addresses the particular needs
506 of a municipality and provide locally relevant advice. This approach may even out the high
507 variability between the municipalities along the four local context dimensions mentioned above
508 (physiographic/physical challenges; human and economic resources; networks, knowledge, transfer,
509 co-benefits, focus and linkages, see Table 3). Adjusting adaption policies to the local contexts is
510 beneficial in a broader national or regional context in that it ensures a better fit across the municipal
511 borders – independent of size and resources. A governance practice that is based on dialogue
512 between the levels of government where the different characteristics of the municipalities and the
513 local knowledge base is taken into account provides opportunity to adjust adaptation policies to the
514 local context, rather than assuming that every municipality should be treated equally.

515 In Norway the multi-level governance structure gives clear responsibilities to the different levels of
516 governments (see section 2), and is akin to a top-down approach. The County Governor is a
517 centralized bureaucracy (Gunderson and Holling 2002, Berkes et al. 2003) that oversees and
518 provides general guidelines not specifically addressing the local context. This is illustrated with the
519 case of Re referred to in section 5 in which the County Governor avoids giving locally relevant.

520 An adaptive co-management process, including different levels of government, increases the
521 likelihood of better coordination of local, regional and national resources allocated to adaptation
522 efforts. Many case municipalities (Svelvik, Tønsberg, Larvik, Re, Sande) ask for better coordination
523 across municipalities facing similar adaptation challenges and/ or municipal structures. They note
524 that this would increase cross-municipal learning experiences, expand adaptation networks, and
525 possibly coordinate cross-border resources. These coordination initiatives, they suggest, could be
526 facilitated through national and regional governments (County Governor). Our case study shows
527 that the County Governor is interested in assuming such a role and wish to be more engaged as a
528 facilitator. This is illustrated by the active role of the Governor in the dialogue seminar.

529 Coordination across municipalities offers a way to even out the municipal differences resulting
530 from size and resources and to address common adaptation challenges.

531 An adaptive co-management process entails a greater facilitation of cross-sectoral and cross-
532 institutional linkages, which ensures better use and release of more resources. Through such
533 processes, more relevant and accurate assessments of local risks and impacts, both current and
534 future, will likely be developed. Through adaptive co-management processes different types of
535 knowledge are brought together to make strategies and plans for climate change adaptation. In this
536 study the transdisciplinary process brought together different types of knowledge (researchers and
537 practitioners) with the purpose of planning the dialogue seminar on adaptation (see section 4) . The
538 planning brought together multiple sources of expertise which resulted in new knowledge and an
539 increased understanding of the different perspectives. Through the interviews with the
540 municipalities (with questions developed in collaboration between researchers and practitioners),
541 the importance of allowing for variations in climate adaptation work at the municipal level became
542 clear. Conversely, it became evident that including the local context in multi-level government
543 practices comes with its own challenges both through the assigned role of the County Governor and
544 through the independence of municipalities to design their own policies. The process allowed for
545 learning, both cognitive and relational, through the results from the interviews and from different
546 perspectives (see also Baird et al. 2014). Finally, the transdisciplinary approach of this paper also
547 illustrates another key point for adaptive co-management processes; the design of the dialogue
548 seminar facilitated the emergence of new knowledge needs. The County Governor first pictured this
549 seminar to entail standard presentations of adaptation issues with time for questions from the
550 participants. Through the transdisciplinary process it became clear that it would be much more
551 beneficial to design the dialogue seminar with the municipalities as a process with group work and
552 presentations. This revealed a need for more local level expertise on climate risks in order for the
553 municipalities to ask informed questions and demand more clearly what was needed to improve

554 work on climate adaptation. Hence, an adaptive co-management process might also entail a greater
555 possibility of identifying knowledge needs that are not covered in the current data base and an
556 opportunity of addressing those needs in further developments.

557 Nearly all (9) our interviewees (Holmestrand, Re, Tønsberg, Lardal, Horten, Nøtterøy, Larvik,
558 Andebu, Sande) note that the resources allocated by the state for advice and provide necessary
559 assessments of risks are too scarce to cover local knowledge needs. Detailed mapping of risk areas
560 in a municipality is only required when there is a risk of loss of lives and health. However, several
561 of the municipalities, ask for a more detailed mapping of risk areas for quick clay and flooding to
562 increase their knowledge about the hazards when planning new housing, infrastructure or business
563 even if these areas are not categorized as at risk for loss of lives and health (see Kirchhoff and
564 Dilling, 2016). This is exemplified in the following quote: *"It was said that the NVE would provide*
565 *more knowledge about the danger from quick clay, but that has not been done. We miss more and*
566 *specific knowledge from national actors"* (Lardal municipality).

567 As discussed earlier, adaptive co-management processes can be organized in different ways
568 (Armitage et al. 2011), but they all include systematic use of networks, working groups and other
569 arenas for regular dialogues, discussions and knowledge exchange between different levels of
570 government. They also include clear targets for these processes and an understanding of the long-
571 term horizon needed to build the necessary institutional arrangements that support knowledge
572 exchange and decision making processes for prioritizing measures at the local level. This clearly
573 requires financial and human resources allocated from both the state and municipal levels in our
574 case study. For some municipalities resources and funding are important but equally so is advice on
575 how to make the right priorities. Some municipalities are economically constrained and must
576 prioritize tasks required by law, and do not necessarily have the resources to prioritize climate
577 adaptation. Furthermore, some municipalities note that climate adaptation is too serious to be

578 handled solely by them. These are interrelated and not mutually exclusive perspectives which call
579 for better prioritization and involvement by the national level, and dedicated economic resources.
580 With respect to adaptive co-management processes this calls for the national government to open up
581 for a more dialogue oriented governance practice across national, regional and local levels. Existing
582 collaborative networks among the municipalities could be expanded and could also include the
583 County Governor and relevant Directorates, as exemplified by the dialogue seminar.

584 Research points to the need for a multi-level governance practice to cope with climate change
585 adaptation (e.g. Tompkins and Adger 2005, Amundsen et al. 2010), and that there is a need to move
586 towards a framework of multilevel governance and new network spheres for addressing
587 environmental issues like climate change. We expand on this notion by arguing that the multi-level
588 governance framework for adaptation policies need to be adaptive and based on co-management.
589 An adaptive practice asserts that policies can be changed according to the challenges faced by
590 climate change and a co-management practice allows for knowledge, resources, and networks to be
591 better adapted to the particular localized exposure-sensitivities and risks. This is highly likely to
592 result in more efficient and pro-active adaptation processes and practices at the local level.

593 ## 7. Summary of findings and conclusions

594 This paper addresses how the local context matters for developing climate adaptation policies
595 relevant and applicable to future challenges. Municipalities vary with respect to physiography,
596 human and economic resources, networks that they participate in, knowledge they possess, how this
597 knowledge is transferred between different government levels and sectors, how and if they link
598 climate adaptation to other municipal tasks, and finally they vary with respect to the barriers to
599 adaptation. Climate change requires a pro-active adaptation policy that is capable of adjusting to
600 changes in multiple conditions. Currently, the Norwegian state level governance structure and
601 practice is organized to provide general requirements and guidance on climate adaptation, leaving
602 the decision on which measures to choose and how to implement them to the municipalities. The

603 main task for the state is to oversee and supervise municipalities to ensure that the general national
604 requirements are fulfilled. This effectively reduces the potentials for contextualized advice and a
605 dialogue-oriented approach that in turn create necessary flexibility both in scope and time. Our
606 results show that current national policy is too general to be applicable for municipalities and to
607 address risks resulting from future climate change. This study shows that the case municipalities
608 require locally adapted information and knowledge and tailored advice from the national authorities
609 in order to adapt. Experiences from other policy areas provide relevant guidance for how this can be
610 done. Adaptive co-management processes need time to develop and find its right format (cf.
611 Armitage et al. (2011), and the process can be facilitated through diverse modes of communication,
612 deliberation and social interactions (e.g. meeting, workshops, study tours and visits). Further, a key
613 feature of adaptive co-management is the testing of policies in practice. The aim is to continuously
614 learn from the experiences and adapt policies accordingly (Lynch and Brunner 2010). These
615 experiences can also be used to inform other communities about the results. As Lynch and Brunner
616 (2010) point out, the collection of different contexts and experiences might create creative policy
617 alternatives that are significant clues for adapting to a changing climate.

618 We argue that adaptive co-management between national, regional, and local levels represent a
619 useful way to address many of the limitations and challenges concerning climate change adaptation
620 at the municipal level. Adaptive co-management allows for flexible responses to diversified local
621 contexts and with respect to changing future conditions. A dialogue-oriented process between
622 different levels of government is needed to ensure this flexibility (e.g. Berkes and Armitage 2010).
623 This may also entail a greater utilization of different types of knowledge, including local and
624 scientific knowledge that may contribute their knowledge to develop a pro-active and locally
625 adjusted climate adaptation. Furthermore, the knowledge held by municipal officials must be
626 recognized and acknowledged as a resource for enriching national advice given to municipalities, or
627 even to become a co-produced advice. Our results show that this may require a change in how the

628 tasks of the different government levels are perceived, expressed and handled. Adaptive co-
629 management requires a flexible and contextualized governance practice in which municipal officials
630 take an active role as partners, which is in contrast to today's more top-down oriented management
631 practices. This shows that the multi-level governance called for to address climate change
632 adaptation at the local level (Amundsen et al. 2010) needs to be expanded to allow for adaptability
633 and co-management. It furthermore requires that the role of the Norwegian County Governors is
634 discussed and revised to include contextualized advise and co-production of adaptation policies.
635 The way this role is interpreted and practiced today suggest that the County Governors are not
636 prepared to take on this responsibility.

637 Conversely, there are limits to adaptive co-management processes that should be acknowledged.
638 First, a higher degree of contextualized policy practice would likely require more resources to
639 addressing current and future climate change adaptation, which demands an increased focus and
640 willingness from both state and municipal levels for long-term allocation of such resources. Second,
641 an awareness of the risks of unequal power relations between different actors in an adaptive co-
642 management process is needed (Watson 2013). In our case, the County Governor oversees and
643 controls that the municipalities comply with national requirements, indicating that there will be
644 unequal power in an adaptive co-management process. However, Norwegian municipalities are
645 entitled to make autonomous decisions and expect their voices to be heard. This might reduce the
646 risks of uneven power relations.

647 Lastly, from a fuzzy decision-making context, which include the pronounced uncertainty level in
648 climate change, flexible policies are both required and preferred. Adaptive co-management is a
649 possible way to achieve such flexibility in both policy and practice, with multilevel governance and
650 different forms of knowledge.

Acknowledgements

We wish to thank Christian Bjørnæs, communication director at CICERO – Centre for International Climate and Environmental Research – Oslo, for facilitating the process with the County Governor of Vestfold and contributing with his skills to the interviews with the municipalities in Vestfold. Funding from the Research Council of Norway, grant number 207622 is gratefully acknowledged.

8. References

Adger W. N., and P. M. Kelly, 1999: Social vulnerability to climate change and the architecture of entitlements. *Mitigation and Adaptation Strategies for Global Change*, 4, 253–266.

Amundsen H, F. Berglund, and H. Westskog, 2010: Overcoming barriers to climate change adaptation – a question of multilevel governance? *Environment and Planning C: Government and Policy*, 28, 276 – 289.

Armitage D., F. Berkes, and N. Doubleday, 2007: *Adaptive Co-Management: Collaboration, Learning, and Multi-level Governance,* University of British Columbia Press, Vancouver.

Armitage, D., R. Plummer, F. Berkes, R.I. Arthur, A.T. Charles, I.J. Davidson-Hunt, A.P. Diduck, N.C. Doubleday, D.S. Johnson, M. Marschke, P. McConney, E.W. Pinkerton, and E. Wollenberg (2009): Adaptive co-management for social-ecological complexity. *Front Ecol Environ*, **7**(2), 95–102.

Armitage D., F. Berkes, A. Dale, E. Kocho-Schellenberg and E. Patton, 2011: Co-management and the co-production of knowledge: Learning to adapt in Canada's Arctic. *Global Environmental Change,* **21**, 995–1004.

Baird J., R. Plummer, C. Haug, and D. Huitema, 2014: Learning effects of interactive decision-making processes for climate change adaptation. *Global Environmental Change*, 27 (5), 1-63.

Berkes F, J. Colding, and C. Folke 2003: *Navigating Social-Ecological Systems, Building Resilience for Complexity and Change*, Cambridge University Press, Cambridge

Berkes F., and D. Armitage, 2010: Co-management institutions, knowledge, and learning: Adapting to change in the Arctic. *Études/Inuit/Studies*, 34, 109-13.

677 Bown N., T. Gray, and S.M. Stead, 2013: *Contested forms of governance in marine protected*
678 *areas: A study of co-management and adaptive co-management*, Routledge
679 Bulkeley H., 2005: Reconfiguring environmental governance: Towards a politics of scales and
680 networks. *Political Geography*, 24, 875–902.
681 Bulkeley H., and M.M. Betsill, 2005: Rethinking sustainable cities: Multilevel governance and the
682 "urban" politics of climate change. *Environmental Politics*, 14, 42-63.
683 Dannevig H., T. Rauken, and G.K. Hovelsrud, 2012: Implementation of adaptation at the local
684 level. *Local Environment Special Issues* 17, 597 - 612.
685 Dannevig H., G.K. Hovelsrud, and I.A. Husabø, 2013: Driving the agenda for climate change
686 adaptation in Norwegian Municipalities. *Environment and Planning C: Government and Policy*,
687 31, 490-505.
688 Dessai S., and M. Hulme, 2004: Does climate adaptation policy need probabilities? *Climate Policy*
689 **4,** 107–128.
690 Elzinga A., 2008: Participation. *Handbook of Transdisciplinary Research*, G.H. Hadorn, H.
691 Hoffmann-Riem, S. Biber-Klemm, W. Grossenbacher-Mansuy, D. Joye, C. Pohl, U. Wiesmann,
692 and E. Zemp, Eds., Springer Science, 345-360.
693 Fidel M., A. Kliskey, L. Alessa, and O. O. P. Sutton, 2014: Walrus harvest locations reflect
694 adaptation: a contribution from a community-based observation network in the Bering Sea. *Polar*
695 *Geography*, 37. 48-68.
696 Fitchett A. 2014: Adaptive Co-management in the Context of Informal Settlements. *Urban Forum*,
697 25, 355-374.
698 Fankhauser, S., J. B. Smith, and R.S.J. Tol, 1999: Weathering climate change: some simple rules to
699 guide adaptation decisions. *Ecological Economics*, 30(1), 67–78. doi:10.1016/S0921-
700 8009(98)00117-7

701 Gunderson L. H., and C. S. Holling, 2002: *Panarchy: Understanding Transformations in Human*
702 *and Natural Systems*, Island Press, Washington D.C.
703 Gustavsson, E., I. Elander, and M. Lundmark, 2009: Multilevel governance, networking cities, and
704 the geography of climate-change mitigation: two Swedish examples. *Environment and Planning*
705 *C: Government and Policy*, 27.1 , 59-74.
706 Heiberg E. 2012: Ansvarsfordeling mellom kommune og stat i arbeidet med klimatilpasning.
707 Vestlandsforskingsnotat nr. 3/2012. Accessed 31 May 2016. [Available at:
708 http://www.vestforsk.no/filearchive/vf-notat-3-2012-ks-ansvarsfordeling.pdf]
709 Hovelsrud G. K, and B. Smit, Eds., 2010: *Community Adaptation and Vulnerability in the Arctic*
710 *Regions*, Dordrecht, Springer Publishers.
711 Hovelsrud, G. K. Jeremy L. White, M. Andrachuk and B. Smit. 2010. Community adaptation and
712 vulnerability integrated In: *Community Adaptation and Vulnerability in the Arctic Regions*.
713 Editors G.K. Hovelsrud and B. Smit, Dordrecht, Springer Publishers.
714 Hovelsrud G. K., B. O. Poppel, and J. D. Reist, 2011: Arctic Societies, Cultures, and Peoples in a
715 Changing Cryosphere. *AMBIO*, 40, 100-110.
716 IPCC, 2013: *Climate Change 2013: The Physical Science Basis*. Fifth Assessment Report of the
717 Intergovernmental Panel on Climate Change.
718 IPCC, 2007: IPCC Fourth Assessment Report, Working Group II: Summary for policymakers. New
719 York: Intergovernmental Panel on Climate Change.
720 Keskitalo E. C. H., H Dannevig, G. K. Hovelsrud, J. J. West, and Å. G. Swartling, 2010: Local
721 vulnerability and adaptive capacity in developed states: examples from the Nordic countries and
722 Russia. *Regional Environmental Change* 11(3): 579-592.
723 Kirchhoff C. J., and L. Dilling (2016): The role of U.S. states in facilitating effective water
724 governance under stress and change. *Water Resources Research* 52 (4), 2951–2964, DOI:
725 10.1002/2015WR018431

726 Kvalvik I, S. Dalmannsdottir, H. Dannevig, G. Hovelsrud, L. Rønning, and E. Uleberg, 2011:
727 Climate change vulnerability and adaptive capacity in the agricultural sector in Northern
728 Norway. *Acta Agricultura Scandinavica Section B – Soil and Plant Science* Supplement, 61, 27-
729 37.
730 Lempert R., N. Nakicenovic, D. Sarewitz, and M. Schlesinger, 2004: Characterizing climate-change
731 uncertainties for decision makers. *Climatic Change*, 65, 1-9 .
732 Lovdata, 2016a: Lov om kommunal beredskapsplikt, sivile beskyttelsestiltak og Sivilforsvaret
733 (sivilbeskyttelsesloven). Accessed 31 May 2016. [Available at
734 https://lovdata.no/dokument/NL/lov/2010-06-25-45]
735 Lovdata, 2016b: Lov om sikring mot og erstatning for naturskader (naturskadeloven). Accessed 31
736 May 2016. [Available at https://lovdata.no/dokument/NL/lov/1994-03-25-
737 7?q=Naturskadeloven]
738 Lynch, A. H., and R. D. Brunner, 2010: Learning from climate variability: adaptive governance
739 and the Pacific ENSO applications center. *Weather, Climate, and Society* 2(4), 311-319.
740 Moser, S. C., and J. A. Ekstrom, 2010: A framework to diagnose barriers to climate change
741 adaptation. *Proceedings of the National Academy of Sciences*, 107(51), 22026-22031.
742 NOU, 2010: Tilpassing til eit klima i endring. Noregs offentlege utgreiingar 2010: 10.
743 Olsson, P, C. Folke, and F. Berkes, 2004: Adaptive co-management for building resilience in
744 socio-ecological systems. *Environmental Management*, 34, 75–90.
745 Plummer R., and J. Baird, 2013: Adaptive co-management for climate change adaptation:
746 Considerations for the Barents region. *Sustainability*, 5, 629-642.
747 Pohl C., 2011: What is progress in transdisciplinary research? *Futures*, 43, 618-626.
748 Preston BL, Mustelin J, and M.C. Maloney, 2013: Climate adaptation heuristics and the
749 science/policy divide. *Mitigation and Adaptation Strategies for Global Change*, 20(3), 467-497,
750 doi:10.1007/s11027-013-9503-x

751 Schneider S. H., and K. Kuntz-Duriseti, 2002: Uncertainty and Climate Change Policy. *Climate*
752 *Change Policy: A Survey*, S. H. Schneider, A. Rosencranz, and J. O. Niles, Eds., Washington
753 D.C., Island Press, 53-87.
754 Sellers J M, and A. Lidström, 2007: Decentralization, Local Government, and the Welfare State.
755 *Governance: an International Journal of Policy, Administration and Institutions* 20(4), 609–632.
756 Smit B., G. K. Hovelsrud, J. Wandel, and M. Andrachuk, 2010: Introduction to the CAVIAR
757 Project and Framework. *Community Adaptation and Vulnerability in the Arctic Regions*, G.K.
758 Hovelsrud, and B. Smit, Eds, Dordrecht, Springer Publishers.
759 Smit B., and O. Pilifosova, 2001: Adaptation to climate change in the context of sustainable
760 development and equity. *Climate change 2001: Impacts, adaptation, and vulnerability –*
761 *contribution of working group II to the third assessment report of the intergovernmental panel*
762 *on climate change*, Cambridge, UK: Cambridge University Press, 879-912.
763 Tompkins E. L., and W. N. Adger, 2005: Defining response capacity to enhance climate
764 change policy. *Environmental Science and Policy*, 8, 562–71.
765 Turner, B., R. E. Kasperson, P. Matson, J. McCarthy, R. Corell, L. Christensen, N. Eckley, J. X.
766 Kasperson, A. Luers, M. Martello, C. Polsky, A. Pulsipher, and A. Schiller, 2003a: A framework
767 for vulnerability analysis in sustainability science. *Proceedings of the National Academy of*
768 *Sciences*, 100, 8074–8079.
769 Turner B., P. A. Matson, J. J. McCarthy, R. W. Corell, L. Christensen, N. Eckley, G. K. Hovelsrud-
770 Broda, J. X. Kasperson, R. E. Kasperson, A. Luers, M. L. Martello, S. Mathiesen, R. Naylor, C.
771 Polsky, A. Pulsipher, A. Schiller, H. Selin, and N. Tyler, 2003: Illustrating the coupled human-
772 environment system for vulnerability analysis: Three case studies. *Proceedings of the National*
773 *Academy of Sciences*, 100, 8080-8085.

774 Tørnblad S., H. Westskog, and L. E. Rose, 2013: Does location matter? Public acceptance of
775 restrictive policy measures at the local level. *Journal of Environmental Policy & Planning*, 16,
776 37-54.
777 Vestfold Fylkeskommune, 2016: Om Vestfold. Accessed 31 May 2016. [Available at:
778 https://www.vfk.no/Om-Vestfold/]
779 Watson A., 2013: Misunderstanding the "nature" of Co-Management: A geography of regulatory
780 science and indigenous knowledges (IK). *Environmental Management*, 52, 1085-1102.
781 West J., and G.K. Hovelsrud, 2010: Cross-scale adaptation challenges in the coastal fisheries:
782 findings from Lebesby, Northern Norway. *Arctic*, 63, 338-354.

783 Missing ref: Ford and Smit (2004) s 12.Grete.

784

785

Table 1: Central characteristics of the case municipalities' work with climate change adaptation

Case municipality (inhabitants Jan. 2013)	Organization of climate change adaptation activities	Resources allocated to climate change adaptation activities	Networks that the municipality participates in
Re (8,994)	Division for health, social, technical and business issues	Few resources allocated	12K. Vestfold Preparedness Forum, Vestfold Spatial Planning Network. Collaborates with Hof and Holmestrand in developing a joint municipal plan
Hof (3,060)	Division for technical, cultural, development and business issues	Few resources allocated	12K. Vestfold Preparedness Forum, Vestfold Spatial Planning Network. Collaborates with Re and Holmestrand in developing a joint municipal plan.
Lardal (2,435)	Division for environment, technical and business issues	Few resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network.
Tønsberg (41,239)	Division for municipal development	More resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network.
Larvik (43,132)	Division for spatial planning and technical issues	More resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network.
Andebu (5,546)	Division for technical, agricultural and business issues	Some resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network.
Holmestrand (10,350)	Organized in two divisions. Preparedness: Division for technical issues. Adaptation: Division for planning and building issues	Few resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network. Collaborates with Re and Hof in developing a joint municipal plan.
Horten (26,595)	A separate section for preparedness. Adaptation in the division for culture, society, environment and business	More resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network.
Svelvik (6,570)	Organized in two divisions. Preparedness: Division for technical issues. Adaption: Division for culture and development	Few resources allocated	D5, Vestfold Preparedness Forum, Vestfold Spatial Planning Network. Coordinates the risk and vulnerability analysis with Sande
Nøtterøy (21,100)	Division for technical issues	Some resources allocated	12K, Vestfold Preparedness Forum, VestfoldSpatial Planning Network.
Stokke (11,398)	Division for spatial planning and environment	Few resources allocated	12K, Vestfold Preparedness Forum, Vestfold Spatial Planning Network.
Sande (8,835)	Division for technical issues	Some resources allocated	D5, Vestfold Preparedness Forum, Vestfold Spatial Planning Network. Coordinates the risk and vulnerability analysis with Svelvik

Table 2: Number of persons interviewed in the case municipalities.

Municipality	Number of persons interviewed
Larvik	3
Stokke	2
Nøtterøy	1
Tønsberg	3
Andebu	2
Lardal	3
Re	2
Hof	3
Holmestrand	4
Horten	1
Sande	1
Svelvik	1
County Governor in Vestfold	2
The Norwegian Directorate for Civil Protection	1
Total persons interviewed	29

Municipality – Population	**Hazards and exposure-sensitivities**	**Adaptive capacity: Human and economic resources**	**Adaptive capacity: Networks, knowledge and transfer (networks – see table 1)**	**Adaptive capacity: Co-benefits, and linkages to other municipal tasks**
Re	Low risk. No significant water ways/rivers and no significant threats of flooding. No housing constructed in quick clay areas. Pipes and drainage not sufficient to meet the occasional extreme precipitation.	Currently not a priority due to perceptions and experiences of low risk. Not enough human resources to work with adaptation and preparedness for future risks.	Few contacts at the state level. Express that they have a sufficient overview of the challenges.	None made.
Hof	Low risk. Some risks of drainage from agricultural fields into drinking water under extreme precipitation events.	Currently not a priority due to perceptions and experiences of low risk. Not enough human resources to work with adaptation and preparedness for future risks.	Few contacts at the state level. Express that they have a sufficient overview of the challenges.	None made.
Lardal	Moderate/Low risk. Quick clay areas which are susceptible to extreme precipitation. A proportionally large number of private waterworks, which are not secured against extreme precipitation events – health concerns. Significant river, but no significant threats of flooding.	The existing human resources are not coordinated. Economic resources lacking to produce proper maps of quick clay areas. Not enough human resources to work with adaptation and preparedness for future risks.	Aware of own knowledge gaps, but not successful in acquiring such knowledge. Miss more knowledge/information from state level actors, and coordination of data bases. Few contacts at the state level	None made.
Tønsberg	Moderate risk – quick clay in existing housing areas and flood risks.	Sufficient resources to handle civil protection and municipal planning. Good communication and coordination between different sectors, optimizing human and economic resources.	Good access to knowledge from state level actors. Miss more detailed and relevant flood maps from NVE.	None made.
Larvik	Moderate risk – quick clay in built areas. Risks of flooding and landslides along significant water way	Dedicated human resources in civil protection, and two involved in climate and energy planning. Have sufficient human resources, but express that they do not have sufficient time to cover all needs.	Notes the challenges of large inter-municipal networks. The municipalities have different needs and better coordination could be made. Have good access to knowledge from state level actors	Adaptation part of Climate and Energy Plan.
Andebu	Moderate/Low risk. Several smaller water ways and areas are secured by construction of buffer zones and protection of river banks against flooding. Possibly problems with quick clay in established residential areas (a couple of houses), but aware of risks when planning of residential areas.	Not enough human resources to handle all the tasks. Too many objectives in the existing plans – and lack of coordination among them. The plans are not always congruent. Proactive thinking in how to solve some adaptation problems.	Are active in developing formal networks (e.g. with Stokke) and see the value in sharing resources with other small municipalities. Few relevant contacts at the state level.	Adaptation is seen in relation to human health.
Holmestrand	Low risk. Occasional storm surge cause flooding in basements which may increase with sea level rise. Quick clay present but not in built areas.	Lack resources to prioritize the area. The person responsible for civil protection has	Few relevant contacts at the state level.	None made.

		this task in addition to already existing tasks that occupies 100% of the posistion.		
Horten	Low/Moderate risk. Presence of quick clay. Express a concern for risks in connection with increased precipitation and storm surge.	Engaged official as Chief Municipal Executive. Have prioritized economic resources to reducing risk and vulnerability.	Have relevant contacts at the state level. Express that the state level has not provided a sufficient overview of risks of quick clay.	Adaptation closely linked with civil protection.
Sande	Moderate risk. Quick clay in the center of the municipality and under existing houses which is under risk of slide.	Human resources available to address the risks from quick clay. A civil protection coordinator. Express that their cross-sectoral coordination is good.	Cooperates with neighboring municipalities. Have relevant contacts at the county and state level.	None made.
Svelvik	Low risk. Quick clay in relation to existing houses, small water ways which may swell with increased precipitation. Storm surge in combination with increased precipitation and under-dimensioned pipes.	Economic challenges which limits the possibilities for working with adaptation. Room for improvement of cross-sectoral communication.	Lack of coordination of data bases from the state level a problem – reduce access to knowledge. Cooperates with neighboring municipalities. Have few contacts at the state level.	None made.
Nøtterøy	Low risk. Presence of quick clay. A long coastline and storm surge will have consequences for spatial planning.	Express that they have sufficient and competent human resources. Have their own climate advisory board which includes the mayor.	Overarching knowledge and advice needed that can be adapted to the local context. Have relevant contacts at the state level.	None made.
Stokke	Low risk. Storm surge in combination with increased precipitation and under-dimensioned pipes. This might also have consequences for drinking water quality.	Not a prioritized area of policy. Also - lack resources to prioritize the area.	Few relevant contacts at the state level. Collaborates with Andebu.	None made

Table 3 – Municipalities: The four dimensions. (Low: low risk to humans, infrastructure and buildings.

Moderate: possible risk to humans and possible damage to infrastructure and buildings

High: Life threatening and high health risk – severe risk of damage to infrastructure and buildings).

Figure 1

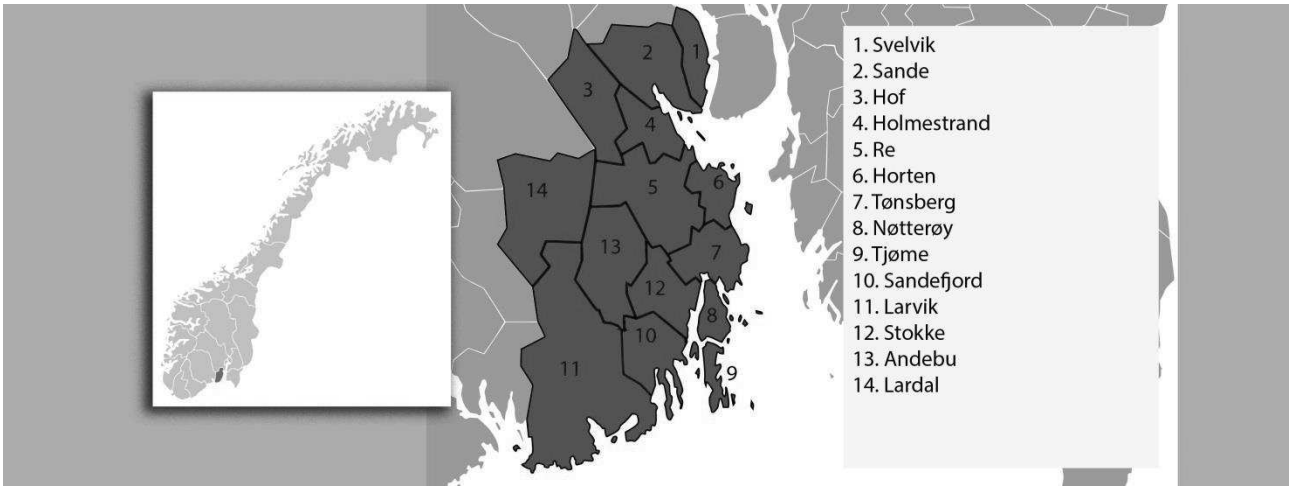

Figure 1: The county Vestfold (in red) in the southern part of Norway.