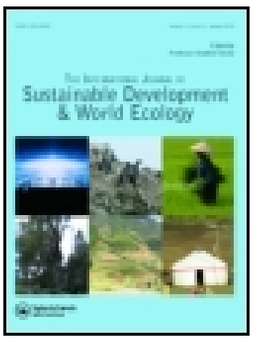

International Journal of Sustainable Development & World Ecology

ISSN: 1350-4509 (Print) 1745-2627 (Online) Journal homepage: https://www.tandfonline.com/loi/tsdw20

Climate change adaptation in Norway: learning–knowledge processes and the demand for transformative adaptation

G. I. Orderud & J. Naustdalslid

To cite this article: G. I. Orderud & J. Naustdalslid (2019): Climate change adaptation in Norway: learning–knowledge processes and the demand for transformative adaptation, International Journal of Sustainable Development & World Ecology, DOI: 10.1080/13504509.2019.1673500

To link to this article: https://doi.org/10.1080/13504509.2019.1673500

INTERNATIONAL JOURNAL OF SUSTAINABLE DEVELOPMENT & WORLD ECOLOGY
https://doi.org/10.1080/13504509.2019.1673500

Climate change adaptation in Norway: learning–knowledge processes and the demand for transformative adaptation

G. I. Orderud[a] and J. Naustdalslid[b]

[a]Norwegian Institute for Urban and Regional Research, Oslo Metropolitan University, Oslo, Norway; [b]Independent researcher, Naustdalslid Research, Ängelhom, Sweden

ABSTRACT

During the last decade, it has become evident that planet earth will be warming. Hence, there is an increasing focus on how to adapt to a changing climate. The adaptation literature underlines the importance played by local government in planning and implementing adaptation policies. This article is addressing learning–knowledge–action processes within and between local (municipal) and central (national and regional) government levels, thereby filling a gap in the literature. The analysis is using empirical data from Norway; a country commonly considered as having a well-developed multi-level governance system, with a strong bottom-up component, thereby apparently meeting a core condition for developing and implementing transformational changes. The study finds that single and double-loop learning are dominating, fostering incremental changes, but combined incremental changes related to technically handling surface water are approaching transitional change. As a first step, the study suggests it is necessary to formulate policies that explicitly combe incremental changes in order to achieve transitional and transformational change. Moreover, policies for fostering oppositional knowledge networks as part of vertical–horizontal governance may be necessary for pushing the system in the direction of transition and transformation.

ARTICLE HISTORY
Received 13 August 2019
Accepted 20 September 2019

KEYWORDS
Climate change; transformative adaptation; learning; knowledge; public sector; Norway

Introduction

From giving priority to mitigating emissions of greenhouse gases, the inevitability of global warming has during the last 10 to 15 years, compelled countries and governments to start addressing climate change adaptation. For Norway, from a situation characterised by municipal officers being confused about how to adapt to a changing climate (Vevatne and Westskog 2007), knowledge on adaptation has gradually been improving. Nevertheless, effective adaptation is still not on par with recognised challenges, especially when taking into account the emerging scholarly demand for transformative adaptation (e.g. Kates et al. 2012; O'Brien 2012; Huq et al. 2014). Furthermore, the importance of learning–knowledge processes as part of multi-level network governance has been underlined (e.g. Ison et al. 2007; Armitage et al. 2008. Pahl-Wostl 2009; Reed et al. 2010). Summarising recent research, Biesbrok et al. (2018, p. 786) found 'bureaucracies are currently seeking ways to navigate climate change adaptation, and that existing institutions and practices are being reconsidered', but, still, most studies show that administrative systems have undergone limited changes in relation to coping with climate-related issues. This aligns with Heikkinen et al. (2019) telling that mostly all adaptive actions are maintaining business-as-usual approaches and status quo conditions.

We are presenting a case study of how the public sector of Norway has addressed climate change adaptation, with a focus on the production and use of knowledge for facilitating necessary societal changes, thereby advancing our understanding of climate change adaptation within a multi-level governance system conventionally considered as having a strong bottom-up component. The positive role of multi-level governance in this respect is confirmed by Lappegard Hauge et al. (2018, p. 18) who found 'that multilevel networks can promote learning about climate change adaptation and even lead to behavioural change in the form of policy implementation.' Promoting the local level, Amundsen et al. 2018, p. 27) hold that 'local government as change agents has the potential to influence processes beyond local community which in turn may reduce systemic barriers', thereby facilitating radical transformation. On the other hand, Naustdalslid (2015), in a study on watershed management found a combination of horizontal and vertical network governance, with an active use of top-down science knowledge together with local bottom-up role models for legitimising broader local actions. Moreover, Hovik et al. (2015) revealed that municipal employees in the water sector had a better understanding of and were more engaged in concrete adaptation than what was the case among employees in the planning sector, indicating sectorial as well as

CONTACT G. I. Orderud geiro@oslomet.no

disciplinary differences in bureaucratic practice. Adding to this, and aligning with other research (e.g. Armitage et al. 2008; Pahl-Wostl et al. 2013), a study of the water sector in Norway revealed that interaction between different types of learning may be necessary for successful outcomes of adaptation actions (Orderud and Winsvold 2012).

Recent research in Norway, therefore, reveals a gap in the understanding of how different levels of the public sector interact, and which role they play for possibly achieving transformational changes. There is also a gap in the understanding of how learning–knowledge processes spell out within the frames of multi-level (network) governance. The overall aim for this article is therefore to improve our understanding of mechanisms and dynamics of the interaction relating to climate change adaptation within the Norwegian governance system – both vertically, between central and local government; and horizontally, across sectors and municipalities. We will examine the content of the knowledge transmitted within this network, seeing it as a learning-knowledge network, and assessing its potential for promoting a more transformational approach for adapting to climate change. This lead to two main research questions:

- How can the organisation of learning–knowledge networks for designing and implementing climate change adaptation in the Norwegian governance system be described?
- How can the content of the knowledge, and the practical adaptation to climate change within this network, be described?

Based on the answers to these two questions, the paper will discuss the potential for capacity building for, and the development of, a more transformational approach to climate change in Norway.

The paper is organised with the next section presenting the 'Theoretical and empirical basis' for the analysis. Then, two sections presenting analyses of the empirical data follows: 'Learning–knowledge networks for adapting to climate change' and 'Knowledge building and actions for adapting to climate change'. The two last sections are 'Discussion', discussing main findings from the two previous sections, and finally 'Conclusion', presenting main findings emanating from the analysis.

Theoretical and empirical basis

Theoretical basis

In recent years, theoretical approaches to climate change and adaptation have swung in the direction of seeing climate change as a wider socio-ecological phenomenon affecting the relationships between nature and society (Hulme 2009; Naustdalslid 2011; Pelling 2011; Knieling 2016). As part of this trend, the concept of transition emerged, opening up adaptation for wider societal, political and cultural involvement. Still, climate change adaptation as transition appeared as just incremental and often operating within 'business as usual' frameworks. Counteracting this, it was argued that climate change is creating fundamentally new environmental contexts for societies, regions and places, with climate change depicted as *'(–) a co-evolutionary process of human and natural systems where societal changes occur together with natural changes instead of just as in reaction to these'* (Knieling 2016, p. 5, italics added). Hence, the view that adapting to a changing climate, as well as mitigating emissions of greenhouse gases, required transformational actions emerged, fostering a literature on transformation issues.

Although O'Brien (2012) showed that definitions of transformation have differed considerably, the definition provided by Assessment Report 5 of the International Panel of Climate Change seems to catch essential dimensions: 'the altering of fundamental attributes of a system (including value systems; regulatory, legislative, or bureaucratic regimes; financial institutions; and technological or biological systems)' (Field et al. 2012, p. 5). In short, transformational change takes place at a systemic scale. Adding to this is a set of dimensions identified by Lonsdale et al. (2015), with transformation framed by wicked problems; requiring complex learning; operating across the scale of systems and in the long-term; and requiring radical changes that also are anticipatory.

Of course, adaptive actions may not be transformational, and hence, several typologies presenting extent of change on a gradient from incremental to transformational appeared. A simple typology distinguishes between incremental and transformational changes. Among these, Park et al. (2012) stand out by underlining that incremental and transformational changes take place as interlinked adaptation cycles, both consisting of four stages of action–learning cycles: problem structuring and establishing the adaptation arena (identifying nature of vulnerabilities and risks, who or what adapts, and what they adapt to and why); developing the adaptation agenda, vision, and pathway; implementing adaptation actions; and evaluation, monitoring and learning. For the last stage, 'monitoring and evaluation activity is considered to stimulate a process of social learning among the different actors involved' (op cit. p. 117), 'as both a governance mechanism, and form of praxis for shaping policies and practices in relation to climate change adaptation' (op cit. p. 118). Moreover, social learning may be elevated to a triple level, and the authors clarify that 'while double and triple-loop learning may occur during both

the incremental and transformative Adaptation Action Cycles, the former is characterised by the decision to continue responding to the same organisational objectives and within the same governance systems.' (op cit. p. 119).

Several contributions have proposed three categories, with the intermediate category not demanding systemic changes but still causing profound changes of existing practices. While the third category generally is termed transformation, the second category goes under several labels; e.g. transition, reform(ist), resilience (e.g. Pelling 2011; Waddell 2011; Bassett and Fogelman 2013; Pelling et al. 2016; Heikkinen et al. 2019). As for the second category, we prefer using *transition*. The concept of *resilience* may comprise transformational dimensions (Meerow et al. 2016) and *reform* is a staple in the jargon of politics, both thereby running the risk of becoming utterly fuzzy.

Lonsdale et al. (2015) links single-loop learning to the first, double-loop learning to the second, and triple-loop learning to the third of these categories, thereby systematically combining learning and change, but facing the challenge of different types of learning fostering several categories of change, as underlined by Park et al. (2012). Nevertheless, moving from two to three categories means facing stronger challenges in making the typology operational in categorising actual changes, not least when taking into account outcomes in the longer term, facing the quest of uncertainty.

As is evident from the presentation above, linking *categories of change* to *learning–knowledge* has been part of research on climate change adaptation. The three-tiered learning typology appears as fruitful. (i) Single loop (experiential) learning through correcting errors and improving performances within the frames of established practices; (ii) double-loop learning requiring changes in existing assumption of practices; and (iii) triple loop learning transforming the structural context of practices and governance norms and practices (Argyris and Schön 1978; Armitage et al. 2008; Pahl-Wostl 2009). Johannessen et al. (2019) in a study of urban water governance defined triple loop learning as being about 'how do we decide what is right?' thereby making it a procedural issue. Procedural changes may or may not facilitate relevant and effective outcomes. Therefore, we argue that a relevance criterion, bringing the actual content of learning–knowledge to the table is necessary. Moving towards triple loop learning may rely on social learning; that is, group-based iterative reflections facilitated by interaction with others (Keen et al. 2005; Armitage et al. 2008). Making the learning typology operational for empirical studies is challenging because there is interaction between the three loops, and learning may appear as contextual, indicating the existence of grey zones and nested loops.

Multi-level governance has been defined as 'negotiated, non-hierarchical exchange between institutions at transnational, national, regional and local levels' (Guy Peters and Pierre 2001, p. 131) and frequently referred to as network governance (Sörensen and Torfing 2005). Hooghe and Marks (2010, p. 21) make a distinction between two types of network governance: Type I governance is concerned with the formal multi-level system of government, whereas Type II governance is more independent of formal jurisdictions and formal lines of authority, with purpose-specific networks that are 'intended to respond flexibly to changing citizen preferences and functional requirements.' The overarching goal is 'greater effectiveness in tackling the problems that the public most care about' (Stoker 2011, p. 18). In this paper, multi-level governance is central since we are analysing both local (municipal level) and central government (national and regional level) agencies. This means we are addressing agencies at each level separately and interactions between these levels within different sectors.

The process character and interactions between different categories of learning and adaptive change indicate complexity. As underlined by Dolsak and Prakash (2018), adaptation policies might lead someone to relax on own actions thereby increasing vulnerabilities, or policies might facilitate adaptation in the short-term while eroding such effects in the long-term, causing maladaptation. Consequently, categorising particular actions and practices as incremental or transformational is challenging. Nevertheless, some will argue transformational change rests on transcending capitalism into something less ecologically, and socio-natural, exploitative (e.g. Klein 2014; Wainwright and Mann 2018; Monbiot 2019). The majority, though, including ENGOs and research community[1], adheres to some sort of ecological modernisation, combining collaborations and technology development within existing systems (e.g. Jänicke and Quitzow 2017; Howes 2018; Dryzek and Pickering 2019). We recognise that transformational changes not necessarily require transcending capitalism, but on the other hand, such transformation may as well emerge as the consequence of a number of incremental changes. A case in point is the roll-back and roll-out processes of hegemonic neoliberalism (Birsch and Siemiatycki 2016), since the 1980s transforming post-WWII Keynesian capitalism, ultimately framing how governments approach climate change adaptation.

Empirical basis

The analysis builds on two empirical sources: the first, and most important, is semi-structured interviews with employees in local and central government agencies in Norway, and the second is document studies. At the local government (municipal) level, we have interviewed heads of planning departments and heads of

engineering departments. At the central government level (national and regional), we have interviewed senior advisers engaged in the field of climate change adaptation in different directorates (national) and county governor's offices (regional).

The interview guide had sections on (i) work tasks of relevance for climate change adaptation and sources for learning and knowledge; (ii) collaboration and cooperation horizontally and vertically within the public sector; (iii) conflicting knowledge within and outside the field of climate change; (iv) barriers against adaptation, and examples of success in adaptation efforts; (v) what knowledge is seen as lacking and what is seen as important future challenges.

We interviewed representatives of 14 small and medium-sized municipalities, 5 county governor's offices, and 7 national directorates. The 14 municipalities covered several dimensions: city-regions and countryside, middle and small-sized municipalities, coast–interior, and macro-regions of Eastern Norway, Western Norway, Mid-Norway and Northern Norway. Except for two municipalities, all those approached in the first round agreed to take part in the project. We replaced those two municipalities with others in the same region. The five county governor's offices were located in the same area as the municipalities, while six out of the seven national directorates were located in Oslo. We conducted all municipality and county governors' offices interviews, except for one of each, by telephone. On the other hand, all interviews at directorate level were face-to-face. The interviews lasted from half an hour to two and half hour, with face–to–face interviews lasting longer than telephone interviews[2]. In most municipalities, we were interviewing an employee responsible for municipal planning and one for water services. In two of the governor's offices and in three directorates we were interviewing two or three employees. In total, 42 interviewees were involved.

The document study comprised white papers, public investigations, consultancy reports, and scientific reports. The focus was on publications issued after about 2010, providing a picture on how knowledge on climate change adaptation and to a certain degree climate change, had developed. The document study contextualised the interview data. Since our study focussed on small and medium-sized municipalities, a comparison with a parallel project (Jordbakke et al. 2017) on climate change vulnerabilities in 11 larger urban municipalities is also part of our study.

Utilising data from several of the five main topics of the interview guide, presented above, the next section presents responses to the *first research question;* learning–knowledge networks within the frames of Norwegian multi-level governance practices. Thereafter, a section analysing the *second research* question follows; actual knowledge for adapting to climate change and concomitant changes, as well as the issue on transformational change. For both sections, we address local and central (regional and national) government levels. After each quote, a bracketed number links the quote to specific interviewees, thereby indicating how much different interviewees are used.

Learning–knowledge networks for adapting to climate change

Central government

The *national level of the central government* (directorates under ministries) are reporting a contact network consisting of mainly Norwegian research centres. Directorates are funding commissioned research and consultancy projects, and, in cooperation with ministries, allocating funds for programmes under the Research Council of Norway, as well as economically supporting environmental non-governmental organisations (ENGO)[3]. Knowledge gained from these sources, is disseminated to lower levels of government (vertically) and to other directorates (horizontally), meeting the principle of science (or knowledge) based management and policy-making. Public Investigation Reports, often written by professionals, form basis for, e.g. white papers and subsequently policy-making, thereby also being a knowledge source for public sector, as well as other stakeholders. Nuancing this picture, directorates serving particular sectors (e.g. infrastructure, health, and agriculture) differ from those supposed to serve several sectors (e.g. environment and civil protection). The latter may draw upon a wider range of research institutes and because of having a coordinating role they will try to establish collaboration with other national-level agencies, while the former to a larger degree have a thematic focus.

Evidently, there is a wide knowledge network at the national central government level, within and outside the public sector. Illustrating the potentiality of collaboration within this network, the 'NIFS' project (Natural risk, Infrastructure, Floods, and Avalanches), the collaboration between the Norwegian Water Resources and Energy Directorate (NWRED), the National Public Roads Administration, and the Norwegian Railroad Directorate stand out[4]. By coincidence, the project happened to get first-hand experience from a 200 years scale flash flood:

> "The [flood] incidence illustrated the interlinkage of vulnerable sites along a water course (–) the idea of holistic water management along a water course appears as a step in the right direction. This knowledge is not yet implemented, but present in so many knowledge centres that in one way or another it must have some impact on future work (–) the cooperation among the three agencies taking part in NIFS has improved considerably, utilising each other competencies." [7]

The NWERD stands out as an important knowledge source for almost all other directorates, illustrating the perceived role-played by water in adapting to climate change.

At the *regional level of the central government*, county governor's offices rely very much on knowledge production initiated and extracted by national-level central government and disseminated through regulations and guidelines, annual instruction letters, white papers, and reports, but also through meetings convened by directorates. Experienced advisers and public officials, though, may rely on a wide contact network, inside and outside public sector. Meetings may serve as a source of learning for employees at national and regional levels:

> "We play a role in relation to the knowledge basis for submitting objections [to local government plans and actions], this is a central topic during our annual meetings (–). Another issue is to have everyone in the whole country to do this in the same way (–) we are using each other´s competence through [presenting and discussing] examples and experiences." [4]

Although the main flow of knowledge is top-down, there is a counter-flow from the regional to the national level, providing contextualised knowledge that subsequently may enhance the generalised top-down knowledge. Commissioned research and consultancy projects might play a similar bottom-up role.

The county governor's office is responsible for central government's contact with local government, the municipalities: guiding, monitoring and controlling. Nevertheless, the national level may take part in meetings with municipalities, presenting important issues, including climate change adaptation. The county governor's offices or the five regional offices of Norwegian Water Resources and Energy Directorate invite to meetings, some on an annual basis, some less and some (perhaps) more frequently.

> "We have since 2008 invited municipalities to attend voluntary meetings on two occasions (–) although varying, the participation is fairly good, but as is often the case, those who already are doing well are more eager to attend than those lagging behind. There are some dark spots we try to engage with (–) we suggest individual meetings with those municipalities, offering guidance and information, hoping to bring them a little bit forward; improving by taking into account issues we recommend." [5]

> "We try to establish arenas for municipalities (–) [it is] a dissemination task to bring knowledge to municipalities (–) [we are] especially addressing surface water, hydraulic issues, pollution, and in a way possible damages (–) we ask for surface water management plans, and then we are challenged on the content of such plans (–) I have to use my knowledge to inform about how to do this (–) surface water strategy and formulating action plans." [11]

Disseminating knowledge from central to local governments fostering local learning–knowledge processes and actions is not plain sailing, and the central level has to take proactive actions. A challenge for both *national and regional central government* is to conduct proper casework of, e.g. development projects, concluding that projects are safe and meeting relevant regulations. On one hand, consultants are formulating plans for municipalities, but since, e.g. the county governor's office 'receive plans quite late in the process, [it is] causing problems if they are not meeting the requirements, it is important that municipalities have the knowledge to formulate tasks for consultants' [12]. On the other hand, for projects run by private developers, riddled by uncertainties and lack of proper knowledge, public officers must consider making an objection[5], which may be difficult. 'Personally, I find making objections difficult since I have not worked that much on such cases to feel sure whether to do so or not. (–) At the end of the day, if documentation showing that uncertainties are properly considered is missing, we will file an objection' [12]. Of course, assessing or even appraising such documentation may not be a straightforward task, as underlined by public officers: is existing knowledge sufficient or is it necessary to conduct new investigations? The decision may rest on tacit knowledge gained through long-term experience.

Regarding the municipal level, Orderud and Naustdalslid (2018) underline that municipal officers ask for regulations and instructions that would make casework of development plans easier, and criticising all the guidelines for just being recommendation. The voluntary character of guidelines is confirmed and appears as a restriction at central government level. Although 'TEK-10'[6] provides basis for raising objections to developments due to climate change adjusted average flood scales, guidelines make it difficult to move beyond demanding that municipalities consider certain concerns.

Local government

When it comes to networks of *municipalities*, we find that almost all planning departments report little or no collaboration or cooperation with other municipalities, whereas the large majority of water–sewage (or technical) departments are part of local networks where climate change adaptation is addressed, although at varying frequency. Generally, municipal officers taking part in the local networks consider it as useful:

> "We consider the cooperation with the other municipalities in the region as useful. We develop a common understanding on this [climate change adaptation], and we learn how we may approach it in each municipality. It develops our awareness, making everyone a little better." [29]

> "The climate network[7] we take part in is a good forum for exchanging information and knowledge among the municipalities, and hence of use for smaller municipalities, but it must not just turn into repetitions – it has to mean something." [36]

In general, networks at the local level are task oriented and for climate change adaptation, this means that cooperation linked to water–sewage and technical tasks dominate. The reason is most likely that municipalities consider climate change adaptation as a technical problem. Furthermore, it is important to keep in mind that municipalities make use of private and professional consultancy for solving concrete tasks, both in relation to planning (e.g. procedures and formulating risk and vulnerability plans) and construction activities (e.g. sewage systems and construction/location of building). Many see consultancy projects as a source of learning:

> "It is somewhat easier when consultants take care of it, they are in front nationally, competent within this field, I believe (–) over time helping to establish best practice, and evidently, other municipalities are watching what we do (–) [when using consultants] suddenly we got something applicable; ok, this is how we can do it! Very timely!" [37]

Of course, extensive use of consultants may not be economically feasible for smaller municipalities, at least not alone. Furthermore, it is a bigger decision to make for the smaller ones when they are on their own: 'accepting that we had to engage a geologist for conducting an investigating meant breaking a mental barrier, (–), admitting that for moving forward, we had to spend 200 000 [NOK] (–) for acquiring knowledge, but we learn from the report and the collaboration with the consultant' [29].

What about the largest handful of municipalities? Central government has been a facilitator and funder of networks comprising the largest cities (municipalities) in Norway. First, Future Cities ('Framtidens byer') for the period 2008–14 (13 municipalities), focussing on environmental and climate-related issues, considered as providing an arena for knowledge production and collaboration among participating municipalities as well as enhancing the interaction with central government (Ramböll Management Consulting 2015). Following up and with a focus on climate, central government initiated the network In Front ('I front') for the period 2015–19, comprising 11 urban municipalities, with a focus on water-related issues. An evaluation of this network (Jordbakke et al. 2017) tells that the National Water Resources and Energy Directorate and the National Directorate of Civil Protection but also other state agencies, as well as the professional organisation Norwegian Water, are central information sources also for these larger cities. One of the aims of the In Front network is that knowledge would trickle down to other (smaller) municipalities, at least in the same region. We found examples of municipalities looking to, e.g. Oslo and Bergen, but not any widespread and systematic trickle-down effect, confirming findings from Jordbakke et al. (2017).

Overall, there is a clear hierarchical character of knowledge production in the public sector, with the central government in a position to frame, guide, and determine the use of knowledge at lower administrative levels. Notwithstanding this hierarchy, lower levels regularly interact with upper levels, providing input in the process of formulating top-down manuals, guidelines, and regulations. In addition, lower levels still have degrees of freedom regarding the contextual content of knowledge, as well as the opportunity to engage with external expertise developing practical solutions to adaptation issues. This may be a source of conflict between central and local government, especially under increasing uncertainty, potentially producing oppositional communities of practices.

Knowledge building and actions for adapting to climate change

The focus of this section is learning–knowledge processes and concrete changes; that is, incremental–transitional–transformational climate change adaptation. The first sub-section is addressing how central government interviewees are conceiving the overall scope of change; from incremental to transformational. Following this, we look at concrete actions related to more intense rainfalls and floods, integrating central and local government levels, which is important for understanding the interaction between learning–knowledge and scope of change, ultimately revealing potentialities for moving towards transformation.

Overall pattern of change: incremental–transitional–transformational

The content of knowledge differs between sectors and levels. The Norwegian Directorate of Civil Protection provides general guidelines and regulations because they are covering different sectorial areas, while directorates that are serving specific sectors, like Norwegian Water Resources and Energy Directorate and the National Road Authorities, provide specific information. In-between these two broad groups, the Norwegian Environment Agency is providing general knowledge addressing several sectors, as well as particular knowledge related to pollution from specific industries. In spite of sectorial differences, there are common patterns when it comes to how respondents conceive of the scope of changes, as the following quotes from central government interviewees illustrate.

> "For sure, we are not doing radical changes; at best, we may approach transitional changes. (–) We are doing

> our usual things, but aim for [climate change] knowledge to seep into all parts of the organisation, over time improving what we do. (–) It is a revolution in awareness. Nevertheless, the outcome is adaptation along existing practices. (–) Making all regional leaders climate change aware and implement this in daily routines is still beyond reach." [6]

> "A central idea, put simply, is that learning-by-doing is very important (–). As for transformation, achieving a sustainable society may perhaps require other things to make us conceive of the challenges we face (–) but people also should change attitudes and understand other mechanisms (–). The mechanisms producing a more sustainable society may be easier to identify when looking back than planning for up front." [3]

> «Mostly, I think we are on the day-to-day, that we learn from practising, but we know our surroundings are changing, so thresholds and our preparedness have to be lifted; perhaps we are approaching transition because we know there are changes, But brand new thinking (–) I do not think we have (–) except for recognising that adaptation is necessary, not just mitigation." [4]

> Trying to take a holistic approach to this [climate change adaptation] is still somewhat new for us, and it is not clear what *holistic* means. Most likely, it is nothing more than trying to add a climate component to regular policy input. Today, it is more like isolated initiatives within different [policy] fields than really coordinated efforts." [10]

In short, when asked, central government officers at the national and regional level generally do not think they are in the business of developing transformative adaptation. It is more like business–as–usual and changing trough small steps, or possibly entering or approaching the mid-category of transition.

Interaction between different levels

For central government, and especially the regional level, a continuing challenge in interacting with local government is translating general and science-based knowledge to something applicable for municipalities. While informing and guiding on general principles of for instance blue-green structure and managing surface water may appear fairly straightforward, taking relevant actions is another story: 'how to actually do this? What resources are necessary? How much land to set aside for coping with surface water? How to design this to become a resource for areas under real estate development? (–) Here we have a long way to go, and whose responsibility is it?' [11]. Relatedly, although information and knowledge about adaptation at the municipal level have increased in recent years, regional and local actors call for detailed guidelines that will make it easier or possible to translate general guidelines into local, contextualised actions. In addition, municipal officers think more detailed regulations and guidelines may help when meeting criticism and opposition from local developers and politicians.

At the municipal level, adaptation is most often relating to concrete tasks, and especially technicalities of managing surface water: 'it is a topic you know you have to take into account, but the main focus is perhaps not on climate, so less important is most correct' [19]. Furthermore, concrete actions are often reactive not proactive; that is, after experiencing, e.g. flood incidences there is more focus on doing something, spurring allocation of resources. This is even the case among municipalities claiming to be proactive: 'increasing pipe dimensions due to more rain may be done, but we have to wait and see what happens. We should take actions if a section of the pipe network does not handle extreme rainfall incidences, causing inundations of adjacent buildings' [42]. On the other hand, several municipalities are aware of the water management strategy of infiltration, retention, and dispersion, in addition to increasing the pipe capacity. Related to the focus on technicalities in handling and adapting to surface water and other physical phenomena, employees in the technical sector often appear as more up to date and concerned about the needs for adaptation than what those in the planning sector do, but there are considerable differences between municipalities in this respect.

Knowledge building and changes – flood incidences

Notwithstanding the pattern emerging from the previous paragraphs, it is necessary to examine concrete cases to get a better grip on the possible scope of adaptation actions. Coping with water-related consequences of climate change has been central in adaptation policies, and therefore appears as an instructive case for learning–knowledge–action and adaptation cycles. We do this by presenting four policy actions, comprising actions that enable and lay the ground for taking specific flood remedying actions, as well as actions directly countering flood incidences.

Risk and vulnerability analyses

It is mandatory at local government (municipalities) to formulate such analyses as basis for planning and development, with governor's office in a monitoring and coordinating role and the Norwegian Directorate for Civil Protection (NDCP) as responsible at the *national level*. Developed by the NDCP, such plans should include procedures for making risk scenarios of extreme events (disasters) within particular geographical areas, thereby relating directly to climate change and floods. Guidelines offer knowledge about how to handle crises, as well as conducting exercises necessary for learning procedures and gaining competence in coping with risks and potential disasters.

NDCP reports a mixed pattern on how well municipalities explicitly relate floods to climate change adaptation. Some are doing well while others do not. In recent years, NDCP has also been facilitating local virtual exercises on handling climate-related extreme events, as for instance a possible urban flash flood in the city of Drammen (NDCP 2016), bringing together representatives of relevant authorities at different levels, as well as some private sector stakeholders. Also at the *regional level* (governor's office), the reported pattern is mixed. According to one interviewee, 'we have learned much from for instance conducting risk and vulnerability analyses and what we have to take into consideration, as geographical differences in vulnerabilities, discussing and getting useful knowledge for trying to move forward' [8]. Other interviewees, though, indicate that '[municipalities] ask consultants to make risk and vulnerability analyses, and often the quality is mixed. (–) Avalanches, flood and surface water have not been sufficiently analysed. Then you do not get any holistic assessment of climate adaptation issues, just bits and pieces' [14].

At the *local level*, most municipalities are not actively connecting risk analyses and climate, as the above quotes also illustrate. Moreover, among the third of municipalities mentioning adaptation to climate change as an issue in connection with their vulnerability analyses, the stated importance differs. One interviewee respond that 'to me, applying knowledge is part of a checklist linked to the risk and vulnerability analysis; that is what it all has been about so far.' [34]. A second interviewee states that 'for sure, if there are any issues emanating from risk and vulnerability analysis related to climate change (–) we have to implement measures (–) if anyone wants to erect industrial buildings just above sea level, we are concerned.' [25]. A third interviewee underlines that 'we have allocated much capacity in order to take into account challenges from climate change as part of formulating our planning document. We have had to respond to demands from Norwegian Water Resources and Energy Directorate and County Governor's office regarding risks linked to floods, avalanches and so on.' [42].

Flood maps

Some 10 to 15 years ago, municipalities strongly asked The Norwegian Water Resources and Energy Directorate (NWRED) to provide *updated flood maps* (Vevatne and Westskog 2007). This has not been a straightforward task due to increasing uncertainty regarding frequency and size of (flash) floods, but NWRED has provided updated flood maps. For river basins less than 100 km^2, a 20% increase in water levels is added for estimating future floods, while there are three categories for larger river basins, adding 0%, 20%, and 40%. Increasing precipitation demands more attention to flood-related avalanches. In guiding and controlling local government, NWRED stick to the regulatory basis given by TEK10[5]. However, when looking forward to the year 2100, things are more uncertain and although stating that it is necessary to take into account climate changes, the legal basis for the estimations are weaker. Therefore, NWRED has produced *due diligence maps for future floods*, not stating whether it, e.g. is a 200-year or 500-year flood, but a flood approaching the size of the strongest flood possible in that area. These maps show areas where the directorate considers it necessary to be cautious about, e.g. erecting buildings and infrastructure facilities. However, it is not mandatory for municipal planners to abide by the information presented in attention maps when taking particular actions.

> "We have knowledge and a role in advising municipalities but face restrictions on instructing because of a lack of quantifications in the legal basis, so we may put our own or other's knowledge to the table, asking the municipality to use this, and recommending particular actions to be taken but often it is difficult to push stronger." [5]

NWRED operates regional offices that organisationally are part of the directorate, causing some ambiguities regarding responsibilities at regional level of the central government, making it crucial to have good case-by-case collaboration, which is demanding. Some also report that current due diligence maps do not provide sufficiently detailed information on future flood zones, and developing better maps is in the loop. Nevertheless, municipalities consider NWRED as an important information source: 'Our information sources are the most competent professionals. If we use information from the NWRED, we are fairly sure that knowledge is quite good' [20]. Furthermore, in connection with possible quick clay slides, 'we demand geotechnical investigations using NWRED's guidelines, a three-step procedure depending on what you discover. So, I feel there is more thorough casework today and we get it to the table at an earlier stage in the planning process' [37].

Topographical maps. Flash floods and debris flows may take unexpected courses. Therefore, having access to digital maps with detailed slope gradients as basis for GIS analyses of flood incidences appear as crucial. Maps constructed by *topographical laser scanning* has the potentiality of meeting this demand. This work has been the responsibility of the State Map Authority (SMA), together with other public authorities at different geographical levels. The default has been two points per square metre, but with the opening of increasing the number of points per square metre, if other agencies allocate funds. In short, agencies at central and local government, including municipalities, are better equipped to simulate flood-ways during

(flash) floods and adding storm surges to higher sea levels, possibly being able to take precautionary measures. As explained by a central government interviewee at the regional level:

> We have much good laser data for maps now, at least in our region, making it possible to construct good models [for floods and seaside storm surges]. This is a job we will have to do. (–) The largest municipalities with good GIS competence are themselves doing much of this, but many other municipalities do not have such competence in-house, making us to deliver something if they ask for it." [13]

Clearly, municipalities having experienced severe flood incidences are keener on taking actions, and some, most often middle sized with resources, have initiated their own GIS projects for mapping possible floodways, relying on internal as well as external resources.

Principles for handling flood and avoiding inundations

In recent decades, the default position in managing surface water has been to increase the dimensions of the pipe network, and still this is part of the tool kit, using an upscaling quotient of, e.g. 1.2 or some may opt for 1.5. The government, supported by professional water management associations like Norwegian Water [Norsk Vann], recognised that more than pipe replacement would be necessary, and introduced the *strategy of infiltration, retention, and safe run-off* through designated flood-ways (NOU 2015). Leaving areas of open land, urban policies for blue-green structures and green roofs are part of this strategy. It seems that planners in several municipalities are aware of these strategies, as well as conflicts of open space versus compact cities. Conditions in a medium-sized municipality may illustrate how knowledge is enmeshing in organisational dysfunctions making implementing policies a challenge:

> "The engineering department is making strong efforts in replacing pipelines for drinking water and waste water, and perhaps there is too little money and resources left for overall planning. (–) The county governor's office has made it very clear that they expect us to avoid mixing surface water and wastewater. (–) The municipality is allocating a lot of money for this. (–) Possibly, we need some other type of knowledge than we in recent years have been hiring, perhaps some more people for conducting overall surface water management, for this to form basis for municipal planning. From my point of view, something is missing. (–) I think there are many initiatives, but they are drowning a little in all the other things we are doing. It takes time, making thematic maps, making rules for how we are operating, what are the responsibility of the municipality and what responsibility should we expect private actors to take." [37]

> "One of the challenges is the internal purchaser–provider model for organising interactions between municipal engineering department and the operating department. (–) the engineering department has worked hard, while the operating department is lagging very much. They tell the problem is capacity, but it is more about priority. The focus of the operating department is pipelines, and they just work on contracts. Therefore, we end up just taking small steps." [36]

Moreover, as underlined by one interviewee, blue–green strategies for urban areas may serve as a beautifying element in urban areas, but such watercourses also may be a source for spreading pathogens and toxic substances.

Discussion

The learning–knowledge network

The empirical analysis describes an extensive knowledge network, with central government in the front seat providing knowledge input to local government. When just considering municipalities, the picture is more mixed. Although all types of municipalities are part of knowledge networks, the range of networks amongst most small and medium sized is restricted. It is just the few largest municipalities (cities) that may be part of extensive networks, networks partly facilitated by central government. On the other hand, medium-sized and large municipalities are facing the challenge of developing effective internal networks. As underlined by one of our interviewees, it was much easier to argue for, coordinate and have things done in her previous small than current medium-sized municipality, compounded by the purchaser–provider model that in recent decades has emerged under the banner of New Public Management.

Nevertheless, for public sector as a whole, the existence of an extensive network is the main picture, but this network has a clear hierarchical structure in public administration learning–knowledge processes, as well as in translating knowledge to practices. In the terms of Hooghe and Marks (2010), what we find is the dominating role-played by Type I networks and very weakly developed Type II networks. Local government levels (municipalities) may certainly seek independent sources of knowledge and information about climate change adaptation. Our interviews show, however, that small and medium-sized municipalities systematically are expecting central government at the regional and national levels to provide information and practical guidelines on how to deal with, e.g. issues related to climate change adaptation. For sure, there is an interaction between central and local government but, ultimately, central government is expected to play, and plays a leading role in provision of knowledge.

Another aspect of learning–knowledge processes and climate change adaptation, though, is that vague and unclear top-down regulations and guidelines may facilitate municipal trials and errors. This may open for

shadow networks producing oppositional knowledge as bases for alternative communities of practice, claimed to be essential for developing new solutions, possibly in the direction of transformative adaptation (Scholz et al. 2014, 2015; Schmidt 2017). Although our study did not focus specifically on shadow networks and communities of practice, the interviews did not indicate or reveal any shadow networks operating as common sources of knowledge. An experienced employee at one of the county governors told about trusted informal knowledge sources, but they were mainly public employees. An interviewee at the municipal level indicated that consultancy companies might provide solutions for how to handle vague and unclear regulations and guidelines emanating from central government, but generally, the commercial consultancy sector may not fall under the category of shadow network producing oppositional knowledge. The reason for this is that consultancy projects, especially at the local level, commonly are task oriented, and in addition assigned following tender competitions using criteria like qualifications, proposed implementation, and price. Nevertheless, there may be bottom-up provision of experiences through public sector channels as well as through the consultancy sector.

The content of knowledge, actions, and changes

Developing the four actions briefly outlined in the section on 'Knowledge building and actions for adapting to climate change' demands moving beyond single-loop learning and into double-loop learning. Other cases of learning–knowledge may fall under the category of single-loop learning. This may comprise actions on improving existing practices, like upgrading sections of existing pipelines after flood incidences, or it may be learning to make better systems of infiltration, retention and safe run-off of water.

The question then is whether single or combinations of several learning–knowledge processes produce incremental, transitional or transformational changes in adapting to climate change. Considered one-by-one, most learning-knowledge processes and concomitant actions appear as incremental when seen from the perspective of climate change adaptation. The next question, then, is whether incremental actions may add up to or leap into transformation, or at least transition.

Combining the four actions presented in the previous section, illustrates a case that may approach and have the *potentiality* of becoming transitional. A GIS-based analysis with layers of fine-grained topography, risk and vulnerabilities, and due-diligence flood maps, appear as having the potentiality of becoming a proactive tool for flood and water management integrated in planning. For this *potentiality to materialise*, sufficient knowledge of conducting GIS-analyses and understanding how to use the results are necessary. Furthermore, resources are necessary, and then the question of politically giving priority to climate change adaptation come into full effect. From our interviews, we found that such support is far from certain. Lack of awareness and knowledge may cater for lack of support, but also short-term economic priorities or some sort of climate change scepticism, or even denialism.

Double-loop learning within the agencies referred above may foster different degrees of changes within those agencies. Take for instance the case of State Map Authority, where laser scanning together with previously introduced digital map bases and market-orientation illustrate double-loop learning that is fostering transitional change in making and using maps. On the other hand, due diligence flood maps of the Norwegian Water and Energy Directorate may not fully foster transitional change.

Another issue is the positive effects and possible opportunities of climate change. We hold that transformation means taking into account possible positive effects when formulating adaptation policies. However, it turns out that the main focus at all levels is on the many negative and threatening aspects of climate change. As underlined by one of the central government interviewees, although being aware of positive effects, they see it as their duty to focus upon threats. When asked, a few interviewees points to new crops and higher output in relation to agriculture as a possible positive effect. The most informed underline that reaping off positive gains would require a lot of research and experimentation. Surprisingly, actually none of our interviewees mention the possibilities (and the challenges) presented by 'the green shift'. A focus on threatening consequences may stimulate business-as-usual practices because the aim very often is maintaining existing systems. However, as underlined by the transformation literature (e.g. Meerow et al. 2016), maintaining existing conditions may very well require transitional and transformational changes.

When it comes to *adaptation learning–action cycles* (Park et al. 2012) there is evidence of deliberate problem structuring and adaptation arenas, as well as development of agendas at central government levels since issuing of the white paper on climate adaptation (White paper 2013), but mixed pattern at local government level. A few small- and medium-sized municipalities appear as having formulated problem structures explicitly taking into account vulnerabilities and risk for adapting to climate change, as well as adaptation arenas, and on this basis developed agendas related to surface water and floods. This is more common among the largest municipalities due to networks among the largest municipalities, facilitated and funded by central government. Similarly, central government levels are generally implementing policies as well as conducting

evaluations for learning, whereas implementation and evaluation differ among (local government) municipalities. In general, the four phases driving adaptation cycles identified by Park et al. (2012) are present in existing Norwegian governance practices. For climate change adaptation, we find single and double-loop learning linked to incremental changes, with the potential of aggregating to transitional changes linked to handling of surface water, but a lack of transformational change; that is, in the words of Park et al. (2012), change management is focussing on finding ways to keep the present system in operation.

This raises the question of how to foster transformational changes; that is, extending and enhancing adaptation cycles to produce transformation outcomes. Resembling a previous study (Orderud and Naustdalslid 2018) our findings indicate that central government is particularly important when it comes to coping with climate change adaptation. Apparently, this runs counter to climate change research pointing to local government as the driver of change, potentially beyond the local community (e.g. Amundsen et al. (2018)). Our study finds few if any practical signs of such a potential today. On the contrary, central government seems to have a key role in facilitating local government learning–knowledge processes as part of policies for enabling and ensuring relevant actions. This may mean providing municipalities with more cross-sectoral and transformation-relevant knowledge, developing guidelines for municipal planning that would lead municipalities to consider more seriously the need for adapting the whole local community to a future with a more unpredictable and changing climate. Perhaps central government also should enforce local government to start transition–transformation processes. Furthermore, regulations requiring local authorities to involve the wider civil society in formulating and implementing policies for adaptation to climate change appear as critical. Here multi-level governance is important and should also include bottom-up processes as part of learning–knowledge processes, and facilitate local networks for contextualising central government guidelines and recommendations for action. This may help facilitate type II governance.

Conclusions

Commonly, central government at national level, assisted by regional level, is initiating and providing content for central and local government learning–knowledge processes, using an extensive national, and to a certain degree international, knowledge network. Local government generally asks for and expects to receive clear and detailed guidelines and regulations for taking action, based on the best (scientific) knowledge available. Thus, knowledge on climate change adaptation is considerably better at central than at local government level, and with central level assisting and stimulating local level to take actions. Therefore, considering public sector learning–knowledge processes as integrated central–local systems appears as necessary for developing adequate adaptation policies for different administrative levels and spatial scales.

Generally, climate change adaptation is incremental and based on single-loop learning and to a certain degree double-loop learning. On the other hand, we also find that interacting incremental changes in certain cases may produce transitional changes, as for instance, handling surface water and floods. Nevertheless, quite often, change is about technical solutions within existing systems. Hence, existing adaptation cycles are currently not producing knowledge necessary for venturing into transformation. The issue then is how to advance adaptation cycles to produce more transition and ultimately transformation. A first step in this respect is explicitly formulating policies that are combining incremental changes capable of facilitating transitional and transformational changes. This requires enhancing central and local government planning and implementation capability, and combining generic and contextual knowledge appears as critical. Part of this is developing effective tools for enabling and facilitating local government in taking adequate and effective adaptation actions or conversely avoiding inadequate actions, taking into account the observed differences between overall planning sector and technical sectors.

Relatedly, a critical question is whether and how to foster shadow networks of an oppositional character for developing necessary learning–knowledge processes for transitional and transformational changes. There is not any clear-cut yes or no to the whether question. A positive path dependent (lock-in) development trajectory may be thwarted by oppositional forces, while negative path dependent trajectories need to face critical and oppositional knowledge. Taking into consideration the lack of transitional and transformational actions (also for avoiding emissions of greenhouse gases), the answer may tilt in direction of the need for oppositional knowledge and thinking. For this to be effective, any oppositional knowledge network must cut across generic–contextual and global–local dimensions of learning processes, and perhaps even better, also facilitate dialectical interaction between the global and local as well as generic and contextual dimensions.

Adequate learning–knowledge processes are necessary conditions for adapting to climate change, but it is not sufficient for the implementation of effective actions. Our study reveals that resources and political priorities are major obstacles to taking adaptation actions, especially in municipalities. Lack of resources

impedes municipal administrations in acquiring knowledge for adapting to climate change, thereby also making it more difficult for municipal officers to argue for taking or avoiding actions by public agencies or private developers. Moreover, municipalities often follow a reactive policy, acquiring knowledge for taking actions after having experienced extreme events causing damage to property and people. Increasing frequencies of extreme events may cause quick changes in political priorities, but establishing necessary knowledge and system for what to do and how may lag behind what is needed.

Notes

1. In Norway, high profile environmental non-governmental organisations like Bellona and Zero, as well as one of the leading climate change research institutes (Cicero) fall in his category.
2. We asked all interviewees whether they agreed for recording. One of the interviewee at the municipal level refused recording. For this one, we took notes during the interview. Recorded interviews were transcribed.
3. Among those, we find World Wildlife Fund, Norwegian Society for the Protection of Nature, Bellona and Zero. Although mostly focussing on reduction of greenhouse gas emissions, such organisations may also play a role in relation to adaptation.
4. The project also included collaborated with external research institutes and consultancy companies, as well as occasional participating by other public agencies like the Norwegian Directorate of Civil Protection and Directorate of Building Quality.
5. In the Norwegian planning system, central government agencies, generally at the regional level, are entitled to and have a duty to make objection to plans that are not meeting regulatory requirements. Such cases may be brought to national level (ministries) for final decision.
6. TEK 10 is a regulation to make sure buildings are meeting, e.g. technical requirements regarding health, environment, safety and energy.
7. National and organised by KS – the Norwegian Association of Local and Regional Authorities.

Acknowledgments

We would like to thank two students; Karoline Ekeberg and Magdalena Thorbjörnsen, who assisted in interviewing and transcribing interviews, and we thank the reviewers for their timely work.

Disclosure statement

No potential conflict of interest was reported by the authors.

Funding

The empirical basis for the article is a project funded by the Norwegian Environment Agency [Miljödirektoratet], project number M-711/2017.

References

Amundsen H, Hovelsrud GK, Aall C, Karlsson M, Westskog H. 2018. Local governments as drivers for societal transformation: towards the 1.5 C ambition. Current Opinion in Environmental Sustainability. 31:23–29.

Argyris C, Schön D. 1978. Organisational learning: a theory of action perspective. Reading (Mass): Addison Wesley.

Armitage DR, Marschke M, Plummer R. 2008. Adaptive co-management and the paradox of learning. Global Environ Change. 18(1):86–98.

Bassett J, Fogelman C. 2013. Déjà vu or something new? The adaptation concept in the climate change literature. Geoforum. 48:42–53.

Biesbrok R, Guy Peters B, Tosun J. 2018. Public bureaucracy and climate change adaptation. Rev Policy Res. 35(6). doi:10.1111/ropr.12316.

Birsch K, Siemiatycki M. 2016. Neoliberalism and the geographies of marketization: the entangling of state and markets. Prog Hum Geogr. 40(2):177–198.

Dolsak N, Prakash A. 2018. The politics of climate change adaptation. Annu Rev Environ Resour. 43(1):317–341.

Dryzek JS, Pickering J. 2019. The politics of the anthropocene. Oxford: Oxford University Press.

Field CB, Barros V, Stocker TF, Qin D, Dokken DJ, Ebi KL, Mastrandrea MD, Mach KJ, Plattner GK, Allen SK, Tignor M, Midgley PM (Eds.). 2012. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation – A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change. Cambridge (UK): Cambridge University Press.

Guy Peters B, Pierre J. 2001. Development in intergovernmental relations: towards multi-level governance. Policy Polit. 29(2):131–135.

Heikkinen M, Ylä-Anttila T, Juhola S. 2019. Incremental, reformistic or transformational: what kind of change do C40 cities advocate to deal with climate change? J Environ Policy Plann. 21(1):90–103.

Hooghe L, Marks G. 2010. Types of multi-level governance. In: Enderlein H, Wälti S, Zürn M, editors. Handbook on multi-level governance. Northampton Mass: Edward Elgar Publishing; p. 17–31.

Hovik S, Naustdalslid J, Reitan M. 2015. Adaptation to climate change: professional networks and reinforcing institutional environments. Environ Plann C Government Policy. 33(1):104–117.

Howes M. 2018. Joining the dots: sustainability, climate change and ecological modernisation. In: Hossain M, Hales R, Sarker T, editors. Pathways to a sustainable economy. Cham (CH): Springer; pp. 15–24..

Hulme M. 2009. Why we disagree about climate change: understanding controversy, inaction and opportunity. Cambridge (UK): Cambridge University Press.

Huq IRS, Anokhin YA, Carmin J, Goudou D, Lansigan FP, Osman-Elasha B, Villamizar A. 2014. Adaptation needs and options. In: Field CB, Barros VR, Dokken DJ, Mach KJ, Mastrandrea MD, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL. (eds.). Climate change: impacts, adaptation, and vulnerability. Part A: global and sectoral aspects. Contribution of working group II to the fifth assessment report of the intergovernmental panel on climate change. Cambridge (UK): Cambridge University Press; p. 833–868.

Ison R, Röling N, Watson D. 2007. Challenges to science and society in the sustainable management and use of water:

investigating the role of social learning. Environ Sci Policy. 10(6):499–511.

Jänicke M, Quitzow R. 2017. Multi-level reinforcement in european climate and energy governance: mobilizing economic interests at the sub-national levels. Environ Policy Governance. 27(2):122–136.

Johannessen Å, Swartling ÅG, Wamsler C, Andersson K, Arran JT, Vivas DIH, Stenström TA. 2019. Transforming urban water governance through social (triple-loop) learning. Environ Policy Governance. 2019(2):144–154.

Jordbakke A, Jul Røsjø M, Skogvold T, Karstensen H. 2017. Kartlegging av 11 kommuners arbeid med klimatilpasning [Mapping climate change adaptation activities and actions in 11 municipalities]. Analyse & Strategi and Multiconsult report M-647/2016. Oslo.

Kates RW, Travis WR, Wilbanks TJ. 2012. Transformational adaptation when incremental adaptations to climate change are insufficient. PNAS. 109(19):7156–7161.

Keen M, Brown V, Dybal R. 2005. Social learning in environmental management. London: Earthscan.

Klein N. 2014. This changes everything: capitalism vs. the climate. New York: Simon & Schuster.

Knieling J. 2016. Climate adaptation governance in cities and regions: theoretical fundamentals and practical evidence. Chichester (UK): Wiley & Sons.

Lappegard Hauge Å, Sandkjær Hanssen G, Flyen C. 2018. Multilevel networks for climate change adaptation – what works. Int J Clim Change Strategies Manage. 11 (2):215–234.

Lonsdale K, Pringle P, Turner B. 2015. Transformative adaptation: what it is, why it matters & what is needed. Oxford: Oxford University Press.

Meerow S, Newell JP, Stults M. 2016. Defining urban resilience: a review. Landsc Urban Plan. 147:38–49.

Monbiot G. 2019. Dare to declare capitalism dead – before it takes us all down with it, The Guardian; [2019 Apr 25]. https://www.theguardian.com/commentisfree/2019/apr/25/capitalism-economic-system-survival-earth (accessed 02-05-2019).

Naustdalslid J. 2011. Climate change - the challenge of translating scientific knowledge into action. Int J Sustainable Dev World Ecol. 18(3):243–252.

Naustdalslid J. 2015. Multi-level water governance – the case of the Morsa River Basin in Norway. J Environ Plann Manage. 58(5):913–931.

Naustdalslid J. 2015. Multi-level water governance – the case of the Morsa River Basin in Norway. J Environ Plann Manage. 58(5):913–931.

NDCP. 2016. Risikoanalyse av regnflom i by. Krisescenarioer 2016–analyser av alvorlige hendelser som kan ramme Norge [Risk analysis for flash floods in cities – extremeevent scenarios that may hit Norway]. Tønsberg (Norway): Norwegian Directorate for Civil Protection and Emergency Planning.

NOU 2015:16. 2015. Overvann i byer og tettsteder [Surface water in cities and towns]. Oslo (Norway):the Ministries' Service Centre, Department of Information.

O'Brien K. 2012. Global environmental change II: from adaptation to deliberate transformation. Prog Hum Geogr. 36 (5):667–676.

Orderud GI, Naustdalslid J. 2018. The understanding and role of uncertainty and risk in climate change adaptation: local and central authorities in Norway. Int J Sustainable Dev World Ecol. 25(7):579–591.

Orderud GI, Winsvold M. 2012. The role of learning and knowledge in adapting to climate change: a case study of Norwegian municipalities. Int J Environ Stud. 69(6):946–961.

Pahl-Wostl C. 2009. A conceptual framework for analysing adaptive capacity and multi-level learning processes in resource governance regimes. Global Environ Change. 19(3):354–365.

Pahl-Wostl C, Becker G, Knieper C, Sendzimir J. 2013. How multilevel societal learning processes facilitate transformative change: a comparative case study analysis on flood management. Ecol Soc. 18(4):58.

Park SE, Marshall NA, Jakku E, Dowd AM, Howden SM, Mendham E, Fleming A. 2012. Informing adaptation responses to climate change through theories of transformation. Global Environ Change. 22(1):115–126.

Pelling M. 2011. Adaptation to climate change: from resilience to transformation. London: Routledge.

Pelling M, Abeling T, Garshagen M. 2016. Emergence and transition in London's climate change adaptation pathways. J Extreme Events. 3(3):1650012.

Ramböll Management Consulting. 2015. Følgeevaluering av Framtidens byer – Sluttrapport [Evaluation of Cities of the Future – final report]. Oslo: Ramböll MC.

Reed MS, Evely AC, Cundill G, Fazey I, Glass J, Laing A, Newig J, Parrish B, Prell C, Raymond C, et al. 2010. What is Social Learning? Ecol Soc. 15(4):r1.

Schmidt JJ. 2017. Social learning in the Anthropocene: novel challenges, shadow networks, and ethical practices. J Environ Manage. 193:373–380.

Scholz G, Austermann M, Kaldrack K, Pahl-Wostl C. 2015. Evaluating group model building exercises: a method for comparing externalized mental models and group models. Syst Dyn Rev. 31(1–2):28–45.

Scholz G, Dewulf A, Pahl-Wostl C. 2014. An analytical framework of social learning facilitated by participatory methods. Syst Pract Action Res. 27(6):575–591.

Sörensen E, Torfing J. 2005. Network governance and post-liberal democracy. Administrative Theory Prax. 27 (2):197–237.

Stoker G. 2011. Was local governance such a good idea? A global comparative perspective. Public Adm. 89(1):15–31.

Vevatne J, Westskog H. (eds.) 2007. Tilpasning til klimaendringer i Oslo-regionen [Adaptations to climate change in the Oslo region]. CIENS report 1-2007. Oslo: CIENS.

Waddell S. 2011. Global action networks: creating our future together. Hampshire: Palgrave-Macmillan.

Wainwright J, Mann G. 2018. Climate Leviathan. A political Theory of Our Planetary Future. London: Verso.

White Paper 33 (2012–2013). 2013. Klimatilpasning i Norge [Climate adaptation in Norway]. Oslo:The Government.