

The Understanding and Role of Uncertainty and Risk in Climate Change Adaptation: Local and Central Authorities in Norway.

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A common claim is that emerging and future climate change is rendering traditional conceptions of uncertainty and risk obsolete. This is because a changing climate makes it quite a challenge to calculate uncertainties, establishing the measurable uncertainty as the basis for quantifying risk. Approaches that are capable of accommodating and possibly countering the wickedness caused by increasing uncertainty are necessary, the argument holds. Following up on previous studies of learning–knowledge and adapting to a changing climate, this article provides an analysis of how differences in the understanding of uncertainty and risk inform and determine governmental adaptation policies and actions of the local and central government in Norway, also discussing governance implications.

The study finds that the understanding of uncertainty and risk generally is poor at the local level, but better at the state level, especially among highly educated staff with a background in e.g. natural sciences and engineering. On the other hand, a traditional understanding of uncertainty and risk is dominating: seeking to establish measurable uncertainty as a basis for quantifying risk. The article discusses combining different approaches of uncertainty and risk, thereby introducing a broader basis for governance, also implying multi-level network governance. On the one hand, this may help the local–central government in handling wicked problems of adapting to a changing climate but on other hand, also possible nurture struggles between different knowledge bases and stakeholder interest, thereby fuelling the wickedness of adaptation policies.

Climate change adaptation – uncertainty – risk – government – Norway

¹ The Oslo and Akershus University College for Applied Science has from January 12th 2017, been granted status as university with a new name.

Introduction

As the 21st Century dawned, coping with adverse effects of socio-natural processes appeared as significantly more challenging than in previous decades. Steffen et al. (2015) has pointed to an increasing pressure on ecosystems at different scales since the 1950s. Society's capacity of intervening in its own environment is said to fuel processes that are changing core dynamics of (socio-)natural systems (Beck et al. 2003). This is making the management of socio-natural challenges increasingly wicked (Hofstad 2013). On the other hand, as Bonneuil and Fressoz (2017) explains, many of the changes claimed as new are not that new but part of a longer development. Still, the magnitude and combined effects of the changes may amount to qualitatively new challenges, ultimately aggravating uncertainties and the stakes for involved actors and potentially challenging the role of scientific knowledge in policy-making (Naustdalslid 2011).

Global warming and climate change are inherent to these trends, and uncertainties and risks are core dimensions of the increasing socio-natural complexity and pressure at different spatial scales. Hence, climate change adaptation is enmeshing in *managing risk and uncertainty*. Climate science has shown beyond reasonable doubt that the world is in a process of global warming and climate change, caused by anthropogenic interference with the climate system (IPCC 2013, p. 15). How fast the global warming and how global warming will translate into climate changes in different parts of the world and in different locations, is far more difficult to foresee. In short: the further we try to look into the future the greater the uncertainty, and the further we move down to the local level the more difficult it becomes to grasp and predict actual consequences of global warming.

The character of climate change as a genuinely socio-natural phenomenon transgressing borders of sovereign nations, sub-national territories, private and public sectors, policy fields

and sectors, commons and private properties, and science disciplines, has made it a central duty and task for governments and public authorities to facilitate and implement adaptive measures. The overarching challenge of adaptation policies is assessing and dealing with probabilities telling that more or less severe effects of climate change are more or less likely of becoming reality in different regions and communities of particular socio-natural systems, and the time perspective of those effects. Such considerations are, explicitly or implicitly, underlying decisions relating to climate change at all levels of governments: local, regional and national, as well as transnational. There is a gap in the literature on systematic analyses of the understanding and role of uncertainties and risks in policies for adapting to climate change at different levels of the government. A more systematic understanding of uncertainty and risk will improve the basis for adapting to climate change.

Ten years ago, Norwegian municipalities had taken almost no adaptation actions (Westskog and Vevatne, eds. 2007). Five years later, adaptation actions had entered the scene, with municipal employees working in the water sector accepting the climate message and pondering about how to adapt to observed and the more uncertain future changes, while the planning sector still lagged behind (Hovik et al. 2015; Orderud and Winsvold 2012).

Nevertheless, the call for more solid knowledge about local effects of climate change was prevalent. This paper follows up on these studies, providing a more in-depth study on uncertainties and risk at different geographical-administrative levels of the governmental bureaucracy, different sectors and professional disciplines. The article is focussing on the following research questions:

Firstly, the article identifies main theoretical approaches for understanding uncertainties and risk, with relevance for adaptation policies and actions. Secondly, applying the theoretical framework, we analyse how differences in the understanding of uncertainties and risks inform and determine governmental adaptation policies and actions of the local and central

government in Norway. Thirdly, we discuss implications of our findings for governance.

The next section, Theory, methodology, and empirical basis, presents the frame for the empirical analysis in section three. The fourth section discusses the results from the analysis, and finally, section five is providing the main conclusions.

Theory, Methodology, and Empirical Basis

Theoretical Basis

According to Nowotny (2015), uncertainty is an inherent part of science, and in particular basic science. The curiosity of discovering and solving problems is a central driving force. Moreover, risk and its outcome used to be considered as positive or negative, but “Today the concept of risk has become impoverished and one-sided. It is now generally associated with a potentially negative and unwanted outcome which is to be avoided or at least its consequences minimized” (ibid, p. 66). Nevertheless, the theoretical understanding of risk seems to have broadened, with different theoretical approaches operating side by side.

In a classical discussion of the problem of risk and uncertainty, dating back to 1921, Frank Knight referred to the distinction between risk and uncertainty as a distinction between *objective* and *subjective* probabilities (Knight 1921, p. 233). Risk is the objective expression of calculating the probability that a phenomenon will happen, “*either through calculation a priori or from statistics of past experience.*” (ibid.) In the case of uncertainty, on the other hand, it is not possible to calculate the probability that the phenomenon will happen “*because the situation dealt with is in a high degree unique*”. (ibid.) Risk, then, does not necessarily mean eliminating uncertainty, but rather calculating probabilities based on empirical data. Importantly, in addition to a priori probability and statistical probability, Knight introduced a third, quasi type of probability that, although having a weaker basis than a priori and statistical probabilities, still provides a basis for measuring risk. Therefore, there is a gradient

from uncertainty to probability, with probabilities representing conditions qualitatively different from uncertainty, but the main dividing line is between situations where decisions are based on scientific knowledge about distributional probabilities, as opposed to situations (uncertainty) where no such rational calculations can be made. Bottom line, risk is simply measurable uncertainty.

More recently but in the same tradition, O'Riordan and Rayner (1991) distinguished between four categories of uncertainty: (i) *technical uncertainty* (lack of data); (ii) *methodological uncertainty* (deficient instruments for calculating probabilities); (iii) *epistemological uncertainty* (issues that we do not know or do not know that we lack knowledge about); and (iv) *indeterminate* or chaotic phenomena (in principle unpredictable). Generally, it is possible to bring uncertainty emanating from the three first categories into probabilities and subsequently risk.

Skinner et al. (2014, p. 196) underline that “uncertainties cannot be managed if they are not identified and they may not be identified if the potential types of uncertainty are not understood (---).” Adequate typologies are crucial, and “definitions and divisions within typologies should be comprehensive and applicable to the area in which they are to be used.” However, after reviewing 30 different typologies pertaining to environmental risk assessments, Skinner et al. (ibid. p. 216) conclude that existing typologies generally “(1) use terminology that is often contradictory; (2) communicate varying frequencies and dimensions of uncertainties (---)”. Nevertheless, drawing upon the review of the 30 typologies, Skinner et al. (ibid) reconfigure and expand the three categories of *location*, *level*, and *nature* of uncertainty (Walker et al., 2003) into a new typology. The core segment is combining nature and location of uncertainty, with epistemic and aleatory (ontic) uncertainty as the two main categories influencing on *decisions*. Encompassing this core is the level of uncertainty, running from determinacy through statistical (knowing the probabilities), scenario (knowing

the outcomes), ignorance (knowing a little) to indeterminacy (not knowing).

According to Skinner et al. (2014, p. 201), *aleatory uncertainty*, is “the inherent randomness displayed in human and natural systems” which “cannot be reduced, although additional research may help to better understand the complexities of the system(s) of interest.” The variability of aleatory uncertainty is caused by nature, human, technology and institutions. *Epistemic uncertainty*, on the other hand, is “the imperfection of knowledge concerning a system of interest” which “can be quantified, reduced and possibly eliminated, depending on the specific situation” (ibid.). Several factors are causing epistemic uncertainty: e.g. linked to system processes, data, model, human, and language.

Walker et al. (2003) make cognitive dissonance part of ontic uncertainty, while Skinner et al. (2014) locate a human dimension, including subjectivity and hence cognition, in both epistemic and aleatory uncertainty, and then into decisions. Zandvoort et al. (2017, p. 2), on the other hand, add *ambiguous uncertainty* to ontic and epistemic uncertainty, defining this as uncertainty “originating from the existence of different cognitive representations pertaining to an issue” of “diverging frames or perspectives” and differing “from disagreement as this pertains to the temporary absence of an unanimously accepted frame of understanding of an issue or its adequate handling.” Consequently, there is some disagreement about the role of human cognition. The typology offered by Skinner et al. appears as most reasonable.

However, all typologies present overlapping categories, thereby making the concept of uncertainty fuzzy, as Markussen (1999) would have it. For instance, aleatory uncertainty is inherent to knowledge, and the history of science will tell that phenomena once being part of aleatory uncertainty frequently turn into epistemic uncertainty due to better knowledge.

Relatedly, thresholds delineating the calculable from what is not calculable are not graven in stone, thereby potentially remaking configurations of uncertainties and risks under epistemic uncertainty. For instance, gradually, science has brought uncertainties linked to climate

change into the category of epistemic uncertainty and moving these uncertainties from indeterminacy into the scenario or even statistical category, although not into determinacy. Still, there are plenty of issues left, and especially the combination of uncertainty factors is causing challenges for science, as indicated above.

Notwithstanding the problems outlined in the previous paragraph, the concepts of *epistemology* and *ontology* of uncertainties are important. *Epistemology* is not just knowledge but about how we acquire knowledge, comprising approaches as e.g. positivism, realism, and constructivism. We may then ask how different approaches are capable of providing adequate knowledge for understanding and handling a certain phenomenon. Is realism providing the needed knowledge or is social constructivism a better approach, ultimately providing proper solutions? Within each epistemology, the issue of adequate knowledge would still apply: is existing knowledge sufficient or is it necessary to acquire new knowledge? “New” is crucial in this respect. Adding more data may bring more knowledge about e.g. context but may not turn into knowledge enabling us to cope with new conditions. *Ontology*, on the other hand, is about what we accept as facts, and there are different ontological approaches, as e.g. relying on empirically observed patterns or abstract, non-observable structures. Uncertainty pertains to the choice of approaches, and within each approach, the need to acquire more, as well as different facts may also foster uncertainty. On the basis of specific epistemologies and ontologies, different methodologies provide ways of doing analyses, and handling and solving cases, as e.g. the uncertainty and risk linked to how climate change materialise in different regions.

Reviewing risk *governance* and public engagements, Vegt (2017) identifies six clusters of approaches, differing according to epistemology and ontology: (i) risk governance; (ii) environmental science, policy and governance; (iii) disaster management; (iv) science and technology studies; (v) post-normal science; and (vi) public understanding of science. Of

these, the two first is categorised as realism/subjectivism; the fourth and fifth as constructivism; and the third and sixth as mixed. The approaches of Knight (1921), O’Riordan and Rayner (1991), Skinner et al. (2014) and Walker et al. (2003) are based on or at least include numbering and calculations which then are providing the basis for quantification. Likely, they would found among the first three clusters of Vegt (2017).

Nowotny (2015) underlines that quantifications under the current governance system are linked to performance indicators and control as part of risk management systems. More data is adding but still something is missing, and this is the understanding that emerging complex systems are characterised by non-linear dynamics, with multiple feedback loops and indirect cause-effects relations. The interaction of smaller risks may lead to cascading consequences across systemic boundaries. Thus, dynamics work at different time and spatial scales: “The complexity of complex systems lies in the non-linear relationships between parts and various dimensions of the whole. (---) What is locally stable must not be stable globally and vice versa” (ibid. p. 135). This leads to risk being socially contextualised, and Nowotny underlines that risks are cultural and social phenomena. This indicates a mixed approach, and Vegt’s (2017) sixth cluster may fit.

Brown and Damery (2009, p. 83) recognise that uncertainty and risk are dependent upon “our awareness or recognition of a problem, its perceived importance, and our apparent ability to resolve it”. Awareness differs, though, and together with confidence forms the basis for degrees of imperfect knowledge. The causes of uncertainty and risk may then have its roots in (i) psychological factors, as e.g. propensity for risk aversion and fear of the unknown; (ii) social factors, as e.g. language, scientific networks building on trust and consensus; and (iii) situational factors, as e.g. types of problems being addressed, including aspects as transparency, scale, variability, and complexity. As underlined by Brown and Damery (ibid.), in practice these three factors are intertwining: trust (a social factor) builds on personality (an

individual factor) and depends on the complexity of the problem in question (a situational factor).

Nowotny's social contextualisation of risk and its cultural embeddedness or Brown and Damery's three factors may align with constructivist perspectives. In this regard, it is important to distinguish between weak and strong forms of social constructivism. The weak perspective tells that uncertainties and risks represent something real but situated in people's social and cultural background. Under strong social constructivism, on the other hand, uncertainties and risks are not representing something real outside the social. It is just social and cultural constructions. It then follows that quantification and the distinction between uncertainty/risk for making choices about actions is irrelevant. Vegt's (2017) fifth cluster is home to the weak versions of constructivism. More likely, the strong version is in the fourth cluster.

Uncertainty and Risk within Climate Change Adaptation

Research on climate change adaptation comprises all theoretical perspectives presented above. Of particular interest in this regard is how IPCC's latest assessment report (AR5), giving ample coverage of the issue, presents uncertainty and risk:

Uncertainty: A state of incomplete knowledge that can result from a lack of information or from disagreement about what is known or even knowable. It may have many types of sources, from imprecision in the data to ambiguously defined concepts or terminology, or uncertain projections of human behavior. Uncertainty can therefore be represented by quantitative measures (e.g., a probability density function) or by qualitative statements (e.g., reflecting the judgment of a team of experts). (IPCC 2014, p 1774).

Risk: The potential for consequences where something of value is at stake and where

the outcome is uncertain, recognizing the diversity of values. Risk is often representing as probability of occurrence of hazardous events or trends multiplied by the impacts if these events or trends occur. Risk results from the interaction of vulnerability, exposure, and hazard. In this report, the term *risk* is used primarily to refer to the risks of climate-change impacts. (IPCC 2014, p. 1772).

The two definitions promote an objective perspective but with an opening for a weak form of constructivism through adding qualitative statements to uncertainty and diversity of values to risk. Moreover, “assessment of the widest possible range of potential impacts, including low-probability outcomes with large consequences, is central to understanding the benefits and trade-offs of alternative risk management actions.” (Field et al. 2014, p 55). For given contexts, or configurations of people and knowledge, there are deliberative processes of feedback between scoping, analysis, and implementation. Pertaining to Vegt’s (2017) six clusters, the IPCC perspective seems to adhere to one of the three first clusters (risk governance, environmental science, policy and governance, or disaster management).

The *Norwegian Directorate for Civil Protection and Emergency Planning* plays an important role for uncertainty and risk pertaining to climate change and disasters. The agency defines *risk* as the relationship between the threat towards a certain value and the vulnerability of the value to this threat. *Uncertainty* is relating to the consequences if an unwanted incidence should happen. *Probability* is the measure of how likely it is that a certain unwanted incidence should happen within a given span of time (DSB 2015). Here, the objective perspective is dominant, setting the stage for the understanding of uncertainty and risk in the public sector of Norway. This perspective also seems firmly grounded in one of Vegt’s (2017) three first clusters.

Notwithstanding the advancements made regarding the understanding and definitions of uncertainty and risk, there are still critical issues pertaining to the IPCC perspective presented

in the previous paragraphs. A core dimension of the discussion of uncertainty and risk relating to climate change and adaptation is that these problems straddle the division between nature and society and between past and future. Decision makers were used to dealing with predictable nature. Climate could be described retrospectively by studying nature, and the weather produced by this climate was entirely within the realms of natural sciences and descriptive (and objective) knowledge of nature. The probabilities of various weather phenomena, like variability in snow and rainfall, flooding, and storms over a certain period of time could be calculated more or less predictably based on more and more detailed and reliable data about nature in the past. This is where the classical concept of *risk cum technical uncertainty* applies. The very reason why we are now discussing adaptation to climate change is that this description of reality no longer applies². The climate producing today's weather is a "co-product" of natural and societal processes (Hulme 2010). Humankind is not only asked to adapt to a climate that has already changed, but indeed to adapt to a future climate that will not only be different from to-day's climate, but will also be more unpredictable given the emission of climate gases that has already taken place.

Meeting the new conditions as described in the previous paragraph, science has made use of and developed quite advanced and complex models for predicting future climate. The results can only be empirically verified in the future. Moreover, the future verification is also highly dependent on, and influenced by, the actions (or non-actions) taken today in order to address the threats described by the models. On the other hand, it is a common method to test model-based predictions by backtracking; that is, testing the model on historical data, assuming that structural forces are and will continue to be the same. This last assumption may not hold, though, making it a challenge to base policies and measures on the idea that it should be

² True, it has been claimed that anthropogenic interference with global temperature and climate may have gone on for thousands of years (Ruddiman 2008; Ellis 2011). But in any case, our practical knowledge about anthropogenic climate change goes only a few decades back in history, and may hence fall under the category *epistemological uncertainty*

possible to establish an objective measure of risk, or making uncertainty measurable.

In trying to grasp the seriousness and complexity of these challenges, science has introduced the concept “wicked problem”, resembling the emerging complexity outlined by Nowotny (2015). Rittel and Webber (1973) made a distinction between “wicked” and “tame” problems, with the latter perhaps being complicated and difficult, although still possibly broken up into smaller and manageable parts. Wicked problems, on the other hand, are not only complicated but also complex in the sense of being interlinked in such ways that if you try to solve one part of the problem you easily end up creating problems in other part of any complex system of interwoven issues (Hofstad 2013). Wicked problems have no clear definition and consequently there are no clear criteria for solving them. This makes it even more of a challenge to measure uncertainty and calculate objective risk, possibly leaving actors, communities, and societies with a complexity of uncertainties. For instance, mitigation of greenhouse gas emissions by reducing transport through higher land use densities may come in conflict with adaptation policies to keep open areas in order to retain and store more water. Production of biofuel may have devastating consequences for food production on a global scale, and land use policies to restrict deforestation or prevent development of climate-exposed land may easily come up against legitimate economic interests. Accepting the message of wickedness, the basic question becomes very simple. Is it possible to handle climate change and adaptation under the logic of risk or society(ies) need to find ways of coping with the logic of uncertainty? Is it possible to translate uncertainties into measurable risks, allowing for decisions about adaptation to climate change based on scientifically verifiable facts? At least, it is fair to say that science is facing great challenges in its efforts of providing traditional measures of risk; that is, measurable uncertainties.

Methodology and Empirical Basis

The analysis applies qualitative methodology, and the main empirical basis for the analysis is semi-structured interviews conducted with employees in local and central government agencies in Norway: 14 small and medium sized municipalities, 5 county governor's offices, and 7 national directorates. The selection of municipalities aimed at covering several dimension: city-regions and countryside, middle and small sized municipalities, coast–interior, and macro-regions of Eastern Norway, Western Norway, Mid-Norway and Northern Norway. In addition, municipalities and county governors were located in the same regions. We contacted the selected municipalities, county governors and directorates through telephone and e-mails (invitation letter). Apart from a couple of municipalities, all responded positively³. We replaced the two municipalities that refused to participate by two other municipalities in the same counties. All interviews at directorate level were conducted face–to–face, while we used telephone for all municipalities and county governors, except for one of each. The interviews lasted from half an hour to two and half hour. Face–to–face interviews tended to last for longer time than telephone interviews. We recorded and transcribed mostly all of the interviews⁴.

The interview guide comprised sections focussing 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) contradictory knowledge; (iv) barriers against adaptation, and success in adaptation efforts; (v) lack of knowledge and important future challenges. Uncertainty and risk appeared under several of these issues, and in particular under the last topic (lack of knowledge)

³ We also intended to include the counties, but it turned out to be more of a challenge to get in contact with the necessary number of counties. Therefore, we decided to leave them out. One reason for the lack of interest might be that several counties are focussing more on climate change mitigation than adaptation.

⁴ All interviewees were asked whether they agreed to recording. One of the informants at the municipal level refused recording. For this one, notes were taken during the interview.

In addition to interviews, the project mapped and made an appraisal of how knowledge on climate change adaptation and to a certain degree climate change as such, had developed in Norway since 2010. This helped contextualise the responses from the interviewees. A comparison with a parallel project⁵ on climate change vulnerabilities in 11 larger urban municipalities was also part of the project.

Analysis of Findings

Informants at all levels underlined that much had happened since 2010, including a number of public investigations and white papers. Concomitantly, measures were providing a more solid basis for introducing informed adaptation policies at all geographical levels of government and in different sectors. In this section, we first present some central outputs and outcomes of these policies. Next, we analyse the interviews conducted at local and central government levels, applying the theoretical approaches presented in the previous section.

Norwegian Adaptation Policies

Taking precautionary action is a central guiding principle of Norwegian climate change adaptation: “When considering consequences of climate change, precautionary based climate change adaptation demands using high alternatives of climate scenarios” (White paper 33 (2012–2013), 2013, p. 36). However, climate change adaptation might be adjusted, taking into account other important societal considerations, and for this purpose, cost-benefit analyses are presented as the central instrument. The White paper also states that there is much uncertainty, but that “the uncertainty of climate scenarios can be reduced by scientific research but there will always be some uncertainty pertaining to future climate” (ibid. p. 36). These principles were based on a public investigation (NOU 2010:10) arguing in favour of an extreme precautionary principle of worst case adaption, meaning that one should make use of

⁵ The project was conducted by Multiconsult and Analyse & Strategi (Jordbakke et al. 2017)

the climate scenario with the most serious consequences as e.g. one scenario for floods and another for draught. Although still adhering to the precautionary principle, the most recent report on future climate in Norway (“Climate in Norway 2100”) recommends that practitioners for the next couple of decades should use existing observations as the basis for planning, not climate scenarios because natural variations will be stronger than climate change “signals” (Hansen-Bauer et al. 2015). For instance, for sea level rise, what remains is the risk for high storm surges and for handling this it is sufficient to use observations of existing extreme values. Of course, many construction activities will have a time horizon extending a couple of decades, making it a challenge for planners and executive officers make real life decisions. The report Climate in Norway 2100 provided an update on the previous Climate in Norway 2100 report, published in 2009 (Hanssen-Bauer et al. 2009), providing a more fine-grained regional picture of future climate as well as using genuinely new knowledge for how the climate system is functioning.

Serving actual construction activities, the Norwegian Water and Energy Directorate (NVE) has issued recommendations for scaling of e.g. storm water sewers using a quotient of 1.2 to 1.5 compared with previous standard, thereby taking into account expected increase in precipitation. Complementing this, NVE has published maps telling where developers and builders should be careful regarding e.g. infrastructure and flood risks. These recommendations do not make any specific actions mandatory. Coordinated by the State Map Authority, the need for more detailed maps is met by developing the map base through digital scanning, thereby providing more accurate topographical gradients. Such maps provide

authorities and others with a better instrument for assessing the combination of e.g. sea level rise and storm surges or surface water flooding⁶.

Although the Planning Act of 2008 made references to climate change and adapting to those changes, still a need for developing a stronger regulatory basis has emerged. A public investigation issued in 2015 addressed the handling of surface water in urban areas (NOU 2015:16), suggesting measures for empowering municipal authorities to force developers and builders (private and public) to integrate climate change adaptation when planning and implementing e.g. infrastructure projects. Making those recommendations part of regulations is still in the political pipeline. From another angle, the DSB has developed procedures for conducting risk assessments⁷ (DSB 2010, 2015), as well as organising multi-level and multi-sectorial integrated staff exercises of e.g. a large flash flood in a city region of Eastern Norway (DSB 2016).

Overall, the initiatives and measures presented above, as cost-benefit analyses, adhere to an objective quantification approach of uncertainty and risk. Considering the theories presented in the previous section, it appears that initiatives for making measurements easier improves the basis for Knight's (1921) statistical probability. For instance, better and more detailed digital maps are reducing the technical uncertainty of O'Riordan and Rainer's (1991). We may also say that DSB's risk assessment procedures have reduced methodological uncertainties. Within the conceptual framework of Skinner et al. (2014), the above instruments together with regional scaling of climate change scenarios have brought the level of uncertainty from indeterminacy and ignorance into scenario, and possibly statistical uncertainty, thereby potentially impacting epistemic uncertainty, as well as ontic uncertainty.

⁶ The standard is two points per square metre, but municipalities are allowed to spend own money for more detailed scanning, using e.g. five or eight points, thereby making the map basis contingent upon local resources.

⁷ It is mandatory for municipalities to conduct local risk assessments.

The regional down-scaling of climate scenarios has come about, not just by applying new data but also by developing new knowledge linked to climate models within the frames of existing epistemology and ontology. Bottom line, the presented initiatives and measures aims at enabling practitioners to bring uncertainties of emerging changes in climate into the realms of risk assessments as an objective endeavour. In this regard, it is business as usual approaches.

Moreover, these initiatives have been taken within the existing multi-level governance system, with a mix of top-down and bottom-up mechanisms but with the top-down having the upper hand. The central government has facilitated and funded a (knowledge) network among the largest cities in Norway, the first period (2008–2014) comprising 13 cities/municipalities⁸ (“Cities of the future”), with climate change issues as one element. Uncertainty and risk were not an explicit topic but entered the scene through increasing knowledge on e.g. climate change adaptation. An evaluation (Rambøll 2015) gave the network a generally good mark, but the network did not sustain after ending in 2014, and the central government initiated a new network comprising 11 of the largest municipalities/cities. In short, funding appears as crucial for having this type of network up and running. Of course, budgets and funding are crucial for whether and how much local and central government engage in initiatives of climate change adaptation, and then indirectly government employees’ understanding of and engagement with uncertainty and risk linked to climate change (Orderud and Naustdalslid 2017). The improved instruments outlined above represent a framework for making it easier to take actions. The actual adaptation work and the understanding of uncertainty and risk at different levels, sectors, et cetera will vary, though. It is to this we now turn by presenting findings from interviews with local and central government employees.

Risk and Uncertainty among Public Sector Employees

⁸ The 13 cities were Bergen, Bærum, Drammen, Fredrikstad, Kristiansand, Oslo, Porsgrunn, Sandnes, Sarpsborg, Skien, Stavanger, Trondheim and Tromsø. From 2009, three business associations attended the network.

Generally, the conceptual understanding of risk and uncertainties is better among employees in directorates than what is the case at regional and local level. In addition, engineering employees⁹ seem to have a better command of central concepts than other educational disciplines. This pattern may be due to training in conducting quantitative calculations of probabilities and risk, and inter alia uncertainties. It is the objective perspective of uncertainty and risk that is professed. In the following, we distinguish between the municipalities (local level) and the state (national and regional level) to broaden and deepen this picture.

Local Government

A study conducted in 2007 of climate change adaptation in the Oslo region revealed that municipal officers considered adaptation policies and measures as riddled with uncertainties:

(---) so far the municipalities have done very little to prepare for and adapt to a changing climate. This is due to lack of guidelines and regulations from the central government; lack of knowledge about what changes will occur, as well as climate change being quite abstract and difficult to handle by the municipalities. In addition, local effects of climate change are considered to be quite uncertain. (Westskog and Vevatne, eds. 2007, p. 86).

The uncertainty was still an important factor five years later (Orderud and Winsvold 2012), although this differed between municipal officers in the planning sector and the water sector, with the latter acknowledging climate change as factual and seeking to gain knowledge on how to adapt. Overall, the interviews conducted in late 2016 and early 2017 reveal that the understanding of risk and uncertainty among employees at the municipal level is just so-so, and especially planners are lacking knowledge.

⁹ This is especially the case for university level engineering graduates.

Responding to a question on what the degree of uncertainty would mean for their work on adapting to climate change, a municipal planner made the statement that “It surely has but my impression is that most of us consider it as fairly certain, I have not heard anyone say anything else.” Most of the municipal officers consider the IPCC message on climate change as certain. Still, one third of them consider it as uncertain. Some respondents do not have any opinion, and some are confusing uncertainty related to global warming with uncertainty related to climate change at regional and local scales. Bottom line, many did not have any clear understanding of the implications of uncertainties for their daily work tasks. On the other hand, uncertainties and risks are indirectly part of how those employees argue or not argue, and what they do or not do.

Generally, employees at municipal level think that uncertainties are handling best by proper and adequate regulations and instructions from above, as illustrated by the following quote: “no one can tell anything for certain. Whenever we are not sure about what to do, we contact with our neighbouring [large] municipality because it is futile for us to have different regulations when we use the same developers, carpenters, plumbers, and so on”. Here, uncertainty (and risk) is about formulating regulations for builders and not really about uncertainty and risk as probabilities and statistics. Similarly, several respondents asked for clearer regulations and instructions from the state: “in my opinion, higher administrative levels should provide clearer instructions (---) their guidelines do not require action to be taken, they are just recommendations (---) I would like to have something firmer, allowing us to back up demands for measures to be taken by builders”. This means that they ask for regulations and instructions making it easier to do executive work and monitoring of plans and construction activities carried out by builders and developers.

A reason for relying on regulations and instructions from higher administrative levels is municipalities’ lack of capacity and capability in handling e.g. development plans submitted

by builders. The builders are fully aware of the legal framework and its grey zones. The following statement is illustrating.

We may ask for documentation on whether an area or plot of land is developable for particular purposes (---) when we are not certain, we not just rely on a simple risk appraisal by the developer but ask for geotechnical surveys according to guidelines issued by the NVE (---) asking for this early in the process removes the uncertainty regarding an area's suitability for particular purposes.

Here, regulations and guidelines issued by higher administrative levels are backing up demands for investigations, but those investigations may not as such reduce uncertainty linked to climate changes.

It makes sense for local government employees to rely on national regulations. Few of them have the capacity and capability of calculating uncertainty, probabilities, and risks for all cases they have to deal with. This also shows that they trust regulations issued by the central government. Accepting global warming contributes to accepting national level regulations. They have an idea about how the national level system is structured: science based (the objectivist approach of uncertainty and risk) and thorough processes before issuing regulations. On the other hand, although accepting the precautionary principle, the extreme version of this principle is not that easy to accept for everyone.

In some municipalities, the understanding of uncertainties and risks is more developed. Commonly, this is the case for municipalities (recently) having experienced e.g. river floods or flash floods. As conveyed by one informant, this makes it easier to have the necessary resources allocated for conducting investigations,:

It is not easy to know how large and devastating any future floods will be (---) we have worked a lot on this issue, establishing a good knowledge base (---) we must

accept flood damages in some places (---) we try to identify the most flood vulnerable areas, focussing more on risk and preparedness.”

Still, it seems to be taken for granted that it is possible to transform the uncertainties into measureable risk. A somewhat more developed response did combine scalar uncertainty with technical instrument (maps), the precautionary principle, and the role played by politicians:

It is a challenge bringing this knowledge down to the local scale [sea level rise] and make it more certain (---) previously the map base did not allow us to illustrate the effects (---) uncertainties regarding knowledge make construction activities more difficult, we have to make use of the precautionary principle but in addition, the policy-making process may also cause uncertainties.

The nature of policy-making as a reason for uncertainty differs from uncertainty caused by knowledge on climate change. However, in a longer perspective, policy-making is influencing on climate change, and local policy-making may be influencing local vulnerabilities, especially for the long-term consequences of and adaptation to climate change. Moreover, local politicians may not like strong national level regulations because it may run against priorities for economic development. Therefore, regulations are also a means for municipal administrations to cope with local politicians. Quite a number of municipal officers hinted at lack of support from politicians as an important reason for inadequate or no climate change adaptation, regarding gaining knowledge and taking actions.

In summing up one may conclude that local managers and planners are generally convinced that climate change is real but they are at the same time deeply concerned about uncertainties relating to local effects and consequences. There is a general call for and an expectation that more research and more knowledge can turn these uncertainties into calculable risks – knowledge which then will be communicated back to local authorities in the form of

guidelines and regulations. This will remove (much of) the burden of uncertainty off the shoulders of municipal officers but not necessarily remove any insecurities caused by a changing climate as well as how to adapt to these changes.

Central Government

For municipal officers, regulations and instructions from higher administrative levels may provide the basis for handling uncertainties related to e.g. development projects, thereby introducing risk. At the *state level*, and in particular for employees in directorates, relying on higher administrative levels is not any option. Although the IPCC to a certain degree is a higher “administrative” level it is more like a research-based knowledge source, contributing science reports and policy recommendations. Handling of uncertainties and risk at the directorate level is very much about engaging with science through research projects, reports, and discussions. There is a close collaboration between directorates and science. This collaboration provides and requires more in-depth understanding of uncertainty and risk among employees in the directorates, an understanding that also is evident from the interviews. The *regional state* (county governors) generally relies on national regulations, instructions, and guidelines, but many also have a good understanding of concepts of uncertainty and risk, again within the objective approach, contingent upon work experience (type and time) and educational background.

Competences in risk, uncertainty, and probability are good among engineers, trained in the methods of calculating risk et cetera, and they have the competence of making critical judgements and assessments, as the two following quotes by engineers are illustrating:

It is difficult to translate the higher climate scenario from global to local scales (---) it is about frequencies of events and how scaling flood paths and water pipes is a

challenge because we do not exactly know the basis for deciding pipe sizes due to the high degree of uncertainty (---) we have got guidelines for how much to increase pipe sizes but these guidelines is not taking into account the intensity of short term rainfalls (---) the statistics at the local scale is lacking (---) next, we must identify criteria for acceptance of risk related to cost–benefit (---) finding the limits for taking measures is quite a challenge.

Climate models tell us that the global temperature will have risen so and so much in 2050 and 2100, and there is a certain uncertainty attached to those scenarios, and then there are some difficulties in making national and even more for regional down-scaling (---) we face large uncertainties. We want to build physical infrastructure in a way that provide the best result for the lowest economic cost, and the higher the uncertainty inherent in the physical environment, the more difficult this is (---) climate change makes this even more complicated (---) I believe it is possible to adapt to a changing climate but the question is about practicalities and costs (---) climate change is causing problems because it is making an unclear picture even more cloudy.

These respondents represent those asking for more and better data in order to conduct necessary assessments, addressing technical uncertainty, and inherently methodological as well as epistemological and ontological uncertainty within the dominant paradigm.

Underlining methodological and epistemological uncertainty one respondent described how a big flood had been eye-opening, directing attention to the need for taking into account regional scale cascading events for understanding and predicting how extreme flood events may develop. Moreover, those who have experienced a 200-years flood raging down a hillside may have acquired a better understanding of the risk involved in extreme flood events.

Another respondent, after stating that the knowledge on global warming and a changing climate is highly certain, goes on to recognize that “taking this into account in planning is a different story (---) land use decisions very often will be determined by developers pursuing short term economic profit.” Although underlining the role of knowledge and the need for more knowledge, this informant was fully aware of the role played by other factors, and that it is not necessarily uncertainties attached to climate change as natural processes but as much the dynamics of several factors that are making the calculation of uncertainties, probabilities, and risks difficult.

The three quotes referred above bring economic factors onto table when it comes to taking adaptation actions. When this is linked to cost–benefit analyses as part of calculating risks, epistemological, ontological, and methodological uncertainty may enter because of the challenges of e.g. applying the discount rate across generations (Schelling 1995), or that future generations’ existence is contingent upon how today’s generations act, and if acting differently today different people will gain in the future (Davidson 2008). However, interviewees did not bring such issues forward. In general, informants voiced the belief that calculating risk hinged on getting the necessary data, but a few were clearly aware of the need to improve the epistemological and ontological basis for making calculations, although within the existing dominant science–policy paradigm.

Others, within the same tradition, distinguished between (point source) pollution and broader environmental conditions. Point source pollution was handled through risk assessments: “the higher the probability for a particular pollution, the larger is the risk, and this we handle by stricter regulations regarding preparedness (---) climate change is just one additional factor to take into account when calculating the risk for an incident.” Adaptation is much more demanding for the second type, the broader environmental changes. Recognising this could lead into questioning of the dominant science–policy paradigm, and a push towards

addressing alternative epistemological, ontological, and methodological approaches for coping with uncertainties.

Several of these quotes are aiming for detailed calculations as the bases for taking action.

However, one of the informants argues that it does not matter much whether it is raining 20 or 40 per cent more, pertaining to using ordinal measuring for coping with uncertainties. This may hold if the adaptive measures cover a wide range of the effects of climate change, for instance if the size of the gutters does not change although the rainfall increases 20 or 40 per cent. This is an empirical question, demanding more in-depth studies and thereby challenging the basis for the reasoning. It is an issue relating to methodological uncertainty.

Discussion

In general, the understanding of the concepts of uncertainty and risk at the local, municipal level is just so-so, although engineers tend to have a grasp on such issues than others.

Nevertheless, municipal officers describe issues directly and indirectly linked to uncertainty and risk. First, they are asking the state level for detailed information and regulations telling how to handle e.g. building applications and real estate development, thereby enabling the municipal officer to formulate and implement adaptation measures. Second, political support for climate adaptation policies and actions proposed by the administration is not at all certain. Natural events are more or less part of the story but the core of these two types of uncertainty is the political will, capacity, and capability to design, implement, and enforce measures, as well as doing monitoring and maintenance work. Therefore, uncertainties caused by lack of adequate regulations and political support may be resolved without any or little change in what traditionally is considered uncertainties and insecurities of particular natural events.

Over time though, and applying a process perspective, adaptation actions taken or not taken will influence on the location and scale of what is often considered natural events. Although it is important to distinguish between uncertainties linked to the occurrence and severity of

natural events and those linked to regulatory-political factors, it is likewise important to link them together in spatio-temporal dynamic processes. Doing so brings into attention the complexity of feedback loops and rebound effects, and instead of the simple nature–society dichotomy, we soon find ourselves enmeshed in integrated socio-natural processes; hence, also the complexity of wicked problems.

Taking note of the complexities and long-term, stochastic uncertainties regarding effects of e.g. climate change, Zandvoort et al. (2017) argue that planning approaches have to take into account ontic, epistemic, and ambiguous uncertainties to achieve coherency, but by making adaptiveness subject to knowledge claims and consensus it could impede on solutions contingent upon uncertainty of an ontic type. Our findings on uncertainty at the municipal level resemble some of the points made by Zandvoort et al. (2017): successfully taking actions mean coherency in addressing different types of uncertainties, but it is necessary to consider the interaction of municipal and state levels, as well as local, regional, and national scales. For instance, the state level (national and regional) is providing knowledge and, hence guidelines and regulations, while the municipal level generally are accounting for contextual facts and ontic uncertainty. Therefore, considered as a whole, we may conclude that the government is handling uncertainty and risk more adequately as a whole than what each level separately.

However, as laid out in section 2, we see epistemology and ontology to also comprising competing systems of knowledge and factual bases, respectively. The public sector is handling uncertainty and risk under climate change as business-as-usual; that is, bringing uncertainties into probability distributions and determining risks through measurements and quantifications. According to Nowotny (2015, p. 126–127), “Bureaucracies have always favoured proceduralism and, more generally, risk management strategies that strengthen procedural rationality at the expense of substantive rationality.” Furthermore, the current

procedural system is merging an auditing tradition and the New Public Management (NPM: governing public sector and services as a quasi-market). Everything becomes subject to risk management.

Two central issues in this respect are (i) what errors follow from applying the epistemology and ontology of traditional uncertainty–risk calculations?, and (ii) what may replace it? On the first issue, one obvious answer is that risks may be miscalculated and misjudged; that is, taking actions based on too low or high estimates of the magnitude and intensity of e.g. floods and storm surges, and droughts and wildfires. Since making conservative risk estimates relying on empirical and historical data may be the preferred approach within e.g.

infrastructure construction, too low estimates may dominate. The recommended upsizing of water and drop pipes may counter such tendencies, but still the uncertainty of what actually will be necessary remains. Another source of errors is that processes are misunderstood, and hence communities and societies are unprepared for what is coming. This may be the case when changes are embedded in complex processes comprising unforeseen feedback loops, making disentangling causalities a scientific challenge, and especially so because society and nature generally is intertwined. Relying on business-as-usual uncertainty–risk calculations may cause systemic lock-in, blocking science and others from asking “radical” questions.

It also should be underlined that possible positive consequences of climate change may be under-/overestimated. However, our finding is that currently both municipal and state employees are generally focussing on how to adapt to possible negative effects of climate change. This may, as claimed by Nowotny (2015) be a consequence of the business-as-usual system of uncertainty–risk.

Turning to the second issue, what may replace the business-as-usual approach? Or is it feasible to replace the current regime? For years, social science has argued for changing the dominant approach. Burton et al. (2006) underlined the need for taking a broader societal

approach as opposed to a more “nature-based” and technological approach, making the calculation of objective risk problematic. More recently, Knieling (2016, p. 4) has argued that transformative adaptation is required. This means moving beyond incremental or piecemeal adaptation, introducing an adaptive strategy comprising “a multitude of factors affecting technology, economy institutions behaviour culture, ecology and paradigms, introducing regime shifts and consequently new regimes.” The business-as-usual uncertainty–risk model would fall short, possibly fail under such an approach. Notwithstanding the arguments put forward by these and other social science researchers, business-as-usual approaches linger on. A better strategy may be to facilitate and foster a multitude of approaches, or at least approaches that introduce some disruptive forces to the dominant approach. Such a strategy may align with approaches favoured by both Skinner et al. (2014) and Zandvoort et al. (2017) of combining different types of uncertainty (and risks). This would also introduce approaches like Swyngedouw’s (1999) two opposite cycles of socio-nature or Moore’s (2015) double internality of society in nature and nature in society as part of an environmental world history. Such approaches might facilitate science, civil society, and policy-makers to ask new questions, thereby possibly developing a better grasp on how to handle wicked problems.

Returning to socio-natural challenges as wicked problem, and hence governance, the inadequate understanding and handling of uncertainty and risk at the municipal level indicate that a top-down approach is necessary. On the other hand, providing the necessary contextual basis for making any assessments and handling of any concrete cases lends weight to a stronger role for the local level, and a bottom-up approach. Apparently, multi-level governance is the preferred governance approach. Furthermore, enabling the combination of different approaches of uncertainty and risk may favour multi-level *network* governance; that is, facilitating disruptive processes and avoiding path dependent lock-ins through systematic use of different knowledge sources and stakeholder groups. Applying Vegt’s (2017)

governance typology, a struggle between e.g. Risk governance and Science and Technology may be more difficult to handle than between Risk governance and Environmental science, policy and governance.

The more interesting issue then turns out to be the balance between top and bottom, as well as between different knowledge sources and stakeholder groups. The government may function with the strongest power firmly rooted at the top or bottom but contingent on effective bottom-up information channels or top-down regulatory frames, respectively. Similarly, certain knowledge sources and stakeholder groups may be more influential than others are. The danger, though, is that the balance is tilting too much in particular directions, or that struggles between different levels, knowledge sources, and stakeholder groups more or less are enmeshing and paralysing public governing, and hence undermining the governance system.

For policy-makers and the government, multi-level network governance appears as a strategy for better coping with wicked problems. However, as the above paragraph indicates, this is not a granted outcome. Struggles may under certain conditions add to the complexity and aggravate the wickedness of existing socio-natural challenges; that is, policy incoherence may cause confusion and potentially undermine governmental legitimacy. Furthermore, inviting different approaches and stakeholders to take part in policy-making processes and subsequently actions also means allowing different perspectives to have an impact on policy design and actions. If not, over time the legitimacy of such processes runs the risk of eroding, and ending any meaningful contributions from different knowledge sources and stakeholders.

Conclusions

The understanding of uncertainty and risk in relation to climate change and adapting to a changing climate is so-so in small and medium sized municipalities, but better at the national level (the central and also the regional state). Nevertheless, the local level expects the state to

provide the means for taking adaptation actions. Although municipal employees underline local politicians as source of uncertainty for formulating and implementing adaptation measures, the overall understanding of uncertainty and risk is one of risk as objective, objective, measurable uncertainty. In short, business as usual approaches to uncertainty and risk. This runs counter to much social science reasoning, arguing that the business as usual approach fall short of what is required for coping with a changing climate. The result may be lack of capacity and capability of handling socio-natural (extreme) events, originating from a changing climate. Introducing and combining different approaches to uncertainty and risk may provide a basis for better coping with emerging uncertainties, thereby improving governing outcomes. Multi-level network governance appears as the appropriate governance system for the interaction of different knowledge sources and stakeholder interests, thereby contributing to countering, or at least making wicked problems less wicked. However, the danger of aggravating complexities also is present, due to struggles between different knowledge sources and conflicting stakeholder interests.

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