Summary of the project "Consequences of climate change for infrastructure owned by municipalities and counties"

Bacground

The project "Consequences of climate change for infrastructure owned by municipalities and counties" has been carried out by Western Norway Research Institute (coordinator), SINTEF, and The Bjerknes Centre for Climate Research. The Association of Executive Managers in Sogn og Fjordane has functioned as the project's reference group. A discussion meeting has been held with representatives from the NOU Climate Adaptation Committee which presented a Norwegian Official Report on climate adaptation in November 2010.

The project has provided research on three themes: (1) Climate vulnerability: assessing possible consequences of climate change for infrastructure owned by municipalities and county councils. (2) Climate adaptation: proposing measures which may be implemented in various municipal sectors and within local and regional planning, given the existing climate projections. (3) Barriers: outlining possible barriers that may arise in connection with climate adaptation.

Physical infrastructure is defined as land-use planning, water supplies, water and sanitation management, public buildings, public transport, transport infrastructure, as well as power supplies and electronic communication. Municipal physical infrastructure refers to infrastructure which is owned by either municipalities or county councils, infrastructure which these bodies have a primary responsibility for operating, and other public infrastructure in cases where this is indirectly relevant for the municipal sector.

The future climate vulnerability of society is a sum effect of how both climate and society change. We have therefore made a distinction between three forms of climate vulnerability: (1) Natural vulnerability: Climate parameters: precipitation, temperature, wind. Effect parameters: run-off, sea level, and storm surges. (2) Socio-economic vulnerability: Extent and loss of farmed and arable land. Quality and level of operation/management of physical infrastructure. Location of physical infrastructure. (3) Institutional vulnerability: Access to competence, administrative capacity, economic resources, knowledge, tools, and instruments for implementing climate adaptation

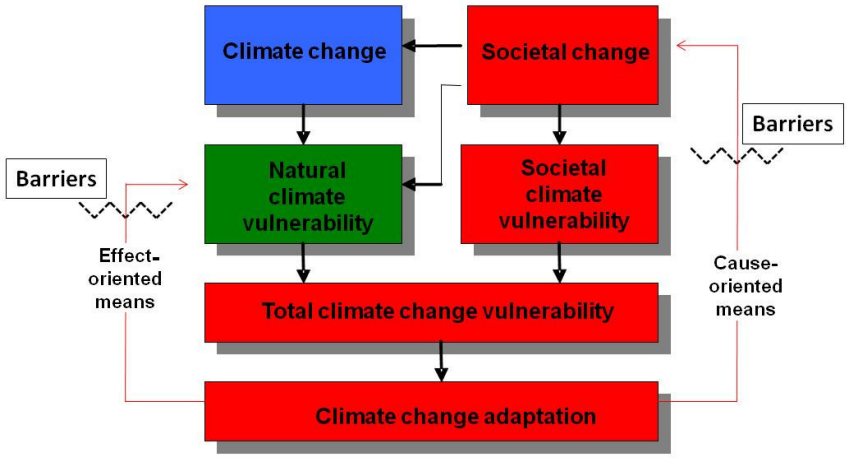

Figure 1: *The analytical model applied in the project*

Method for working with climate adaptation in connection with infrastructure owned by municipalities and county councils

Relating to the possibility of climate change entails deciding how to relate to *risks*. There are at least three approaches to this: (1) Taking risks, i.e. taking the least dramatic projections of climate change as a starting point and hoping that things do not turn out worse. (2) Considering averages, i.e. look mainly at the average values for

projections of climate change. (3) Avoiding risks, i.e. taking the most dramatic projections of climate change as a starting point and hoping to be positively surprised if matters turn out better than expected. NOU Climate Adaptation argues that it avoiding risks is the most beneficial option, as do the authors of this report. Moreover, we have stressed the importance of considering the entire value range in different climate projections, because in principle, all values between the extremities represent equally likely outcomes. As a contrast, we might have selected a mid-range value and presented it as a more likely outcome than e.g. the maximum or minimum values.

Assessments of *uncertainty* are central in the debate on climate change and climate policy. One the one hand, it is important to be clear about the great uncertainty associated with this field. At the same time, it is vital to avoid a state of non-action based on the assumption that 'everything' is uncertain. A possible solution to this dilemma is to try and differentiate our understanding of uncertainty. We have therefore suggested a two-dimensional approach to describing uncertainty. The first axis pertains to where uncertainty is located; i.e. where in the systems 'climate', 'nature', or 'society' the uncertainty in question exists. The other axis pertains to the type of uncertainty at hand, where we distinguish between basic uncertainty, model uncertainty, scale uncertainty and data uncertainty.

On the basis of the discussions of NOU Climate Adaptation and discussions from this project, we propose the following *ten criteria for prioritization of climate adaptation measures*:

1. Adapt to the climate of today.
2. Establish sufficient institutional capacity for implementing climate adaptation measures.
3. Carry out climate vulnerability analyses.
4. Inform the public about local vulnerability and adaptation challenges.
5. Consider whether a 'wait-and-see' attitude is sensible before implementing further measures.
6. Make strategic priorities prior to operational work.
7. Cause-oriented measures should be carried out before effect-oriented measures.
8. Give priority to 'no-regret measures' (measures that are sensible regardless of climate scenarios).
9. Climate adaptation must not lead to considerably higher emissions of greenhouse gases.
10. Climate adaptation must not be in conflict with the overall goal of sustainable development

The term barrier refers to identifiable 'resistance' against implementing a desired climate adaptation strategy or measure. In our analyses, we have distinguished between four main categories of barriers: Conflicts of interest, barriers related to the choice of instruments, organizational barriers and uncertainty barriers.

Overall assessment of climate vulnerability

If we consider the above climate vulnerability assessments all at once, comparing our three vulnerability categories – natural, socio-economic, and institutional vulnerability – vulnerability appears as somewhat equal in the sense that we have considered these in much the same way in our rough distinction between 'high, 'mid-range' and 'low' vulnerability. It is obviously wrong to compare direct rankings in such different systems. As an example, it is not easy to determine whether or not 'high' natural vulnerability (e.g. in the form of increased precipitation and flood hazard) is equally serious as 'high' vulnerability within the socio-economic vulnerability (e.g. in the form of increased construction near rivers and thus increased exposure to flood risks). Our comparison across vulnerability categories still gives reason to raise one important point: it is not sufficient to see natural vulnerability se in isolation when assessing climate adaptation measures. In many cases, socio-economic changes may be just as decisive for the overall future climate vulnerability as climate change seen in isolation. This insight may also determine the choice of adaptations strategies and measures. The clearest example of this is found within agricultural production, where several previous analyses have showed that climate change may turn out positive for the agricultural sector. Our conclusion is that if expected changes in climate and society are considered all at once, it is more correct to say that agriculture is associated with great adaptation challenges, and that these challenges are as related to societal changes as to climate change.

If we compare our infrastructure categories, we see greater variation than overall and between vulnerability categories. In our analyses, harbours appear to be the least vulnerable sector, while agricultural production; buildings; and water and sanitation appear to be the most vulnerable. The sectors transport; information technology; and energy supplies are found in a mid-range category.

We have also attempted to present regional variation in climate vulnerability. Because we apply a two-dimensional assessment (in some cases three-dimensional) of climate vulnerability (natural and socio-economic – we have in some cases split the socio-economic vulnerability category into socio-economic and institutional

vulnerability), it often proves difficult to generalize on the overall regional variation. The natural vulnerability often has a different regional variation than the socio-economic; or we have more certain knowledge of one of the two (or three) vulnerability dimensions. Below, we have still attempted to give a concise summary of regional variation in overall climate vulnerability for the different infrastructure categories.

- Agricultural production: Difficult to estimate because it is generally difficult to quantify the sum effect of climate change on production conditions.
- Placement of infrastructure: Western and Northern Norway are probably the most exposed to rock falls, mud slides, and avalanches, whereas Eastern Norway and central parts of Western Norway are the most flood-prone.
- Buildings: Rot problems are expected to occur all along the Norwegian coast, and in inner parts of Eastern Norway and Trøndelag.
- Water and sanitation: A general precipitation increase is expected all across Norway, with the smallest increase along the coast and the highest in inland regions. The oldest pipelines are generally found in Oslo.
- Roads: The greatest challenges should be expected in Western and Northern Norway, but good national vulnerability assessments are still to be carried out.
- Harbours: Ocean-level rise and increased wind speed will probably affect Western Norway the most, and this is also the region with the greatest transport volume. However, the greatest socio-economic vulnerability is found in Northern Norway, where an increase in the volume of sea transport is expected.
- Transport work: The greatest problems are expected along the coast and fjord areas in Western Norway and in Northern Norway.
- ICT and power supplies: The regional variation in relevant climate parameters indicates that the greatest negative change will take place in Trøndelag and Western Norway.

Overall assessment of climate change adaptation

As for climate adaptation it would be sensible to distinguish between measures which are mainly directed towards municipalities and counties and measures which are directed towards the state, but are still of relevance locally and regionally. Furthermore, it may seem sensible to distinguish between key measures and less extensive measures within climate adaptation.

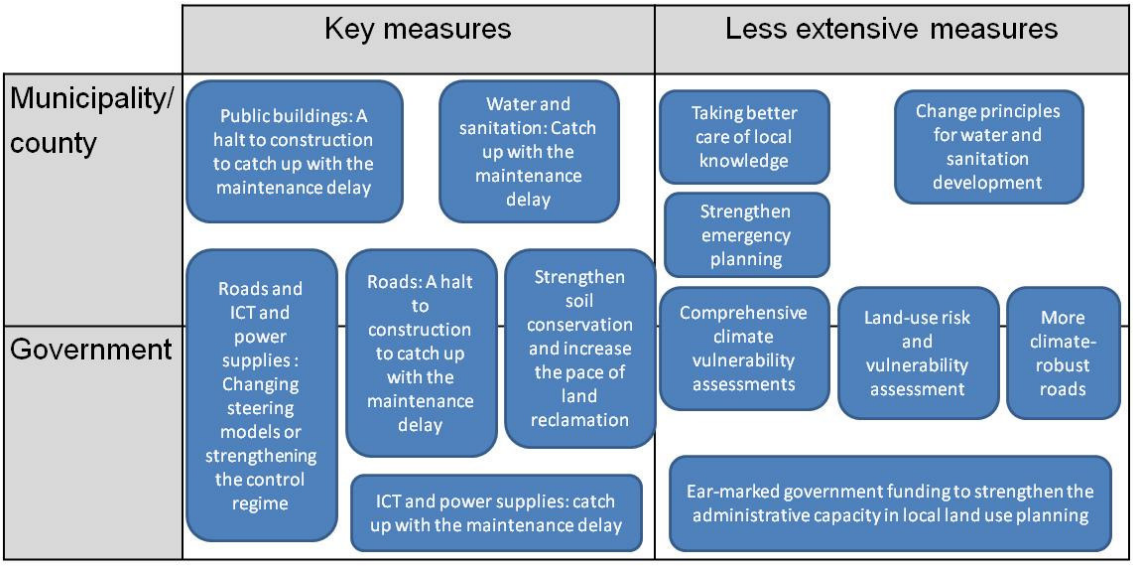

Figure 2 *Main categories of suggested climate change adaptation measures*

The key measures that mainly encompass municipalities and counties include the following: ”A halt to construction” to catch up with the maintenance delay in public buildings, and catching up with the maintenance delay within water and sanitation. In the interface between the state and the municipalities we find the following three key measures: Changing steering models or strengthening the control regime both within ICT/power supplies and in the road sector, ”a halt to construction” to catch up with the maintenance delay in the road sector,

and strengthening soil conservation as well as increasing the pace of land reclamation dramatically. A key measure which mainly pertains to the state – in collaboration with private actors – comprises catching up with the maintenance delay within ICT and power supplies.

The less extensive measures pertaining to the municipalities and counties include, first of all, two measures shared by all infrastructure categories: Taking better care of local knowledge and strengthening emergency planning. In addition, it is challenging to change principles for water and sanitation development, including a greater extent of surface water treatment.

In the realm between the state and the municipalities, two measures are common for all infrastructure categories: carrying out a comprehensive climate vulnerability assessment and following up the demand to carry out a land-use risk and vulnerability assessment. Another shared challenge is to build more climate-robust roads. According to the recommendations of NOU Climate Adaptation, this challenge could entail the introduction of ear-marked resources to strengthen planning competence in the municipalities.

Overall assessment of barriers for climate change adaptation

It is important to be aware of the fact that our assessments of barriers are hypothetical barriers in relation to implementing adaptation to climate change. We have based these on views and suggestions presented by interviewees in the state, counties, and various municipalities. An analysis of actual barriers would have to be done after carrying out adaptive measures, and very few municipalities and counties have come that far at this point. The main insight of our analyses is, first, a possible method that each municipality and county may apply to analyze possible barriers; second, to arrive at some form of check-list that actual barriers which may occur (on the basis of previous experience). The character and strength of such barriers will to a great extent depend on the local situation.

Having considered the various barriers for all categories of infrastructure all at once, it is clear that the type of barriers that occur are most often weak local (political and/or administrative) competence and/or weak administrative capacity. This corresponds to other analyses of municipalities' view of barriers in municipal environmental work. Second, we find a lack of risk and vulnerability assessments and/or planning of climate change adaptation, as well as uncertainty associated with climate projections. This is also in line with previous findings from studies carried out by the Directorate of Civil Protection and Emergency Planning and others. A maintenance delay is mentioned together with two other categories pertaining to weaknesses in the local organization: Poor distribution of responsibility and/or coordination, and lacking consideration of climate change in connection with planning, routines, and measures.

The ranking of barriers we have carried out must not be understood as a weighting of barriers according to 'importance' in terms of offering the greatest 'resistance' against the implementation of adaptation measures. Even though a barrier is mentioned several times (such as 'weak competence' and 'administrative capacity') this may in practice be less difficult to overcome than a less frequently mentioned category (such as 'maintenance delay', which would be much more costly to overcome than strengthening competence and increasing administrative capacity). The ranking can however be used as a check-list for the types of barriers one may expect to encounter.

Uncertainty

Uncertainty is a key aspect of climate change. It is important to be aware of a basic difference regarding how research and decision-makers relate to uncertainty and knowledge production. Decision-makers often expect that one of the purposes of bringing about new knowledge is to reduce uncertainty, while research often focuses on shedding light on uncertainty in the production of knowledge. In other words, there is reason to ask whether there is a mismatch between decision-makers' expectations concerning preciseness of steering signals and knowledge which can be brought about in the type of analyses this project encompasses. Therefore, there is reason to ask whether the question of climate adaptation is by nature a policy area that ought to be subject to the cautionary principle. It is highly demanding to develop a practical framework for such a policy area. There are elements of such a policy in the Norwegian governance of the Gene Technology Act. In any case, uncertainty should not be used as an excuse for non-action – a delay of measures will in many cases increase costs dramatically. Examples include seaside construction that disregards ocean-level rise, construction in areas that may become more prone to natural hazards in the future, and irreversible encroachments on farmed and arable land.