Robust decisions for managing climate risks in Sweden

1. Aim and goal

This research programme aims to facilitate robust decision making, in order to improve societal planning to manage uncertain climate risks and natural disasters in Sweden. To achieve this, the project will analyse how robust decision frameworks can best be integrated into ongoing planning processes at regional and municipal level, and into critical infrastructure projects of national importance. Based upon the experiences obtained, recommendations for future use will be formulated. The long-term goal is to strengthen societal capabilities in Sweden by developing tools that enable prevention of, rather than reaction to, crises caused by climate change. Overall, this will increase resilience.

2. Background and research questions

Planning and implementation of preventative measures relating to climate change requires the major uncertainties inherent in risk assessments relating to natural disasters and extreme weather events, and how these might change over time, to be considered. Uncertainties relating to changes in society must also be taken into account, including how vulnerabilities are altered and affected by complex dependencies between different systems and parts of society (e.g. indirect effects of climate change).

If these uncertainties are not managed in a smart way, they could result in significant economic costs or increasing risks of accidents and disasters. One smart approach is to make more *robust decisions*, i.e. decisions that have acceptable results with respect to various potential outcomes and that avoid excessively costly or catastrophic outcomes. Robust decisions also encompass flexible or adaptive solutions, e.g. delaying costly or far-reaching decisions until more is known about how the uncertainty is developing. Robust decisions generally contribute to increased resilience, i.e. the capability to resist and resolve disruptions, recover and maintain and improve essential functions.

Robust decision making is based on a different approach to managing climate risks that has been described as a move away from 'Predict-then-Act' to a 'Seek Robust Solutions' paradigm (Weaver et al. 2013). However, there are many different approaches or methods, here called *robust decision frameworks*, which fall within the latter paradigm (e.g. Hallegatte et al. 2012, Ranger et al. 2013) and it is unclear which method is most appropriate in different contexts. One important aspect of robust decision making is that it starts from the *vulnerabilities* in a system.

Internationally, robust decision making approaches are increasingly being applied in different areas, including flood risk management in New York, London and the Netherlands (Hasnoot et al. 2014), and freshwater resources in California and Lake Superior (Weaver et al. 2013). In Sweden, robustness is stated as an important goal in recent regional climate adaptation plans (Länsstyrelsen i Stockholm 2014, Länsstyrelsen i Skåne 2014). Moreover, recent reviews of the current status of adaptation to climate change in Sweden highlight the need for better understanding and management of uncertainties (Andersson et al. 2015) and the potential of robust decision making in Sweden (Knaggård 2015).

Given this background and predicted future challenges, the research program will examine **four research questions**:

i) In what planning contexts/situations in Sweden is robust decision making related to climate risks and natural disasters particularly needed?

ii) How can such robust decision making best be introduced and applied in these contexts and situations?

iii) Can the introduction of robust decision making change the perception of climate risks and risks of natural disasters among decision makers?

iv)What are the current limitations on greater use of robust decision making related to climate risks and natural disasters in Sweden?

3. Methodological approaches

Given the long-term goal to strengthen societal resilience to challenges posed by climate change, the research project will follow four overall methodological approaches:

1: Integration into ongoing processes is important. As pointed out in previous research, climate change adaptation needs to be integrated into current processes in all sectors and at all levels, rather than developing its own means and structures (Glaas 2013, Wamsler et al. 2014). The impacts of climate change, including more frequent natural disasters, and the inherent uncertainties in analysing these impacts must thus be included in ongoing adaptation processes in society. One process identified as vital is risk and vulnerability analysis (Andersson et al. 2015, p. 265). Other relevant processes are long-term planning and decisions on major investments. The proposed project will use three ongoing processes in Sweden in collaborative work on how they can strengthen their robust decision-making.

2: Collaboration with process owners is crucial. One insight regarding how decision-making support tools can be developed and used, which derives mainly from experiences obtained using the research programme Climatools[1], is that the needs of process owners must be considered. This means that researchers need to collaborate closely with e.g. civil servants and politicians. The proposed research is thus transdisciplinary, meaning that users, i.e. process owners, will be involved throughout the research process rather than simply being a target group for communication in the final stages of the work (Mobjörk 2010).

3: Understanding risk perception and its role in decision-making makes it easier to develop relevant methods. The importance of individual risk perception among experts has been demonstrated in previous studies (Sjöberg 1999, 2002, Sjöberg et al. 2005), suggesting that experts and decision-makers are affected by their individual perceptions of risk. It has also been argued that more robust decision-making on climate challenges requires changes in risk perceptions and prioritisations in society (Hjerpe et al. 2014). This project will therefore investigate risk perception among the actors involved and analyse whether they are affected by involvement in a process shaped by robust decision-making.

4: Intervention in ongoing processes gives a better understanding of how robust decision-making can be applied. In order to investigate how robust decision-making can be achieved and the importance of decision-makers' risk perception in this, we will not only analyse three ongoing processes, but also intervene in these processes. This intervention will target a fictive case, but will set a plausible challenge to which experts and decision-makers must respond. This approach can help achieve a deeper understanding of a robust decision making framework and how it may be used in ongoing processes. It will also lay the foundations for analysis of risk perception among the experts and decision makers involved.[1]

Based on these four fundamental methodological approaches, the project will develop robust methods for supporting decision-making for climate adaptation, in close collaboration with ongoing processes in Sweden that involve stakeholders at local, regional and national level. We have also identified three planning processes that represent different levels of decision-making and timescale, which we will study and interact with in the project:

1) ***Risk and vulnerability analyses at municipal and county level***. FOI will be working with the County Administration Board in Västra Götaland in different projects to develop processes relating to municipal RVAs, to integrate aspects of climate adaptation into these RVAs and to develop visualisation tools for compiling and visualising overall risk. The county has 49 municipalities, which all perform their own risk and vulnerability analysis. Based on these, a regional RVA is carried out. The proposed project will build on work currently underway in Västra Götaland, but will add the component of how RVAs can be used to support robust decision-making, e.g. in the "*Västsvenska paketet*", an infrastructure project in Western Sweden. Municipal

[1] In addition to these methodological approaches, a range of specific research methods will be used in WPs, including literature reviews, construction of conceptual models (Hansson 2013), semi-structured interviews (Dillman et al. 2014) and workshops/focus groups (Morgan 1997). For more details see section 4.

RVAs have a short timescale, normally a few years, but are relevant as a basis for investment decisions.[2]

2) ***Long-term urban and regional planning***. Here we will be monitoring the updates to the Regional Development Plan for the Stockholm Region (RUFS) being undertaken by Stockholm County Council (SCC) and the County Administration Board in cooperation with the municipalities in Stockholm County. This process was initiated in early 2015 and is expected to be completed in 2018. It involves updating the regional plan for Stockholm, which will then guide planning efforts in the municipalities. The RUFS has a medium to long timescale, 30-50 years, and forms the basis for more detailed decisions and for controlling decision-making, e.g. by prioritising land use.[3]

3) ***Planning critical infrastructure.*** Here we will monitor the process of designing the final repository for short-lived radioactive waste being prepared by SKB. The final repository is associated with extremely high safety requirements and SKB has great experience of dealing with extreme scenarios. We will specifically study how to deal with the great uncertainty in terms of future sea level rise over the course of the final repository's active life (timescale ~20-100 years). Lessons concerning robust decision-making learned from planning a large critical system will be disseminated to other planning of critical infrastructure. In addition, SKB will conduct its own project examining how thinking concerning managing uncertainties associated with climate change has developed within SKB.[4]

4. Work plan and organisation

The research programme comprises six work packages (WPs). The timing and relationships between these WPs are illustrated in Figure 1.

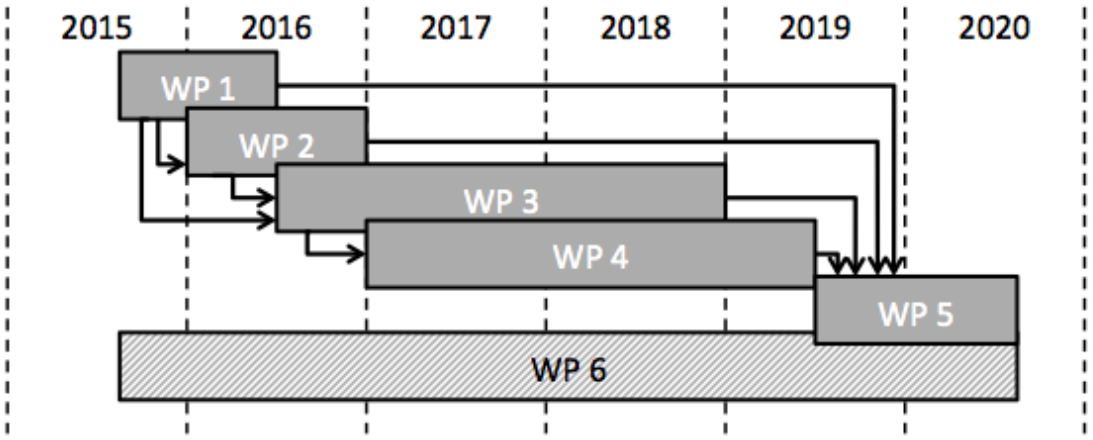

Figure 1: Time plan and relationships between WP1-6.

WP1: Mapping types of decisions and robust decision frameworks

Objective: To create a conceptual map of general types of decisions and robust decision frameworks.

A review of state-of-the-art literature on robust decision making literature will seek to: 1) Characterise different types of decisions prevalent in climate change adaptation according to when robust decisions

[2]The County Administration Board in Västra Götaland has agreed to participate in the programme. Our contact person is Markus Green, Disaster Management and Civil Protection Officer.

[3]SCC has agreed to participate in the programme. Our contact person is Bette Malmros, Regional Planner.

[4]SKB has agreed to participate in the programme. Our contact person is Jens-Ove Näslund, Research Coordinator for the SKB climate program.

are particularly useful, and 2) classify existing robust decision frameworks based on other user-relevant criteria (e.g. complexity, resources needed etc.) and the foundations for decision-making suggested to be appropriate. The review will enable development of a conceptual map of decisions and robust decision frameworks that will serve as a tool for analysing the Swedish context in WP2 and finding suitable decisions to test in WP3. **The primary research methods** in WP1 will be literature reviews, general morphological analysis (Ritchey 2006) and conceptual analysis based on philosophy of risk (Hansson 2013). **WP leader:** Wikman-Svahn. **Deliverables:** One report and at least one presentation.

WP2: Current foundations for decision-making for climate adaptation

Objective: To examine the current foundations for climate adaptation decisions in the three planning processes investigated and how they fit within different robust decision making approaches.

Here we will investigate the current foundations for climate adaptation decisions, primarily those relating to vital societal functions, and how robust methods can be introduced to support these decisions. The investigation will comprise document analysis of foundations used in decision making for climate adaptation in Sweden in relation to the three processes. This will generate knowledge about what these foundations cover, particularly with respect to uncertainties, trans-boundary climate challenges and extreme outcomes. In a second step, we will apply the generic knowledge obtained in WP1 to identify which robust decision making approaches might be most appropriate depending on the climate challenges addressed. **The primary research method** in WP2 will be document analysis. Theoretically, WP2 stems from the literature on robust decision making (WP1), climate risks (Mabey et al. 2011), complex risks (Sonnsjö and Mobjörk 2013) and challenges from indirect effects (Mobjörk and Johansson 2015, Foresight 2011). **WP leader:** Mobjörk. **Deliverables:** One report, one scientific article and at least one presentation.

WP3: Testing robust decision frameworks by intervention in ongoing processes

Objectives: 1) To identify three kinds of decision processes that are representative for the case studies, 2) to choose an appropriate robust decision framework for each of these decision processes and 3) to test these frameworks in workshops with decision makers.

Based on the results from WP2, we will identify three kinds of decisions that have to be made in each of the three ongoing processes studied. For each kind of decision, we will identify 5-10 people involved in the process who are willing to analyse a fictive decision with robust decision making. Examples of relevant people in this regard are civil servants and politicians involved in planning and construction processes or security issues. The risk perception of these people will be investigated in WP4 before and after the analysis. In the three ongoing processes, we will identify three robust decision frameworks that have potential to support the selected decision processes based on the knowledge acquired in WP1 and WP2. These frameworks will be tested in two workshops with participation of the people identified above, in order to gain a deeper understanding of advantages and disadvantages with the chosen methods. Foundations and scientific information needed for the test will be prepared by the research group. **The primary research methods** in WP3 will be participatory methods. **WP leader:** Mossberg Sonnek. **Deliverables:** One report, one scientific article and at least two presentations.

WP4: Perception of climate risks and the influence of robust decision frameworks

Objective: To investigate the perception of risk among decision-makers and to examine whether and how it is affected by the decision-makers being involved in a robust decision-making process.

Here we will investigate the perceptions of climate risks and natural disasters held by relevant actors working with decision-making and decision-making processes. In interviews, we will examine whether these perceptions change as the interviewees learn more about robust methods of supporting decision-making. The interviewees will be identified in WP3. The format involves one interview at the beginning of the project, and one follow-up over the course of 1-2 years in order to see whether the introduction of robust methods for supporting decision-making in WP3 affected subjects' perceptions of climate risk. In addition, we will conduct a survey of all relevant individuals in our three planning cases, in order to obtain a more complete picture of risk perceptions. This will provide a better understanding of specific risks associated with the cases and highlight similarities and differences

between them. **The primary research methods** in WP4 will be semi-structured interviews and a survey. **WP leader:** Wester. **Deliverables:** One report, one scientific article and at least two presentations.

WP5: Synthesis
Objectives: 1) To analyse the results from WP1-4 and use them to produce a manual on how to apply robust decision frameworks, 2) to draft two scientific articles and one final report and 3) to communicate the results widely.
Over the course of the final year, the project manager will lead a synthesis process in which experiences from the entire project are analysed and documented. The requirement for synthesis over the course of the first four years of the project will be reviewed continually. During the synthesis, a manual on applying robust decision-making tools will be produced in close collaboration with stakeholders from Stockholm County Council, SKB and the County Administration Board in Västra Götaland. Current limitations on extended use of robust decision making in the context of climate risks in Sweden will also be analysed, based on the results from WP2-4. WP5 will focus strongly on production of co-authored scientific articles by the team and on presentations to the scientific community and to local and regional communities involved in risk management and climate change adaptation. **WP leader:** Carlsson-Kanyama. **Deliverables**: A manual, two scientific articles, one report and at least seven presentations

WP6: Project management
Because the project involves collaboration among different types of researchers and between researchers and societal stakeholders, there will be great demands on sensitive and effective project management and communication. In order to make this possible, the research group will meet every two weeks for short updates, sandwiched between longer seminars and workshops to which outsiders will be invited. The project manager has a great deal of experience in managing transdisciplinary and interdisciplinary research processes, and in researching and investigating climate change adaptation. **WP leader:** Carlsson-Kanyama.

5. Communication and utilisation of research results

Communication will take place internally and externally with various target groups. Internal target groups include the participating researchers and selected civil servants and politicians involved in the RUFS process, the work with RVAs in Västra Götaland and SKB's work on a final repository for nuclear fuel. External target groups include the commissioning authority (MSB); politicians and civil servants working with planning and RVA at municipal and regional level in Sweden; decision-makers at public utilities and in trade and industry; and the international research community. We will also be working with KTH's communications officers throughout the entire process, and will adhere to the plan for communication activities presented in Table 1.

Through our in-depth investigation of how robust decisions can be integrated into on-going processes and the manual we develop on using robust decision making, we will provide unique and useful information for stakeholders at regional and local level in Sweden that will enhance their capacity to adapt to climate change. Moreover, our investigations about risk perceptions among decision makers and experts, which will be published as briefings in Swedish and in scientific publications, will make a novel contribution to the public debate on climate change adaptation. We anticipate that our results, including the manual on using robust decision making in a Swedish context, will be highly valued at regional and local level in Sweden and should be made accessible at the climate adaptation website run by SMHI. We also anticipate that our mapping of how decisions about climate change adaptation are taken today will be unique and helpful for process owners at regional and local level, including those carrying out risk and vulnerability analyses.

Table 1: Communication activities

Communication activity	Year	Frequency
Presentations and discussions with MSB	All years	At least once per year
Updating the programme website	All years	Twice per month
Participating in seminars organised by stakeholders	All years	At least four times per year, six times during the last year
Publishing short summaries of results	All years	At least twice per year
Attending scientific conferences	2016-2020	At least once per year
Submitting scientific articles	Every year starting 2017	One to two per year
Publishing reports with project results	Starting 2016	Three times
Publishing manual for robust decision making and final report	2019&2020	Once per publication
Organising our own seminars for stakeholders	2018 and 2020	Twice
Internal workshops	All years	At least four times per year

6. Coupling to undergraduate studies and PhD training

A substantial part of the project work will be carried out at KTH, School of Architecture and the Built Environment. The Department of Sustainable Development and Environmental Science and Engineering, SEED (Division of Industrial Ecology) and the Center for Banking and Finance (CEFIN) will be involved and there will be numerous opportunities to include lectures about climate change adaptation, risk perception and robust decision making in undergraduate courses on e.g. Environmental System Analysis and Decision-making; Environmental Management; Energi, klimat och miljö; Statistik och riskhantering; Risk Communication, Theory and Practice; Risk, Media and Controversy; Risks in Technical Systems; and Risk Analysis.

We will also invite Master's students to carry out their thesis work under the supervision of project researchers, thereby building additional capacity about transformative adaptation to climate change. Examples of suitable Master's courses to recruit students at SEED are: Applied Industrial Ecology; and Environmental System Analysis and Decision-making. Concerning PhD training, there are several courses at SEED with relevance for the proposed project, e.g. Industrial Ecology: Application and Research. There are also a number of PhD students at SEED working on related subjects, e.g. Jiechen Wu is working on predicting effects of future climate change on urban nutrient flows and consequences for their management. One researcher in this program (Wester) is currently supervising a PhD student in the field of risk and decision making at KTH (Björn Nevhage).

7. Public benefit and capabilities in society

Sweden faces considerable challenges in terms of the great uncertainties in climate change and its consequences for Swedish society. The most extreme emissions scenarios, which cannot be regarded as improbable, may lead to a global rise in average temperature of 6 °C by 2100, and the consequences of such a rapid and extensive change have not yet been investigated. Vital societal functions must still work effectively in a changed climate with more extreme weather events and natural disasters. However, current decision support has not adapted to the challenges that lie ahead, especially as regards extreme climate change. This project will increase understanding and acceptance of robust methods for supporting decision-making in Sweden and will demonstrate, using good examples, how these can be integrated into ongoing processes.

Overall, the research programme will strengthen the capability of Swedish society to prevent, rather than to react to, crises. New methods and tools promoting a transdisciplinary approach by putting the process owners at the centre will enhance the capability for making robust decisions at local, regional and national level. Understanding of how and why decisions concerning climate adaptation are currently made will increase, facilitating the introduction of robust decision making. Robust decisions lead to a more resilient society and thereby to higher capability to prevent catastrophic outcomes to natural hazards. Knowledge about decision makers' risk perceptions is also a

powerful tool for understanding how the decision making process best could support robust decisions that strengthen resilience.

Of the three policy instruments identified by MSB to build capability, this research programme mainly supports knowledge management. Many actors, mainly within the public sector but also in industry, will benefit from the knowledge gained of how the inherent uncertainties in climate change can be handled in practical decision-making situations. This competence is one of the dimensions identified by MSB as necessary for building and maintaining societal capability. Knowledge from the programme will also be fed continuously to other processes in MSB, e.g. the national risk and capability assessment; allocation of 2:4 grants; and the education programme.

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