The use of multi-criteria decision analysis in understanding Arctic change in a cryosphere context

Author list: Dina Abdel-Fattah, University of Alaska Fairbanks; Love Ekenberg, Stockholm University; Aron Larsson, Stockholm University

Our changing climate has invoked ecological, political and societal transformations, which have the potential to severely and negatively affect the interests and livelihoods of a diverse group of stakeholders. The ensuing transitions must address a variety of issues, from environmental concerns to socio-economic development in order to be feasible and sustainable. The current situation and discourse on climate change indeed seems to be alarming, however it also presents an opportunity for the exploration and development of compromising solutions, that can mitigate the risks of diverging stakeholder interests escalating into conflict scenarios. The complex problem of climate change needs novel applications to address it. As an interdisciplinary team of physical, social, and computer scientists, we use our strengths from each of our disciplines to innovatively address issues related to climate change. We suggest a new multi-stakeholder, multi-criteria approach to understand the effects of a changing Arctic and more broadly the cryosphere. By analysing climatic changes in the cryosphere against a set of criteria under uncertainty, we are better able to reflect the affected environmental, social and economic components, leading to better and feasible decisions for sustaining the cryosphere.

Decision and risk analysis is a well-established field in computer science. However, to the best of our knowledge, there has been limited convergence and application of this field with decision analyses in an Arctic and specifically, a cryosphere context. We argue that the utilization of decision and risk analysis for climate change decision-making can be an extremely valuable approach, to not only further our understanding of the environmental, societal, and economic possibilities under a changing climate, but to also further develop the field of decision and risk analysis in creating outcomes given high uncertainty and limited information.

One of the central challenges in such an approach is how to assign weights while avoiding too much information loss while also preserving correctness in the weight assessments. Using criteria ordinal rankings usually avoids some of the elicitation difficulties that appear when precise numbers are used. However, techniques for ordinal rankings can vary in their accuracy. Increasingly, the field has recognized and developed methods to utilize information from decision-makers in a systematic manner. Decision-makers have usable knowledge of decision situations that can be expressed in criteria orderings. Nonetheless, these so-called surrogate weights based only on ordering can be too weak for accurate representation. We therefore recommend using information on relational strengths.

We consider the entire range of values as the alternatives presented across all criteria, as well as how plausible it is for alternative to outrank the remaining ones, which provides a robustness measure. The results of using such a process are (i) a detailed analysis of each scenario performance compared with the other scenarios and (ii) a sensitivity analysis to test the robustness of the result.

We apply this decision and risk analysis framework in a novel application in the changing Arctic - the mitigation of glacial lake outburst floods (GLOFs). GLOFs pose potential hazardous impacts in a number of downstream communities worldwide. In order to better understand their potential for occurrence and impact, the following interdisciplinary work is being conducted, that consists of the following three steps. Firstly, an analysis will be undertaken to identify the criteria that can be mitigated in the event of a GLOF. Secondly, these criteria will be used to create 3 to 4 mitigation strategies, which range from low-effort to high-effort, from an economic and human resource perspective. Thirdly, the developed mitigation strategies will be assessed to generate several scenario analyses. Fourthly, a review of the variables used in both the mitigation strategies development and an elaborated multi-stakeholder multi-criteria analysis will be conducted. Variables will be reviewed with regards to their feasibility and sensitivity to one another. Lastly, a review of any potential conflicting stakeholder interests will be conducted. We have nearly 70 interviews from a wide variety of stakeholders in both Juneau and the Kenai Peninsula in Alaska, two communities that experience recurring GLOFs, regarding their GLOF decision-making as well as their risk perceptions and concerns regarding these events. Stakeholder interviews will be coded to determine if there any conflicting interests regarding each identified mitigation strategies. The qualitative analysis of the stakeholder interviews will be used to help determine the actual feasibility of each mitigation strategy. An optimal mitigation strategy will be identified based off this research, with the intention that it can be shared with the communities in both Juneau and the Kenai Peninsula for their review and assessment, and ultimately for broader application in other cryosphere contexts.