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Managing assumptions in climate risk assessments using assumption-based planning

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Making assumptions is inevitable when performing any risk assessment, especially when it comes to climate risk. Assumptions can be conceptualised as assertions that are taken for granted, and in climate risk assessments, these may relate to models, data, scenarios and risk follow-up. The assumptions need to remain valid for the duration of the activity that the risk assessment concerns. In general, there is uncertainty about whether an assumption will remain valid in the future, and if it is not valid, this may have consequences. Making assumptions thus introduces a type of risk that has been labelled as assumption deviation risk. An option to avoid this type of risk is to conduct an uncertainty assessment with respect to the future state or condition that the assumption concerns. In practice, this quickly becomes infeasible for the large number of assumptions that are typically made in climate risk assessments and, in fact, in any risk assessment. We apply an alternative approach to manage the assumption deviation risk by monitoring the assumptions as time proceeds and implementing various strategies to control existing and emergent uncertainties. The approach is based on the assumption-based planning framework. In the present paper, we apply this previously proposed framework for establishing such strategies to climate risk with a focus on just one instance: flooding risks resulting from a changing climate. Our preliminary findings indicate that assumptions are not adequately treated in flood risk assessments, making it difficult to know how assessments are affected when changes happen or new knowledge becomes available.

Keywords: assumptions; assumption-based planning; climate risk

1. Introduction

Risk assessment is a key tool in planning and decision-making processes involving different types of risk, including climate-related risk. Risk assessments depend on assumptions, which can be conceptualised as assertions that are taken for granted. The assumptions may relate to, for example, models, parameters, data, scenarios and risk follow-up, and the assumptions need to remain valid for the duration of the activity that the risk assessment concerns. The uncertainty related to the validity of the assumptions in the future, along with the potential consequences if they do not, introduces assumption-deviation risk (Aven, 2013).

An option to handle this type of risk is to conduct a probability assessment with respect to the future state or condition that the assumption concerns and integrate this assessment into the risk metric using the law of total probability. In practice, this quickly becomes infeasible for the large number of assumptions that are typically made in risk assessments. It also tends to introduce new assumptions as part of the probability assessment. Several proposals have been made for how to assess and manage assumption deviation risk (Aven, 2013; Tasneem Bani-Mustafa, 2020; Berner and Flage, 2016; Flage and Askeland, 2020).

Assumption deviation risk becomes especially critical for climate risk analyses, as the uncertainty with respect to the time dimension is fundamental for assessing climate risks. For example, while many risk analyses operate in a time horizon of a few years, climate risk assessments often relate to 2050 and beyond, while the state of the world – locally and globally – is obviously highly uncertain for such time horizons. Climate risk thus represents an interesting use case for assumption deviation risk and a learning ground on how to handle this type of risk. It also provides useful results with respect to mitigating climate risk, which probably represents the most important risk for mankind globally. Reading the paper it should be kept in mind that climate risk is a good example, but that the principles adopted here can be translated to any other risk analysis.

Instead of assessing assumption uncertainty directly in the risk assessment, we consider managing the assumption deviation risk by monitoring the assumptions as the assessment and later the activity proceeds and implementing various strategies to control existing and emergent uncertainties. The approach is based on the assumption-based planning framework (see Section 2). In the present paper, we apply this previously proposed framework for establishing such strategies to climate risk with a focus on just one instance: flooding risks resulting from a changing climate (see Section 3). The assumption-based planning framework has previously been implemented in a risk assessment context (Berner and Flage, 2017). That approach requires sensitivity to be assessed, which we are unable to do as we do not have access to the models underlying the risk assessment case considered. We therefore apply the original assumption-based planning framework in the present work. Our findings indicate that assumptions require long-term follow-up of risk analyses in general, but especially with respect to climate risk (see Section 4). Otherwise, risk assessments may gradually lose value or even lead the user into a false sense of safety. Our use case on flood risk assessment illustrates that well. The fact that we take an existing risk assessment and implement the assumption-based planning framework on top of it also illustrates that the applied technique is feasible.

2. Assumptions based planning framework

The assumption-based planning (ABP) framework is described in Dewar (2002) and visualized in Figure 1. This framework specifies a process involving some key steps and concepts: The first step is the development of a plan. The assumptions underlying this plan are then identified, from which a set of ”vulnerable, load-bearing” assumptions are identified. An assumption is load-bearing ”if its failure would require significant changes in the organization’s plans” (Dewar, 2002, p.66), and vulnerable ”if plausible events could cause it to fail within the expected lifetime of the plan” (Dewar, 2002, p.71). The next step is to develop ”signposts” for the vulnerable, load-bearing assumptions. A signpost is ”an event or threshold that indicates an important change in the validity or vulnerability of an assumption” (Dewar, 2002, p.92). The next step in the process is to identify ”shaping actions,” which are ”organizational action[s] to be taken in the current planning cycle and is intended to control the vulnerability of a load-bearing assumption” (Dewar, 2002, p.109). Shaping actions is thus about identifying and implementing measures that ensure the underlying assumptions remain valid. In the words of Dewar, shaping actions are ”supposed to cause (good) things to happen” (Dewar, 2002, p.115). There is, however, no guarantee that the shaping actions will be successful. The last step of the process is therefore to develop ”hedging actions,” which are ”organizational action[s] to be taken in the current planning cycle and is intended to better prepare the organization for the potential failure of one of its load-bearing assumptions” (Dewar, 2002, p.123). Hedging actions are thus strategies that decrease the impact an assumption has on a plan. The aim is to reduce the negative effects if an assumption does not hold. The phrase ”in the current planning cycle” is essential as it indicates that a hedging action is carried out before the activity/plan is carried out. This distinguishes it from contingency actions, which are implemented only if deviations from the plan actually occur.

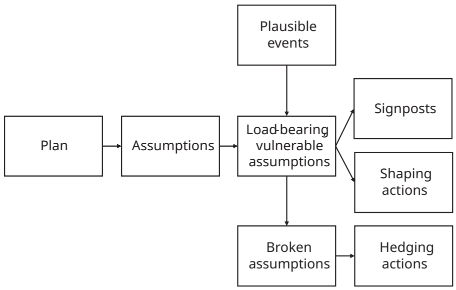

Fig. 1. Visualization of the framework for assumption-based planning; based on Dewar (2002).

3. Use case description

As a use case, the paper "Risk assessment for areas prone to flooding and subsidence: a case study from Bergen, Western Norway" (Venvik et al., 2020) has been chosen. The paper represents a rather recent and well-written contribution to flood risk assessment of an environment we know well, which makes the add-on assumption-based planning analysis feasible. It should be noted that the present authors are not hydrological experts, such that our results should be taken as examples illustrating a methodology. A more thorough analysis might be performed together with the original authors (Venvik et al., 2020) in the future.

Bergen city is rather vulnerable to flooding due to large amounts of annual rainfall, its surrounding mountains, its location by the sea with the old city and other parts of the city close to sea level, and its history reaching back about 1000 years (increasing subsidence vulnerability). It is important for the city to know about and mitigate flood risk. The flood risk study Venvik et al. (2020) combines the two elements of flooding:

- Rising water level due to flooding, which again is (directly or indirectly) caused by rainfall or by sea level rise.
- Lowering of the ground level, that is, subsidence, which is caused by geological conditions. For Bergen these conditions are mostly driven by cultural layers of soil, where decay processes lead to subsidence. This type of subsidence increases with decreasing ground water levels.

The goal of the original study (Venvik et al., 2020) is to provide a map of areas in Bergen vulnerable to flooding. To achieve that, the flooding vulnerability map from the INXCES project (Boogaard et al., 2016) was used. Storm surge data were taken from the official Norwegian storm surge maps. The subsidence level was inferred from satellite radar data. The risk analysis was performed using GIS tools like ESRI (2018) to create overlays for the various pieces of information. The result is a map of Bergen showing the vulnerability to flooding on a grid down to $10 \times 10m$, providing a good overview of flooding risk.

4. Analysis

Our assumption-based planning analysis proceeded with the following steps

(1) Marking of text sections of the original paper, which relate to assumptions. For example in the introduction it is stated

> It is expected that 60% of the world's population will be living in urban areas by 2030.

which represents an assumption. Identified assumptions where re-written as a clearly stated assumption, such that the above example becomes

> 60% of the world's population will be living in urban areas by 2030

(2) The identified assumptions were consolidated within the work group, combining duplicated assumptions and removing irrelevant assumptions. In this way we end up with 23 assumptions from the paper for further analysis.

(3) All consolidated assumptions were scored with respect to strength of knowledge (SoK) (low, medium, high) considering criteria related to (a) phenomenological understanding/goodness of models, (b) amount and reliability of data, (c) expert agreement, and (d) realism of assumption (see Berner and Flage (2016)). The categorization works rather well, but some ambiguity remains due to overlap in the criteria and subjective interpretation of the terms.

(4) From the scores, the assumption risk (Low, Medium, High) was inferred using the rules Low: at least 2x high and no low; Medium: maximum one low; High: minimum one low and no high, where 'low', 'medium' and 'high' refer to the strength of knowledge scores. This results in 10 assumptions scoring 'Low Risk', 7 assumptions scoring 'Medium Risk' and 6 assumptions scoring 'High Risk'.

(5) For assumptions that were scored 'Low', no assumption deviation mitigation is considered. For all other assumptions, the group went through the assumption mitigation suggestions (see Figure 1), specifying what actions could be recommended, managing the risk from assumptions that might change over time, changing the risk picture and leaving the city vulnerable to flooding risk.

For all assumptions that were scored 'Medium', at least a signpost activity was specified. Depending on the type of assumption, also other mitigation actions were specified.

For all assumptions that were scored 'High', a signpost and at least one additional mitigating action was specified, depending in detail on the type of the assumption.

(6) For the sake of space in the present paper, we have chosen 7 assumptions that are presented in detail in Tables 1 and 2. The choice was merely related to providing a good illustration of the methodology, not to provide good risk or mitigation results.

Table 1. Results for assumption deviation analysis of 7 selected assumptions

Assumption	Risk	Comment	Signpost	Shaping act.	Broken a.	Hedging act.
60% of the world's population will be living in urban areas by 2030	Low	The development is clearly visible. Good example of low assumption uncertainty. Even the definition of "urban area" is changing and the increase in area usage puts additional pressure on water drainage.				
The sea level will rise by up to 1 m by 2090.	Medium	Large uncertainties. It could get much worse, also because of turning points.	Closely monitor sea level and compare to assumptions. Monitor new knowledge on relevant variables (with respect to hazard, exposure and vulnerabilities), impinging in sea level rise.	Assess prevention measures (e.g. building walls versus nature based solutions that could be more inclusive and have socio-economic or gender related co-benefits)		
A precipitation of >60mm/h, where 20mm/h run in the sewer system and 40mm/h on the surface is assumed to represent an extreme storm or a 100-year event.	High	It is highly uncertain whether the value 60 mm/h represents a 100-year event for the future. Also the amount the sewer system can take might be uncertain and depends on external factors (e.g. maintenance).	Monitor precipitation and sewer system capacity and compare with assumptions.	In the lowest parts of the city regulations wrt. vulnerable objects might be strengthened.		

Table 2. Results for assumption deviation analysis of 7 selected assumptions (continued)

Assumption	Risk	Comment	Signpost	Shaping act.	Broken a.	Hedging act.
The dataset for present-day 200-year storm surge is relevant wrt. occurence of future flooding events.	High	Present-day storm surge is not suitable for extrapolation into the future in times of major climate change.	Monitoring of storm/ sea level correlations and developments.	In the lowest parts of the city regulations wrt. vulnerable objects might be strengthened.	Large amounts of persistent and intense rain may lead to limits of adaptation, meaning that it might not be possible to prevent harm.	Alternatives to be identified.
Input data covering the time period 2015–2018 are suitable for the analysis of future flooding issues.	Medium	This should be updated in the future. Data for 2018 may already be considered ’old’.	Closely monitor data and update the analysis. Also perform trend analysis.			
Flood models are sufficiently accurate.	High	Recent events have shown that flood models have considerable uncertainty.	Perform checks using flood data.	In the lowest parts of the city regulations wrt. vulnerable objects might be strengthened.		
Climate adaption actions will be executed adequately, including interaction between multiple actors and disciplines, strengthening the role of government agencies as ‘knowledge translators’.	High	This assumes that government agencies act objectively, while recent trends show that this is not always the case.	(if there is doubt on the objectivity of responsible actors, it cannot be assumed that signpost actions are efficient)	Leave only framing decisions to politicians and the details to subject matter experts.	This assumption is highly uncertain. It needs to be considered that there is such as thing as ”limits to adaptation.”	Hedging actions should be implemented.

5. Discussion and conclusions

The above discussion shows clearly that assumption deviation analysis is relevant for any risk analysis with a long-time horizon and has a particular importance for climate change risk, where uncertainty plays a fundamental role. Given the multiplicity of factors involved in the interface between natural hazards, the range of exposed assets, people or infrastructure, and vulnerability of all these systems, special attention to the role played by assumptions in risk analysis is key. In many cases assumptions may become invalid before a risk-triggering event occurs, such that the risk scenario plays out differently than it was assumed in the analysis. New knowledge may lead to better understanding of exposure, to changes in vulnerability or even limits to adaptive capacity making the assumptions used obsolete. It should be noted that the potential shifting of the risk space over time also plays out in traditional analyses, where, for example, the risk analysis is performed early in the design, and later design decisions are taken, which might invalidate previous assumptions.

The aim is to reduce the negative effects in case an assumption does not hold and to do so in an anticipatory manner, during the planning stage, through the use of signposts, shaping actions and hedging actions. In the context of climate change risk these signposts, shaping actions and hedging actions add a layer of protection against the unavoidable range of uncertainties and the likely occurrences of obsolete assumptions. In this paper we have illustrated the potential improvements in risk analysis through the use of the assumption-based framework using the case of sea level rise in a city with a rich heritage infrastructure. From the chosen use case of Section 3 and the related results presented in Section 4, it is evident that the effect of assumption deviation is critical for climate risk analyses. The suggested method for long-term follow-up of risk analyses is simple enough to be implemented in practice and should be efficient to maintain the value of risk analyses.

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