Universität Zürich[UZH]

Guidelines for the assessment of climate adaptation measures in Switzerland at the local level and under uncertainties

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Imprint

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Contractors:
University of Zurich
Winterthurerstrasse 190
CH-8057 Zurich

University of Fribourg
Chemin du Musée 4
CH-1700 Fribourg

Authors:
Veruska Muccione (University of Zurich), Christian Huggel (University of Zurich), Thomas Lontzek (University of Zurich), Nadine Salzmann (University of Fribourg), Philipp Ott (University of Zurich)

FOEN support:
Pamela Koellner, Roland Hohmann, Thomas Probst, Martina Zoller and Hugo Raetzo

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1 Introduction

The economic evaluation of different adaptation options is an important tool to help policy-makers setting priorities in the decision-making process, in particular in face of considerable uncertainties of unpredictable climate events, and the associated highly complex system of interactions between physical processes and human behaviour. Little is known about the costs and benefits of adaptation measures and options with respect to a range of climate change impacts scenarios. Therefore, the need of a method allowing for a systematic analysis and concrete results for Switzerland is identified. Here, we proposed a novel approach to investigate physical and economic impacts of climate change in Switzerland, which utilises a numerical stochastic optimization of the climate impacts and economic system.

During the first phase of this project from May 2013 to May 2014, we formulated a dynamic, stochastic model and used dynamic programming to explore the optimal adaptation decisions under uncertainty in face of uncertain impacts from climate change caused debris flows and flooding in the region of Grimsel/Guttannen. This case study has been a first attempt to apply the dynamic stochastic approach at the local scale. Results of the study suggest that excavation as compared to dam/relocation is an "optimal" measure for the case Grimsel/Guttannen. Hence, it provides policy and decision makers with optimal measures.

The study was designed and implemented on a local scale, using the aforementioned example of Guttannen. The results provide objective key information for a decision making process at the local scale, but the project did not intend to directly interact with the actors and stakeholders in Guttannen in view of implementing adaptation measures. Guttannen served as the case for the exploratory study. The case study, and in particular the development of the model, the results, and feedback received during two expert workshops provided very valuable experience. A particular challenge in Guttannen was the large uncertainty involved with future scenarios and outcomes. The natural system is highly complex, and the impacts of climate change cannot easily be traced 1:1, or modeled. Important activities and studies are ongoing that should add further understanding of the system but there will remain important uncertainties with respect to the future behaviour of extreme events and related downstream effects. The decision makers thus need to take decisions for risk management and adaptation in view of large uncertainties, which is a major difficulty but a common challenge for decision makers. This is where this project comes in and tries to contribute to the evaluation of different adaptation options from an economical and socio-political perspective.

During the second and final phase of this project (this document), from June 2014 until May 2015, we have streamlined the approach of our model in order to provide decision and policy makers with guidelines to support the decision process on adaptation measures under uncertainties using a numerical stochastic optimization of the climate impacts and economic system. The guidelines outline a suite of key questions and actions that would need to be considered at each stage. In addition, they also give guidance and background information on possible answers based on inputs received by in-depth qualitative interviews with key experts from academia, cantonal and federal agencies and consultancy firms. The guidelines are expected to be used by officers and policy makers at the cantonal and federal level as well as by experts from consultancy firms and academia.

The present document can be divided in three main parts (modules) of the guidelines that have in principle a chronological order but also interact with each other, case dependently. The first module (M 1) is dedicated to the framing, scoping and problem definition, namely frames perceptions of climate change adaptation based on a process regarding the understanding of the social-political context of the Swiss mountain communities. The frame was developed during a

series of qualitative interviews with key informants selected by means of purposive sampling (Bryman 2012). Interviews were carried out between December 2014 and February 2015. In the second module (M 2), we streamlined the dynamic optimisation process developed for Guttannen where we integrated the results obtained from the qualitative interviews. The third module (M 3) involves knowledge sharing and communication of the model outputs amongst the actors involved in the framing and scoping process. It should be pointed out that the process is not linear but interactive with the different modules feeding back into each other. The added value of these guidelines that have been elaborated in parallel during the practical work on the case study Guttannen is that they are generalisable and reproducible for other cases with limited resources and computational power.

The guideline-document is organized as follows. Section 2 provides a description of the Module 1; Section 3 of Module 2; and Section 4 outlines some recommendations for knowledge sharing and communication of the outputs (Module 3). A schematic representation of the process embedded in these guidelines is provided in Figure 1. Appendix I finally provide a detailed description of the interview process and its results.

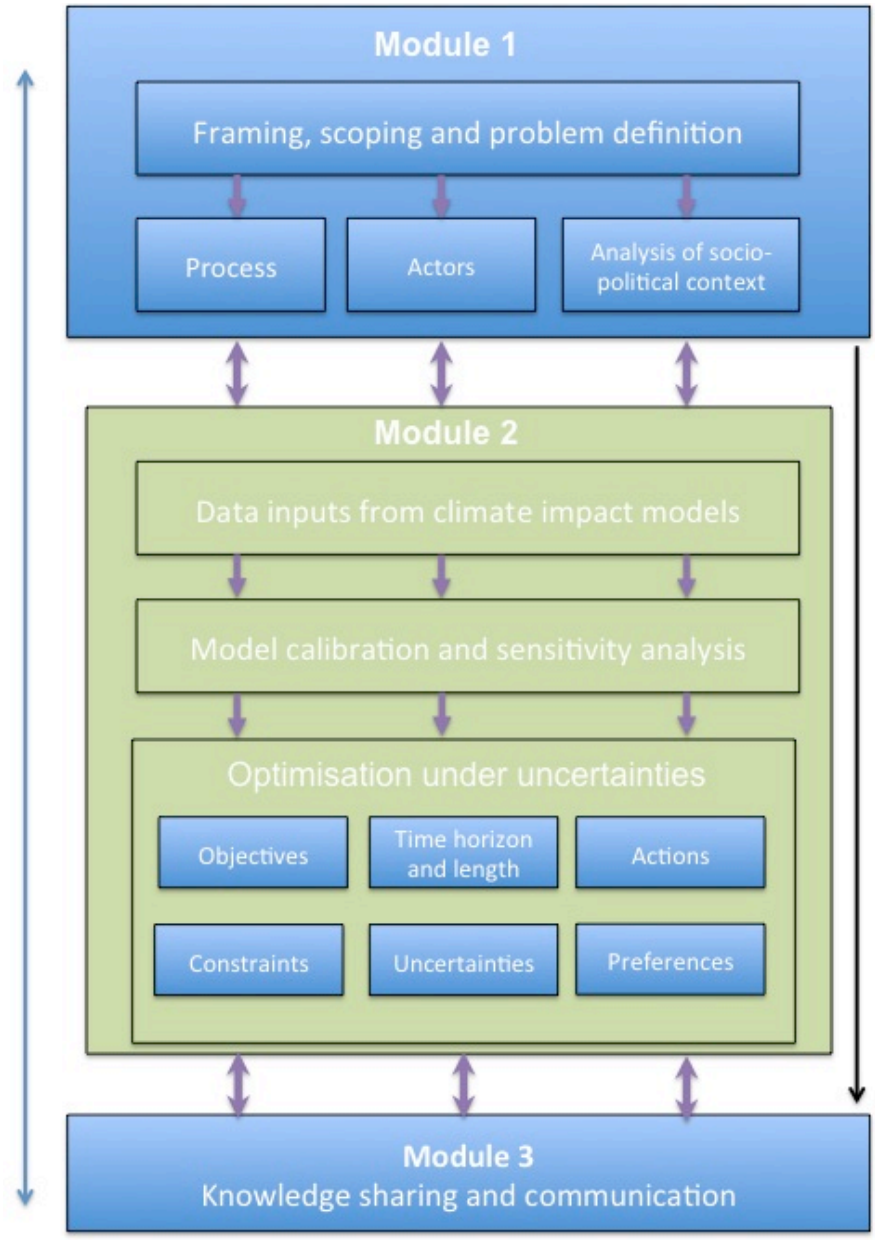

Figure 1 Schematic representation of the process embedded in the guidelines.

2 Module 1: Framing, Scoping and Problem Definition

This module provides guiding for the framing and scoping stage, which sets up the scene for any further elaboration of adaptation measures in Switzerland and at the local level. We define framing according to Dewulf (2013) as "…the process by which issues, decisions, or events acquire different meanings from different perspectives…" On the one hand, M1 provides a list of key questions that users should address when starting defining the frame. On the other hand it suggests possible framing and scoping options based on inputs from key experts.
Generally, framing and scoping relates to the definition, evaluation and harmonization of the actor's perspectives and interests, such that commonly agreed and balanced objectives can be defined, that are needed for the eventual adaptation measures. The scope of this stage is to frame climate change adaptation in the socio-political context of small Swiss mountain communities although it could also apply in other settings, and should therefore be of more general value. Following Hackmann et al. 2014 and Huggel et al. (2015) and based on our experiences of the BAFU project number 2006-02060/1836/02, questions that could be asked during this phase are:

- Which stakeholders should be involved in the adaptation process?
- What are their beliefs and values, and why?
- What are their objectives and priorities, now and in future, and why?
- What are their constraints?
- What are their perceptions of climate change and climate adaptation?
- What is their vision for adaptation to climate change?
- How should the adaptation process be framed?

Inputs to these questions were provided in consultation with the project partners and a series of qualitative interviews with key informants carried out between December 2014 and March 2015. Inputs have allowed us to elaborate options for framing and scoping as outlined in sections 2.1 and 2.2.

2.1 The framing process and its actors

The framing and scoping process of climate change adaptation at the level of small Swiss mountains communities should happen at the local to middle level (from communities to cantons) with the top level (federal/national level) mainly facilitating knowledge sharing and capacity building. The top level can also provide technical and financial support where needed. The federal or national level through its agencies can additionally have the role of mediating exchange of knowledge and information between climate experts and lay people.

It is important to consider, when attempting to frame and define a problem such as climate change adaptation, that the different realities of the specific sites can be extremely heterogeneous and that one format will not fit all. Taking into account the specific context in which the problem is being framed, different categories are suggested for framing climate change adaptation at the local level:

1. A frame based on the experiences of the Bafu Pilot Programme[1]:
    a. The framing process is defined first in a small group of (local and external) experts; and then
    b. followed by a participatory process through a series of workshops with all involved stakeholders to share opinions and reach a common understanding.
2. Framing adaptation as embedded in the local development plans of the region and/or community.

[1] http://www.bafu.admin.ch/klima/13877/14401/14913/index.html?lang=fr

3. Framing climate change and adaptation starting from the concept of local vulnerabilities. Vulnerability is identified by means of scientific assessments as well as perceptions based on local and traditional knowledge.

In the context of Swiss mountain communities, we suggest to include the following actors in the framing process:

- Local communities (population in general)
- Private sector
- Cantons and their agencies
- Tourism sector
- Local administration
- Directly impacted population
- Others (case dependent; e.g. federal agencies, experts, affected population, voters, Schwellenkoorporation[2], farmer associations, infrastructure and energy sectors and other stakeholders)

2.2 The socio-political context

The framing process should be inclusive and take into account the different and sometimes opposite interests of multiple actors. In order to support the framing and scoping process and to reach a common understanding amongst the different categories of stakeholders is helpful to analyse the socio-political context of the region of interests. Climate change has been for several years discussed mainly in terms of its biophysical nature where socio-political aspects have only marginally been integrated in an exclusively natural science framework. The last IPCC assessment report (IPCC 2014a & IPCC 2014b) and more prominently the World Social Science Report (ISSC/UNESCO 2013) show that people and societies are an integral part of the problem and its solution. In order to promote new and innovative solutions the social dimension needs thus to be incorporated into the framing process of climate change and adaptation. This implies understanding people's beliefs and values, their attitudes, practices and visions for change (Hackmann et al. 2014), which possibly have also caused part of the current challenges at the local scale (e.g. land use planning, etc.) in addition to the impacts of global climate change.

The interviews with key experts helped clarifying the socio-economic and political context of the Swiss local mountain communities. An important lesson learnt is that contrarily to what is in general a positivist approach to addressing the biophysical nature of climate change, the social, political and economic realities of the different communities are very heterogeneous, and therefore any tentative of framing climate change and adaptation should be highly contextualized. Beliefs, values, attitudes and practices are also rather heterogeneous between and within Swiss communities. Thus, to enhance successful implementation of adaptation and to reduce conflict amongst the different actors, we suggest integrating the socio-political dimension as follows:

1. Apply social research methods to understand beliefs, values, attitudes, perceptions and practices of the different actors involved in the framing process (Brymann 2012).
2. Problem contextualization. Any activity requiring an understanding of societal problems must be put in the respective societal context. This implies integrating the different languages and forms of knowledge of the actors in ways that the issue at hand becomes relevant in the context of application (Mauser et al. 2013).
3. Define objectives of different actors based on contextualisation in a joint and iterative fashion (Lynch 2012, Dewulf 2013, Huggel 2015).

[2] Schwellenkoorporation are in Switzerland statutory bodies made by landowners and dealing with water conservation and management issues.

Some general aspects to be considered when integrating the socio-political context of the Swiss mountain communities are:

- Swiss mountain communities are typically highly resistant to changes
- Local perceptions and traditional knowledge are highly influential in disaster risk management and can thus promote or hinder implementation of adaptation.
- Climate change and adaptation have in general low priority in the local administrative agenda.

3 Module 2: Data Calibration and Optimisation

After having established a frame suitable to the context of the situation of interest, optimal adaptation measures to cope with the climate impacts must be found. In our case, this relates to debris flows and floods at the local level in Switzerland under considerable uncertainties. The term "optimal" implies that decisions today are made such that the expected value of a specific objective cannot be further improved. In economic terms, the objective could be to minimize costs or to maximize the utility or welfare considered by the decision maker.

In our case study, the decision maker thus seeks to identify a set of optimal adaptation measures in the presence of impacts from climate change. As the impacts are stochastic, at any time period (decision period) the decision maker has imperfect information about the occurrence of adverse impacts in the next period. This uncertainty will eventually lead to a choice of adaptation measures that ex post might turn out to be not optimal. However, those measures are optimal ex ante, reflecting a potential risk premium that the decision maker is willing to pay. Hence, a typical formulation of the problem is as follows:

"Maximize some objective (e.g. the present expected value of some welfare measure) by choosing from a feasible set of actions (e.g. adaptation measures), under some specific constraints faced by the authority choosing these actions (e.g. social constraints)."

In order to operationalise this formulation, an optimization model must be defined, and a parameter vector must be specified. This requires addressing several components, which can be broadly categorized into:

1) Objective
2) Time horizon and length of a decision period
3) Set of actions (decisions)
4) Constraints on decisions and states
5) Uncertainties
6) Preferences of the decision maker

A schematic representation of the problem is provided in Figure 2 with examples of possible adaptation measures in case of hazards from debris flows and floods.

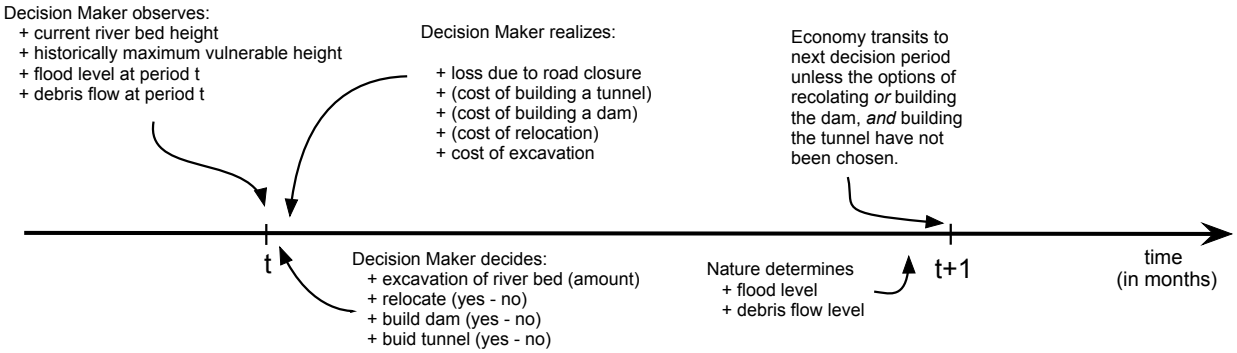

Figure 2 Schematic of a decision period

In the following part we look more closely at each of these categories and discuss them in light of the feedback obtained during the expert interviews. A more detailed report of the results of the expert interview is provided in Appendix I.

Outputs from climate and climate impact models are also needed at this stage for the calibration and sensitivity analysis of the optimization model. Sources of data must be clearly specified as well as the plausibility and the uncertainty range of the output results in terms of means and extremes. Thereby, the probability density function and its changes need to be discussed with the decision makers and it must be decided for which types of events the adaptation measures must be fitted to.

3.1 Objectives

For any decision-making process aiming on achieving optimality, we need to specify an objective function, which specifies what, actually needs to be optimized. This could e.g. be the sum of welfare in each decision period or total profits. Broadly speaking one needs to formulate the objective by addressing the following questions:

- What should be optimized?
- Should the decision maker maximize some welfare norm of a certain group?
- Could the decision maker minimize the costs of achieving a certain goal, such as e.g. ensuring no losses to the residential area?

Objectives can be highly contextualized and depend on a) who the decision makers are; b) the history of the communities in terms of dealing with adaptation and disaster risk reduction; and c) the regional development strategy of the region. As an example, if the community is located in a region highly dependent on tourism, then it is likely that the tourism sector will be highly influential in defining the objectives of the decision makers. Possible objectives of the decision makers for Swiss mountain communities can be:

- Security
- Limiting emigration
- Guarantee no changes in lifestyle and well-being
- Guarantee no losses and achieve this at the minimum possible cost

3.2 Time horizon and length of a decision period

Here, the focus is on the planning horizon as well as the frequency with which the decision maker can effect the actions. The planning horizon can be defined as the time interval over which the objective is maximized. The following questions should be addressed at this stage:

1. What is the planning horizon? That includes a terminal-time value of operational benefits from a long-lived investment (such as a dam, road, tunnel). It might not matter much if the time horizon is 200 years or 210 years, but it is not advised to ignore a terminal value in optimization problems.
2. What is the length of a decision period? This parameter is important in particular because it defines the frequency with which the decision maker can react to events/developments that had not been previewed at the time of decision taking due to the various inherent uncertainties.

In general the planning horizon (first question) can be anything from legislation (5 years) to a generation (25 years) period. The upper limit is mainly related to the operational benefits of long-lived investments (e.g. hard infrastructures), while the lower limit is associated with the realities of political cycles on the ground. The length of a decision period is often equal or shorter than a legislation period.

3.3 Set of actions (decisions)

The focus is on the potential set of adaptation actions that the decision makers have at their disposal in the optimization process. The questions to be asked at this stage are the following:

- What is the potential set of actions, which the decision maker has at disposal in the optimization process?
- Are some of these actions only temporarily available?
- Are some of these actions irreversible?
- Why are certain actions not an option (e.g. relocation)?
- Which actions are subsidized at the cantonal and national level and why?
- What is the time length of implementing these actions? (E.g. excavating the river bed might be decided and executed much quicker than building a dam, or a new cantonal road)

It is important to highlight that "measures are heterogeneous and context dependent". We observed from our key experts a tendency to focus on preventive measures both hard and soft. Hard measures are in general irreversible while soft measures are more flexible and can be amended over time. In general, measures should be embedded in people's way of life. In this sense, measures should guarantee the least change because resistance to change in these communities is considerably high.

Reasons why certain actions might not be an immediate option include that for instance the communities do not receive subsidies from the cantonal and national governments. In general hard infrastructure project in Switzerland receive 30%-40% from the federal government and 30%-50% from the cantonal government. The remaining amount can be contributed by the communities (about 10% or so). Certain actions might be considered as mere maintenance work (e.g. excavation of river bed in the event of debris flow) and thus receive no subsides. Understanding how subsides change the cost-benefits landscape and how it influences the optimization problem is certainly relevant at this stage.

3.4 Constraints on decisions and states

There can be very many possible constraints in the optimization problem. Some constraints are financial and some others social. The questions to be asked at this stage are the following:

- Is the decision maker limited by a certain budget?
- Does the decision maker need to achieve a certain return in a given time interval (e.g. making sure that the financial losses of debris flows do not exceed some value in a legislation period)?
- Is the decision maker limited due to social or political constraints e.g. are there any parties that would prevent specific (but optimal) measures?
- How does the decision maker deal with public repercussions of his/her actions?
- What are the synergies of adaptation with established political systems? And what are the barriers?

We can see how in general some of the questions asked at this stage could be already answered in Module 1. In general more than budget constraints or constraints related to financial and economic aspects, constraints also have a social and political nature. In terms of social constraints, we have already mentioned how resistance to change and ambition to maintain the same quality of life can strongly influence the adaptation strategy and implementation in mountain communities. Hence, it is clear that extreme measures such as relocation can only be seen as a last resort option, for example when the running costs of preserving a community largely outweigh the costs of

relocation. However, it is also interesting to notice that relocation might have several socio-political costs that are not quantifiable such as those associated with loss of identity and kinship. We recommend developing adaptation measures that are embedded in the socio-political realities of the local communities in order to make them better negotiable and accepted.

3.5 Uncertainties

There is a broad set of variables and parameters that are uncertain. In fact, everything that is to come in future exhibits some degree of uncertainty. The task is to identify the uncertainties of relevance to the problem at hand. One source of uncertainty is the evolution of the climate and its regional impacts e.g. in terms of precipitation and temperature. Another source of uncertainties is parametric uncertainties. The questions to be asked at this stage are the following:

- Are the costs of the action variables subject to changes?
- Is the set of rules and laws within which the decision maker acts subject to possible changes?
- Are social aspects also an important source of uncertainty?

3.6 Preferences of the decision maker

Identifying (individual?) preferences is an important step in formulating a model. Basically, a modeler considers three categories. 1) Preferences regarding the evaluation of welfare or monetary benefits at different points in time. 2) Preferences for resolution of uncertainty: how risk-averse is the decision maker. What is the implied premium the decision maker would want to incur for resolving uncertainty. 3) How important is smoothing of welfare or monetary payoffs to the decision maker? Answers to these questions will depend on who is the decision maker. The questions to be asked at this stage thus are the following:

- Who is the decision maker (e.g. a single person, some local governing body, the federal government)?
- How does the decision maker value the future welfare against today's welfare?
- How important is smoothing of welfare or monetary payoffs to the decision maker
- What is the implied premium the decision maker would want to incur for resolving uncertainty?

The following decision makers can be identified in the Swiss mountain communities:

- Community as a whole
- Voters
- Mayor (Gemeindepräsident) and local council
- Cantonal authority
- Informal institutions (people and organization with vested interests)

The decision makers should in general have long-term perspective, e.g. at least look into the welfare of the next generation. In reality, one or two legislation periods (5 to 1o years) are to be considered more realistic.

4 Module 3: Knowledge Sharing and Communication

To improve the consideration of climate impacts (damage) in economic models and the development of adaptation measures at the local scale, a close and intensive collaboration across science-policy-practice is necessary. Adaptation is recognised in recent studies as a process that necessitates different sources of knowledge (IPCC 2014a, Huggel et al. 2015). The contributions of scientific knowledge as well as local and traditional knowledge have both important roles to play in the adaptation process, but it is important to notice that actors involved in the adaptation process can have divergent interests. Thus, it is important to have a clear and transparent exchange of knowledge throughout the whole process of establishing preferred adaptation measures under uncertainties. Knowledge sharing can take place at different level amongst the different actors involved in the framing process and the experts or officers developing these guidelines. This stage is positioned at the end of Figure 1. However it should be noted that a considerable exchange of knowledge should take place throughout the whole process. Module 3 is expected to consolidate such knowledge and to operationalize the results obtained in Module 1 and 2 so that a successful implementation of adaptation measures can take place. We point out that these guidelines do not cover the phase of negotiation of adaptation measures and their implementation, which should be ideally taking place at the end of the process.

Key informants have highlighted in particular existing tension between science and practice, where practice is here understood as implementation of certain policies at the local level. The objectives of scientific assessments are not always in line with the needs of people on the ground. Time frames also diverge considerably between science-policy and practice, in particular climate change and adaptation require long term planning horizon, while in most cases the planning horizon of local administrations is at most a legislation period. In order to solve this tension we propose here a model for knowledge exchange that emphasizes an iterative exchange of knowledge between science, police and practice. We refer to the model of "co-production of knowledge" (Lemos and Morehouse 2005, Dilling & Lemos 2011) where, science is not anymore the active knowledge producer and society the passive recipient, but knowledge is rather co-designed and co-produced. Empirical evidence has shown that this approach has proven effective in delivering environmental solutions (Hegger et al. 2012). In such approaches, research questions on societal challenges such as climate change and adaptation do emerge only from transparent exchange and interactions between scientists or experts with stakeholders from civil society and governmental organisations (Mauser et al. 2013). It can be said that the co-design of knowledge starts already at the framing, scoping and problem definition stage. The next stage concerns the handing over of the research questions or problem defined to the research community (Module 2). This stage requires understanding of spatial and temporal scales by all actors involved to assure that the questions can translate in realistic and manageable projects. The third stage (Module 3) is the dissemination of the results obtained throughout Module 1 and 2. This includes translating results into languages understandable to all societal actors involved in the framing process followed by discussions on the valuation, relevance and applicability of the results (Mauser et al. 2013). Synergies and conflicts should be addressed at this stage. It is expected that the consequential actions taken from these results will lead to further negotiation and finally to the implementation of adaptation measure at the local level.

Appendix I – Results of the Expert Interviews

Key informants were selected by means of purposive sampling (Bryman 2012). This implies selecting key individuals not in a probabilistic way but regarding the relevance to the specific research questions. Informants were contacted by email. In the email it was informed about the thematic areas of the research, main objectives as well as some practical information on the length of the interview, suggested dates and locations of the interview. Informed consent was obtained to record the interview and make use of the information provided during the interview as long as anonymity is guaranteed. An interview sheet was prepared before each interview in order to insure that all important topics are covered; the interview sheet was sent to informants in advance of the scheduled interview. Overall eight people were interviewed, namely four consultants, one cantonal authority and three researchers from academic institutions (two sociologists and one economist). The interviews were transcribed and coded by using NVivo Software[3]. The use of coding for content analysis is commonly employed in qualitative data analysis (Corbin & Strauss 2015). Codes are constructs of words that synthesise concepts appearing in individual pieces of language-based data with the scope to identify patterns and categories (Saldaña 2013). The coding followed a procedure common in qualitative research where categories were created in accordance to the research questions.

The framing process

The key experts suggested the following categories of stakeholders to involve in the framing process:

- Local communities (population in general)
- Private sector
- Cantons and their agencies
- Tourism sector
- Local administration
- Directly impacted population
- Others (federal agencies, experts, organisations for adaptation, affected population, voters, schwellenkoorporation, farmer associations, infrastructure and energy sectors)

The number of informants per each category is reported in Figure 3. It can be seen how the majority of informants agree that the local community in general is an important actor in the process, suggesting that the process should be as inclusive as possible.

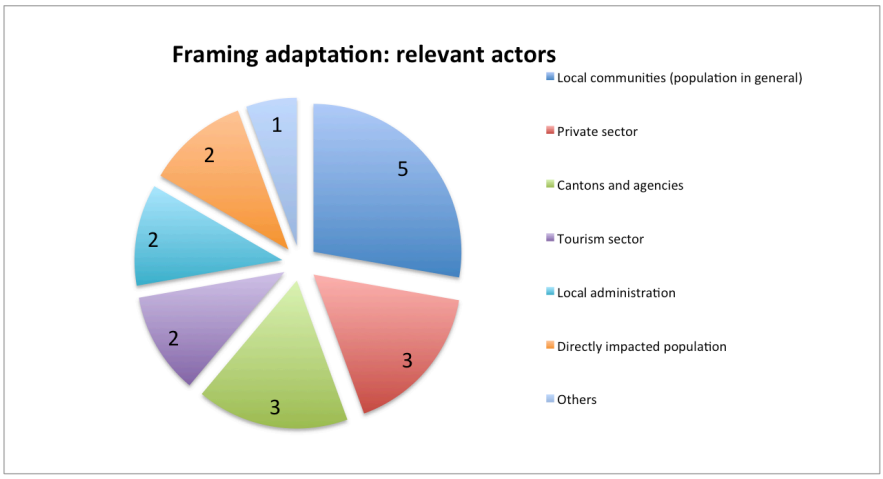

Figure 3 Number of answers per each category of relevant actors.

[3] More details about NVivo and its features can be found here: http://www.qsrinternational.com/

In terms of the framing process, it emerged that the process should be bottom up where the leadership goes from the bottom to the middle level. The role of the top level, here identified as the federal agencies or national government, should mainly be of:

- Knowledge and capacity building provider
- Provider of technical and financial support to the local and cantonal level
- Acting exclusively in the area of its own competencies (e.g. the Bafu in the area of the federal adaptation strategy).

One of the informant (a cantonal representative) suggested that the framing process should be a two-step process:

1. The framing process defined first in a small group
2. Followed by a participatory process through a series of workshops with all involved stakeholders to share opinions and reach a common understanding.

Currently, the model of the Bafu Pilot Programme[4] was appreciated by several of our informants. In this sense, such process appears to be in line with the two-step approach suggested above. Moreover some informants suggested that the process should not be framed directly under the banner of "climate change adaptation", but rather be embedded in the context of the local development strategy. A social scientist was of the opinion that such processes should be highly contextualized as it is impossible to generalize them and that one format will not fit all. The informant highlighted the importance of focusing on vulnerability as a possible way to frame adaptation. Vulnerability can be defined in this context first more scientifically and then in terms of vulnerability perceptions of the involved stakeholders.

Social Aspects

In terms of beliefs and values, the following aspects were recurrently reported during the interviews:

- Beliefs and values vary across stakeholder categories. There are often synergies but mostly trade-offs amongst the different categories.
- Beliefs and values are contextualized and heterogeneous within and between communities.
- In general, people care only about what they can see.
- In general, people care about where the money goes.
- People prefer to maintain their lifestyle unchanged.

Table 1 summarises the main results concerning priorities of local actors associated to the different stakeholder categories.

Table 1: On the left column we have the main stakeholders or actors identified by the informants and on the left column their priorities. In brackets it is indicated the number of respondents (if more then one).

Stakeholders	Priorities (number of respondents)
Local People	• Safety (4x) • Maintain life quality (2x) • Tourism (if it is in a touristic area) (3x) • Preserve the natural environment • Delivery of public services • Agriculture
Local authorities	Economic

[4] http://www.bafu.admin.ch/klima/13877/14401/14913/index.html?lang=fr

Scientists	• Objectives of their studies • Impacts on people in general less relevant
Environmental groups	Environmental protection
Private sector	• Depend on the business • Short term thinking - reaction time very short (e.g. reaction in case of natural hazards)
Politicians (cantonal and federal authorities)	• Adaptation is only one amongst several issues. • Adaptation has often a low priority.

In terms of attitudes of people in general living in these communities, they think they know everything about natural hazards and how to cope with them. They base their conclusions on historical knowledge and believe that this will be enough to cope with changing environmental conditions. They are rather reluctant to listen to experts and scientists, since local people assume that scientists and experts have only limited knowledge of local realities. However, once there is an event that goes beyond what they have experienced so far and found themselves unprepared, then the attitude is in general to blame the authorities in charge and ask for a quick resolution of the problem. Local communities seems afraid to engage in any type of development that could change their way of living, their institutions and infrastructures. Concerning more specifically local and middle political level, the attitude is to take climate change and the need for adaptation as a long-term issues compared with more short term pressing issues. In general, the political level prefers short-term approaches to decision-making, which is not always in-line with adaptation approaches.

In terms of vision for change, it appears to be a rather hard subject in the local mountain communities. The approach of the people in general is to leave things unchanged. They would rather take the risk than change their life-style because of climate change. Thus, any adaptation approach has to be absorbed and embedded in people's current way of life and ideally has to be something they have experienced already.

Objectives:
The objectives of the decision makers mostly cited by our informant were: 1) security and 2) limit emigration from the area. Financial and economic objectives appeared to be rather secondary. An economist suggested that the decision maker should minimize the costs of achieving a certain goal, such as ensuring no losses to the area at minimum costs, while other people formulated these objectives more generally as striving for positive benefits vs. costs ratios. Other informants referred more to very general objectives, like communication, community development and maintaining the quality of life in the region.

Time horizon
There was widespread agreement amongst our informants that the length of a decision period is in general a legislation period (5 years).

Actions
It is interesting to notice from the set of answers that most of the measures are rather vague. The informants found rather difficult to pin down measures that will work for all the realities. Answers from our informants are summarized in Table 2.

Table 1 Adaptation measures suggested by the informants with the corresponding number of respondents per each measure.

Measures	Number of Informants
Preventive measures (e.g. avalanche walls, protection forests, prevent GLOFs)	4
Measures that guarantee least changes	3
Flexible measures with positive co-benefits	2
Soft measures (e.g. sensibilisation of the population as preventive measure) (2x)	2
Adapt local economy (e.g. move away from winter tourism)	1
Promote regional development	1
Have less infrastructural measures	1
Limit development in risky areas	1
Impact monitoring	1

The action that was agreed to be either not an option or a last resort option was relocation. This is again related to the conclusion that measures should guarantee the least changes and preserve the life in the communities. Some informants suggested that relocation could be an option only when the running costs of keeping the community alive might overtake the cost of relocation. However, in general relocation is seen as a very costly option, which has both political and social constraints.

During the inception phase of our project, results produced for the area of Guttannen showed that excavation is a preferable adaptation option based on our assumption and modeling. However when this result was presented at a workshop hosting representatives of scientific and policy communities, the policy representatives showed only a limited interest in such measure. Thus we pertained important to ask our informants "why excavation is not an option?" The informants were at first surprised that excavation could be the most optimal measure as they were convinced that such measure has very high costs. They also see an issue in the disposal of the excavated material. Most importantly some of the informants agreed that the measure is not of high priority because it is not subsidized by the federal or cantonal governments. A consultant outlined this in very clear term as follows: "*When you build something you receive 30%-40% from the federal government and 30%-50% from the cantonal government. The remaining percentage is the contribution of the community (about 10% or so). Excavation is considered like maintenance work, which is not subsidized by the national government and only partially by the cantonal government...*"

Constraints

Resistance to change and ambition to maintain the same quality of life were recurrently mentioned by our informants as being the one important aspect. Moreover, it was stressed that political and social factors are very context dependent and it is virtually impossible to generalize on these factors. The short-term views of politicians versus the long-term frame of climate change and adaptation is also considered an important political constraint together with the willingness to recognize climate change and adaptation as political issues.

The most important barrier identified by our informants was the resistance to change. Adaptation measures not embedded in the way of life of the communities will face great barriers and widespread opposition. The same goes for synergies with established political systems. Synergies of adaptation can be identified in embedding adaptation in the existing development processes of the region and not communicating adaptation as something new or disconnected.

Uncertainties
In terms of uncertainties, six out of eight informants agreed that rules and laws are very stable in Switzerland and that great changes are not to be expected. Social uncertainties appear to be more relevant than uncertainties in costs of action. A social uncertainty mostly mentioned is emigration. Along these lines, costs are strictly related to social uncertainties, as it is difficult to invest in a community when there is great uncertainty whether the community will still exist in few decades from now. More than uncertainty in the cost of action, it is the uncertainty in the cost of impact that is depicted as important. Some informants think that it is better to implement preventive adaptation measures since the costs of inaction over time might be much higher.

Decision Makers
The following decision makers can be identified in the Swiss mountain communities:

- Community as a whole
- Voters
- Mayor (Gemeindepräsident) and local council
- Cantonal authority
- Informal institutions (people and organization with vested interests)

The federal authority is not recognised as a decision maker in the matters of local communities. In terms of informal institutions, people and organizations with vested interests constitute powerful family and economic players (energy and water companies, farmer associations, etc). The informants think that the decision makers should in general have long-term perspective, e.g. at least look into the welfare of the next generation. In reality, one or two legislation periods (5 to 1o years) are to be considered more realistic.

The status of exchange between science-policy-practice in Switzerland
The informants highlighted some tension between science and practice, where practice is here understood as implementation of certain policies at the local level. Two major problems emerged in discussing status of exchange between science-policy-practice in Switzerland:

1. Large gaps between the objectives of scientific assessments and the realities on the ground (e.g. at the local level).
2. Different time-frames, e.g. long-term frames of scientific models and adaptation approaches vs. short-term priorities and needs of local communities and their representatives.

In order to address the first issues, key informants provided an interesting suite of suggestions:

- Scientists and experts should put more efforts in communication and capacity building.
- Scientists and experts should communicate to local people in lay terms not only the results but also the inputs to their models.
- More emphasis should be put on the contextualization of scientific models and approaches.
- The federal agencies should try to balance and mediate information between scientists and practice.
- Scientists should be well informed ahead of problem formulation on how the political side works both at the middle and local level.
- Federal agencies should give to scientists clear instructions on their needs and expectations and such expectations should be realistically formulated.
- In the dialogue between science-policy-practice there must be openness and the needs of the different stakeholders should clearly be addressed.
- Scientific uncertainties should be clearly communicated as well as the methods to address them.

Concerning the second issues, the following suggestion was advanced:

- Both scientists and politicians should be informed about and adapt their time frames in advance of the problem formulation.

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