Swiss tourism in the age of climate change - vulnerability, adaptive capacity, and barriers to adaptation

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PAR

Cecilia MATASCI

acceptée sur proposition du jury:

Prof. E. Gnansounou, président du jury
Prof. Ph. Thalmann, directeur de thèse
Dr B. Abegg, rapporteur
Dr P. de Haan van der Weg, rapporteur
Prof. M. Rebetez, rapporteur

ÉCOLE POLYTECHNIQUE
FÉDÉRALE DE LAUSANNE

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Glossary

AC	Adaptive Capacity
ACQWA	Assessing Climate Impacts on the Quantity and quality of WAter
AHP	Analytical Hierarchy Process
AMSL	Above Mean Sea Level
ARE	Federal Office for Spatial Development
BLN	Federal Inventories of Landscapes and Natural Monuments of National Importance
CARAVAN	Climate Change: A Regional Assessment of Vulnerability and Adaptive capacity for the Nordic countries
CCHydro	Climate Change and Hydrology
CEAT	Urban and Regional Planning Community
CEO	Chief Executive Officer
CIA	Average thermal comfort
CID	Daytime thermal comfort
CHNE	Northeastern Switzerland
CHS	South of the Alps
CHW	Western Switzerland
CO_2	Carbon dioxide
CR	Consistency Ratio
DDPS	Federal Department of Defense, Civil Protection, and Sport
DETEC	Federal Department of the Environment, Transport, Energy, and Communications
DHM	Digital Height Model
DJF	December January February
E	Exposure
ECE	Economic Commission for Europe
ELA	Equilibrium-Line Altitude
ELA_0	ELA for which the steady state of the glacier equals zero
EPFL	Swiss Federal Institute of Technology of Lausanne
ESPON	European Observation Network for Territorial Development and Cohesion (previously called European Spatial Planning Observation Network)
ETH	Swiss Federal Institute of Technology of Zurich
FAO	Food and Agriculture Organization of the United Nations
FDEA	Federal Department of Economic Affairs
FDF	Federal Department of Finances
FDHA	Federal Department of Home Affairs
FIF	Research Institute for Leisure and Tourism
FOEN	Federal Office of the Environment
FSO	Federal Statistical Office
GDP	Gross Domestic Product
GHGs	Greenhouse Gases
GIS	Geographic Information System
GLIMS	Global Land Ice Measurements from Space
GLM	Fitting Generalized Linear Model
GS	GastroSuisse
GWN	Digital stream network
HES-SO	University of Applied Sciences Western Switzerland

HS	Hotelleriesuisse - Swiss Hotels Association
HSR	Institute for Landscape and Open Space, University of Applied Sciences Rapperswil
HTW	Institute for Tourism and Leisure Research, University of Applied Sciences
IDHEAP	Swiss Graduate School of Public Administration
ILF	Institute for Landscape and Open Space
ILO	International Labor Organization
IPCC	Intergovernmental Panel on Climate Change
ITF	Institute for Tourism and Leisure Research
IUKB	University Institute Kurt Bösch
JJA	June July August
MAB	Man And Biosphere
MCA	Multicriteria Analysis
MIADAC	Modeling Sectoral Climate Change Policies: Mitigation, Adaptation, and Acceptance
MOVE	Methods for the Improvement of Vulnerability Assessment in Europe
NCCR	National Centre of Competence in Research
NELAK	New Lakes in Deglaciating High-mountain Areas: climate-related development and challenges for sustainable use
NOGA	General Classification of Economic Activities
NRP	National Research Program
OcCC	Advisory Body on Climate Change
OECD	Organization for Economic Co-operation and Development
P	Precipitation
PCA	Principal Component Analysis
PESETA	Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis
PGIS	Participatory Geographic Information System
PI	Potential Impacts
PIK	Potsdam Institute for Climate Impact Research
PRI	Primary Surfaces Layer
RI	Random Consistency Index
REME	Research Group of Economics and Environmental Management
RMS	Cablecars Switzerland
S	Sensitivity
Ss	Sunshine
SAB	Groupement suisse pour les regions de montagne
SAC	Swiss Alpine Club
SAJA	Swiss Alps Jungfrau-Aletsch
S.D.	Standard deviation
SECO	State Secretariat for Economic Affairs
SECO/Tourism	State Secretariat for Economic Affairs – Tourism division
SGH	Swiss Society for Hotel Credit
SNSF	Swiss National Science Foundation
SRES	Special Report on Emission Scenarios
ST	Southern Ticino
STV-FST	Swiss Tourism Federation
SWIDCHI	SWIss Database of climate CHange Impacts
Swisstopo	Federal Office of Topography

SWOT	Strengths, Weaknesses, Opportunities, and Threats
TCI	Tourism Climate Index
TI	Tourism Intensity
TSA	Tourism Satellite Account
UNEP	United Nations Environment Program
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFCCC	United Nations Framework Convention on Climate Change
UNIGE	University of Geneva
UNWTO	World Tourism Organization
V	Vulnerability
VACCIA	Vulnerability Assessment of ecosystem services for Climate Change Impacts and Adaptation
W	Wind appreciation
WEF	World Economic Forum
WMO	World Meteorological Organization
WP	Working Package
WS	Workshop
WSL	Swiss Federal Institute for Forest Snow and Landscape

Contents

Résumé

Cette thèse analyse les impacts des changements climatiques sur le tourisme en Suisse. Elle examine en particulier la vulnérabilité régionale, l'adaptation et les barrières qui entravent ce processus. Ce travail a pour but de mettre en place un secteur du tourisme suisse plus durable et plus adapté à ces changements.

Dans la première partie, nous avons analysé la vulnérabilité régionale aux changements climatiques de ce secteur pour l'horizon 2030-2050 afin de définir les régions dans lesquelles une action d'adaptation est davantage nécessaire. Nous avons considéré en particulier les impacts générés par les changements d'adéquation de la météo pour les activités touristiques, la réduction de la couche neigeuse, la fonte des glaciers et du permafrost, le changement en fréquence et en intensité des dangers naturels, la réduction de la disponibilité en eau et les changements de la beauté du paysage. Nous avons sélectionné 70 indicateurs décrivant l'exposition, la sensibilité et la capacité d'adaptation de chacune des 85 régions touristiques définies dans le cadre de cette étude. Nous avons collecté, pondéré et assemblé les résultats de simulations sur les possibles impacts et les données statistiques couvrant l'ensemble de ces régions. Les résultats obtenus nous ont aidés à déterminer les facteurs influençant la vulnérabilité. De plus, ils nous ont permis de définir son hétérogénéité spatiale. Et finalement, les résultats nous ont montré les points sensibles de vulnérabilité, régions où l'implémentation de mesures d'adaptation semble être prioritaire.

Afin de valider la légitimité des résultats et d'analyser la perception des personnes travaillant dans le secteur, nous avons comparé le produit de l'analyse avec les résultats d'une enquête en ligne que nous avons élaboré. Dans celle-ci, nous avons demandé, parmi d'autres questions, d'évaluer la vulnérabilité de sa propre région touristique face aux impacts des changements climatiques. 566 acteurs du tourisme suisse ont répondu au sondage. Les différences entre les deux méthodes sont évidentes: les résultats de l'enquête montrent qu'une forte vulnérabilité est perçue surtout parmi les acteurs du tourisme des Préalpes. D'autre part, la carte de vulnérabilité désigne plutôt les régions de montagne, et en particulier le canton du Valais, le Tessin et Uri, comme spécialement vulnérables. Ces différences peuvent être dues à la tendance des acteurs à être influencés, dans leur évaluation, par des impacts déjà visibles comme la diminution de la couche neigeuse. Les répondants semblent donc avoir tendance à indiquer comme vulnérables des régions où les changements climatiques affectent déjà le tourisme. Par ailleurs, les dissimilitudes entre les deux méthodes dépendent des poids donnés par les 13 experts aux 70 indicateurs utilisés dans l'analyse de la vulnérabilité.

Dans la deuxième partie de la thèse, nous nous sommes penchés de plus près sur l'adaptation. Nous avons étudié en particulier le choix des mesures qui ont déjà été implémentées ou sont planifiées pour le futur. Nous avons aussi analysé l'évaluation de ces mesures par les acteurs. Notre examen suggère que le secteur s'adapte déjà dans le pays. Trois catégories d'adaptation existent: le développement de l'offre, la réduction des risques et la communication sur les impacts et sur les mesures prises. Au titre de développement de l'offre, on peut considérer l'élargissement de l'offre touristique sur l'année entière. L'innovation et le développement des activités proposées constituent d'autres mesures possibles. Mais il reste aussi le maintien et même le développement des activités liées à la pratique du ski et d'autres sports d'hiver. La conservation de ces activités était une option populaire dans le passé, avec la diffusion des canons à neige. Aujourd'hui, cette stratégie commence toutefois à montrer ses limites dans plusieurs régions, qu'elles soient économiques ou écologiques. De nombreux acteurs ayant répondu à l'enquête ont mentionné l'enneigement artificiel comme une mesure efficace seulement sur le court terme et qui doit être remplacée par d'autres stratégies dans les années à venir. En effet, de plus en plus de régions se focalisent sur l'innovation et la diversification de l'offre et canalisent leurs efforts sur l'évolution du tourisme tout au long de l'année. Notre étude confirme les résultats d'études précédentes qui arrivent à des conclusions similaires.

De plus, en collaboration avec le projet *ClimAlpTour- Le changement climatique et son impact sur le tourisme dans l'Espace Alpin*, nous avons mené un processus participatif d'adaptation dans une région sélectionnée comme cas d'étude (la région d'Aletsch). Ce travail nous a permis d'étudier des voies possibles d'adaptation et d'analyser d'éventuelles barrières au processus.

Finalement, dans la dernière partie de la thèse, nous nous sommes penchés plus en détail sur ce dernier aspect, et nous nous sommes focalisés sur les barrières qui entravent le processus d'adaptation. Ils existent maints éléments qui peuvent empêcher l'implémentation d'une adaptation effective et efficace. Ces éléments peuvent être d'origine économique, technologique, sociale ou institutionnelle. En nous basant sur les résultats du sondage et sur des entretiens en face-à-face avec des acteurs de régions concernées par l'adaptation, nous concluons que les barrières à l'adaptation pour le tourisme suisse se rapportent surtout à des facteurs économiques et sociaux. Le manque d'argent peut clairement être un frein à l'adaptation. D'autre part, il apparait que le manque d'information et de coordination parmi les différents acteurs peut tout autant miner le processus. Ceci alors même que la volonté d'agir des acteurs et l'acceptation des mesures par la population semblent être hautes dans le pays (dans la mesure qu'il ne s'agisse pas de mauvaise adaptation et que les mesures n'aient pas d'effets négatifs trop importants sur la société, l'économie et l'environnement).

Au niveau cantonal et national, beaucoup de choses sont déjà faites pour contrer les effets des changements climatiques, en particulier avec l'élaboration de la stratégie d'adaptation suisse. Les bases pour une transition efficace vers un tourisme plus adapté semblent donc avoir été posées. D'autre part, il ne faut pas oublier que le secteur est confronté à de nombreux autres défis qui ne sont pas directement liés aux changements climatiques et qui menacent tout autant la viabilité du secteur. De plus, par son empreinte non négligeable sur l'environnement et en contribuant à l'émission de gaz à effet de serre, une transformation durable du secteur non seulement du côté économique et social, mais aussi du côté environnemental se montre nécessaire.

Mots-clés: Changements climatiques, tourisme, Suisse, vulnérabilité, exposition, capacité d'adaptation, adaptation, participation publique, barrières à l'adaptation

Abstract

This thesis analyses the impacts of climate change on Swiss tourism. It looks in particular at the regional vulnerability, adaptation, and barriers that hinder this process. The final goal of the work is to make a contribution in bringing about a smoother shift to a more sustainable tourism sector better adapted to the changing conditions.

In the first part, the thesis examines the regional vulnerability of Swiss tourism to climate change for a 2030-2050 time horizon in order to define which regions are most in need of taking action. We analyzed in particular the impacts generated by changes in climate suitability for tourism activities, snowpack reduction, glaciers melting, permafrost melting, natural hazards, water scarcity, and changes in landscape and scenic beauty. We selected 70 indicators describing the exposure, the sensitivity and the adaptive capacity of each of the 85 defined areas. We collected, weighted and assembled simulations on the possible impacts and statistical data covering the whole country. The results obtained allowed us to identify the most important drivers influencing vulnerability. Moreover, they permitted the assessment of spatial heterogeneity in vulnerability. Finally, the data allowed us to identify hotspots, areas in which the implementation of adaptation measures is most crucial.

To validate the legitimacy of the results and to analyze the perception of people working in the sector, we compared outcomes with the results of an online survey we designed. It was carried out among 566 Swiss tourism stakeholders and asked them to evaluate the vulnerability of their particular region. Differences between the two methods appeared: the outcome of the survey indicated that those living mainly in the Prealpine regions perceived their regions as the most vulnerable. Meanwhile, the outcomes of the geographic “hotspot” analysis showed that the mountainous regions, mostly in the Valais, Ticino, and Uri cantons, were the most vulnerable. Differences may be explained on one hand from the predisposition of stakeholders to be influenced by impacts already visible like snowpack reduction. Therefore, they might be more likely to identify the most vulnerable regions as the ones in which climate change is already affecting the tourism sector. On the other hand, dissimilarities also depend on the scores given by the 13 experts which weighted the various indicators used in the vulnerability map.

In the second part of the thesis, we examined adaptation. We analyzed in particular which measures are already being implemented or have already been planned for the future. We also looked at how stakeholders evaluate the efficiency of these measures. Our analysis suggested that adaptation is already taking place in the country. Three categories of adaptation exist. These can be summarized as following: development of the supply, risk reduction, and communication on impacts and on implemented measures. The development of the supply can be seen both as the promotion of year-round tourism, in addition to innovation and diversification of tourism activities offered. It could also include the further development and securing of snow sports activities. The maintenance of winter tourism was a popular option in the past, with the wide spreading of snow cannons. Now, however, this strategy is beginning to show its economic and environmental limits in multiple regions. Various stakeholders in the online survey cited artificial snowmaking as efficient measures only on the short term that should be replaced by other strategies on the long run. Consequently more and more regions are focusing on diversification and innovation, putting more effort in offering year-round tourism. Our results confirm outcomes of past studies on the topic, which found similar results.

Moreover, in collaboration with the ClimAlpTour project, we carried out a participative adaptation process in a selected case study region (the Aletsch region). We did this in order to study possible adaptation paths and to analyze possible impediments to the process.

Finally, the last part of the thesis looked more in particular at this latter aspect, focusing on barriers to adaptation. Many elements can hinder the implementation of effective and efficient adaptation. These can have either economic, technological, social, or institutional origins. Based on stakeholders' opinions, we saw that, for Swiss tourism, the barriers relate mainly to economic and social issues. The lack of money can clearly be an impediment to adaptation; also in addition to this, however, we found that the lack of information and coordination among stakeholders can also seriously hinder the process. This even if the willingness to act in order to adapt is high among stakeholders and the acceptability of the measures is important among the population (up to a point to which measures do not lead to maladaptation and that they do not carry too many negative impacts on the society, economy, and environment).

Much is already being done at the Swiss national and local levels to combat the impacts of climate change in the country, in particular with the elaboration of the Swiss adaptation strategy. The groundwork for an effective transition of Swiss tourism seems therefore to have been laid. However, it should not be forgotten that the sector is facing many other challenges not directly linked to climate change and which also threaten the viability of the sector. Moreover, due to its significant footprint on the environment and its contribution to greenhouse gasses emission, the sector also needs to incorporate sustanaiblity in its adjustment and change.

Keywords: Climate change, tourism, Switzerland, vulnerability, exposition, adaptive capacity, adaptation, public participation, barriers to adaptation

1 General introduction

1.1 Goals of this research

This thesis is part of the MIADAC project (Modeling Sectoral Climate Change Policies: Mitigation, Adaptation, and Acceptance) in the National Centre of Competence in Research on Climate Change research program (NCCR-Climate).[1] It deals with vulnerability, adaptation, and barriers to adaptation in the tourism sector in Switzerland in relation to climate change.

Swiss tourism is clearly affected by climate change due to the strong impacts of the latter in the Alps, its exposure to natural hazards, and generally the dependence of the sector on both weather and landscape conditions (Ecoplan/Sigmaplan 2007; OcCC/ProClim 2007). Moreover, tourism is an important pillar of Swiss economy and society since it is so strongly interlinked with other domains and sustains the livelihood of many people in the mountain regions (König and Abegg 1997; STV-FST 2011). It is therefore important to analyze more in depth the impacts of climate change on the sector and to prepare adaptation measures. The concept of adaptation is intimately linked to the concept of vulnerability. The more vulnerable a region, sector or society, the more severe the consequences of climate change are and therefore the more adaptation becomes important.

Several earlier studies analyzed the topic, mainly the impacts of climate change on winter sport activities through snowpack reduction (Bürki 1995; Elsasser et al. 1995; Abegg 1996; König and Abegg 1997; Bürki 2000; Elsasser and Messerli 2001; Elsasser and Bürki 2002; Abegg et al. 2007; Müller and Weber 2008; Uhlmann et al. 2009; Gonseth and Matasci 2011; Pütz et al. 2011; Rixen et al. 2011; Serquet et al. 2011; Beniston 2012a). Some studies considered other impacts, such as changes in climate suitability for tourism activities (Abegg and Steiger 2011; Serquet and Rebetez 2011) or changes in the amount and seasonality of precipitations and the frequency and intensity of natural hazards (Beniston et al. 2011; Beniston et al. 2012b).

Some studies looked at the economic impacts that climate change could have on the sector, as for example Müller and Weber (2007) for the Berner Oberland and Meier (1998) and for Switzerland the Ecoplan/Sigmaplan report (Ecoplan/Sigmaplan 2007). However, very few studies looked at other impacts affecting the sector, such as permafrost melting or changes in scenic beauty, and none to our knowledge investigated simultaneously all most relevant impacts affecting the sector. Little research was carried out specifically on the subject of adaptation of the tourism sector (Hoffmann et al. 2009; Hill et al. 2010). To our knowledge, no research dealt specifically with barriers to adaptation in the Swiss context.

There exists a large number of international studies dealing with climate change impacts on tourism and with possible adaptation measures. For an overview related to winter ski tourism, we can mention the work of Yang and Wan (2010). Additional interesting studies on winter sport tourism not mentioned in their paper were carried out by Scott et al. (2003), Scott et al. (2007a), Scott et al. (2008), Steiger and Meyer (2008), Tervo (2008), Dawson et al. (2009), Hoy (2009), Luthe (2009), Steiger (2009), Hoy et al. (2011), Steiger and Abegg (2011), Pickering et al. (2010a,b), Pickering (2011), Töglhofer et al. (2011), Sobol (2012), and by Steiger (2012). As regards impacts on other activities than wintersport, we can mention in particular the work on glaciers melting of Voda (2008), Wang

[1] http://www.nccr-climate.unibe.ch/index_en.html. Last accessed 22.12.2011.

(2010), Scott et al. (2007b), and of Carey et al. (2012) and the work of Ritter et al. (2012) on permafrost melting and its impact on alpine trails and routes. Other studies also looked at changes in climate suitability for tourism activities, such as Scott and McBoyle (2001), Lise and Tol (2002), Hamilton et al. (2005a, b), Gossling et al. (2006), Hamilton and Tol (2007), and Perch-Nielsen et al. (2010a). Fewer studies dealt specifically with vulnerability mapping and barriers to adaptation in the tourism sector (Prettenthaler et al. 2006; Perch-Nielsen 2010; Holsten et al. 2011; Holsten et al. 2012; Roman et al. 2011).

In short, Swiss studies focused mainly on snowpack reduction. Very few looked at other impacts, such as permafrost melting or changes in scenic beauty and none to our knowledge investigated simultaneously the set of most relevant impacts affecting the tourism sector. What is also lacking up to now is an assessment of regional differences and of possible ways to address these impacts and to overcome barriers to adaptation.

This thesis aims at closing these gaps. The general objectives of this work are consequently:

1. To develop and apply different methodologies designed to assess the magnitude of impacts and the distribution of the vulnerability of tourism in Switzerland to climate change, and to use these methodologies to identify focal areas of vulnerability ('hot spots');
2. To identify and analyze possible adaptation measures on regional and national scale;
3. To define a framework for the identification and evaluation of barriers to adaptation and to suggest ways that these barriers can be overcome.

For the first objective, we developed or made use of three different methodologies, combining two top-down and one bottom-up approaches. First, we developed a tailored vulnerability map, in which the exposure, the sensitivity, and the adaptive capacity of the different tourism regions are depicted. The map also allowed for the identification of major climate change vulnerability hotspots in which the implementation of adaptation measures is most crucial. Second, we made use of a cluster analysis in order to assess similarities of exposure, sensitivity, adaptive capacity, and vulnerability among regions. Finally, we gathered stakeholders’ perceptions of regional vulnerability and compared the results with the aforementioned vulnerability map. The methodological developments related to the vulnerability map and the comparisons of the different results allowed for a discussion of the limitations of vulnerability mapping.

Next, we approached the second objective by carrying out a participative adaptation process in a case study region. In this region, we launched the process together with local stakeholders. The process was designed for the identification, selection, and implemention of the most appropriate effective public and private adaptation strategies in the near future on a regional level. Moreover, face-to-face interviews and an online survey sent to different stakeholders helped to broaden the knowledge on past, present, and future adaptation in the Swiss tourism sector.

The third objective is accomplished by designing a framework concerning barriers to adaptation and testing it with face-to-face interviews and the online survey cited above. This method revealed the opinion of various Swiss tourism stakeholders on the existing barriers to the adaptation process and on ways to overcome them. A phone interview of 1007 Swiss citizens provided additional data for this analysis.

General results should allow us to identify the most effective strategies and how they could efficiently be implemented. They should also help define where it is most important to realize them. We created an interactive web platform (http://wiki.epfl.ch/tccch) with the purpose of sharing the available information and the results of this study with the stakeholders. In sum, the topic of this thesis is of particular relevance due to the vulnerability of the tourism sector to climate change, to the importance of tourism for the Swiss economy, and in a broader sense due to the urgent need for more detailed assessments of possible and effective adaptation measures.

In this thesis, we primarily addressed adaptation-related issues. It should however be kept in mind that tourism is also a significant emitter of greenhouse gases (GHGs). Mitigation (GHGs reduction-related measures) should therefore not be forgotten (Figure 1.1 and Section 2.2). It should also be kept in mind that the Swiss tourism industry is not an isolated sector; it is part of a far more complex system, tightly intertwined with other domains such as agriculture, health, forestry, and energy production. Impacts and evolution of these sectors will influence tourism and *vice versa*. The same is true for impacts and changes taking place outside the country.

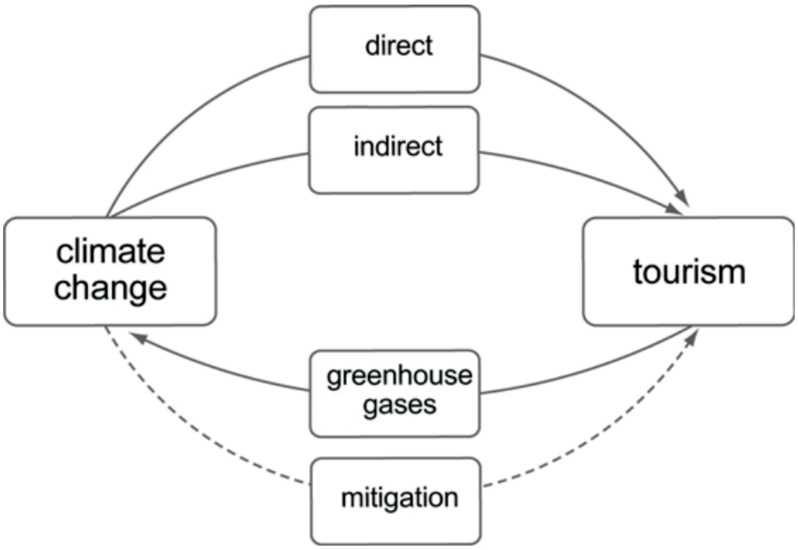

Figure 1.1: The strong link between tourism and climate change: the former contributes to the latter with its high GHGs emissions; the latter impacts the former with both direct and indirect changes in climate conditions (adapted from Perch-Nielsen (2008)).

1.2 Main hypotheses developed in this thesis

To answer and widen the research questions presented in Section 1.1, we developed 8 hypotheses that we tried to corroborate throughout this work:

Hypothesis 1: Climate change is already producing effects on weather patterns, landscapes and natural hazards; this affects the tourism sector in particular, since it is highly exposed to these factors. Both private and public stakeholders are generally aware of these changes and have started to adjust to the new conditions

Effects of climate change have been felt in Switzerland for many decades. Signs of snowpack reduction and melting glaciers were for example already obvious in the 1990s. The tourism sector did not idly watch as it happened, on the contrary; it took different measures, efficiently or not, to face the impacts. In Chapters 4, 5, and 6, we examine the evolution of these measures and analyze their effectiveness and efficiency over time.

Hypothesis 2: The vulnerability of tourism in a region is not only determined by its exposure, but also by its sensitivity and adaptive capacity. Therefore, regions most exposed to the effects of climate change are not necessarily the most vulnerable ones.[2]

Exposure is described by the Intergovernmental Panel on Climate Change (IPCC) as the *'nature and degree to which a system is exposed to significant climatic variations'* (IPCC 2001). For tourism in Switzerland this relates to the magnitude of various impacts, ranging from changes in climate conditions to snowpack reduction or glaciers melting. Nonetheless, the most vulnerable regions are not necessarily the ones in which these impacts are the strongest. Other aspects, such as the local structure of the tourism industry, the economy, and the infrastructure (sensitivity), in addition to the capacity to adapt determine the extent to which tourism in a particular region will suffer from the effects of climate change. We discuss this topic in Chapter 4.

Hypothesis 3: Adaptation processes are often part of a larger process of restructuring and do not happen deliberately, though not necessarily less efficiently

The Swiss Alps are particularly affected by climate change. Snowpack reduction and the melting of glaciers and permafrost are for example already being observed. Artificial snowmaking and the shift to summer tourism are two common adaptation measures. Often, however, stakeholders do not label them as specific adaptation measures to the consequences of climate change. They describe these rather as step-by-step responses to other, more general social, economic, and ecological changes (like, for example, changes in tastes, international competitition, population structure, and mobility patterns).

In order to test this hypothesis, we examine in Chapter 5 how often measures are taken not only because of the impacts of changes in climate conditions, but also because of an interrelated flux of societal, economic, and environmental changes. In particular, we shall examine when adaptation to climate change is planned as such (as part of a specific strategy, for example) and when it takes place more organically.

Hypothesis 4: The most vulnerable regions are not only among the ones that are most likely to adapt but also among the ones that are most likely to initiate mitigation initiatives

Mitigation and adaptation are often seen as two separate measures; they are, however, two sides of the same coin and can go together. Barriers to action concerning mitigation actions are frequently psychological – generally related to limited knowledge about the problems –, ideological, sunk costs, behavioral inertia, distrust toward experts and authorities, perceived risks of change, and positive but inadequate behavioral changes (Gifford 2011). Our hypothesis is that the perception of the risks fosters action and removes barriers related to mitigation. We shall therefore analyze in Chapter 5 whether mitigation strategies take place more frequently, if at all, in regions where stakeholders feel more impacted.

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[2] For a definition of exposure, sensitivity, adaptive capacity, and vulnerability see Section 4.3.

Hypothesis 5: Social infeasibility and other barriers related to social acceptability like the lack of information and coordination, stakeholders' unwillingness to adapt, and the rejection of the chosen adaptation measures by the local population, can strongly hinder adaptation processes

The literature often posits that the main hurdles to the adaptation process are economic, technological and institutional (Brooks et al. 2005). In line with recent literature (Smit and Pilifosova 2001; Adger and Vincent 2005; Grothmann and Patt 2005; Blennow and Persson 2009), we examine in Chapter 6 the hypotheses that social components, in particular, low social acceptability and cognitive and normative barriers, significantly hinder the adaptation process. For example, a 2009 study of Blennow and Persson carried out among Swedish forest owners observed that the strength of belief in climate change and in adaptive capacities is a crucial determinant of observed adaptation. They found that economico-socio-political arrangements alone could not explain the process of adaptation to climate change. Grothmann and Pratt (2005) obtained similar results. In their study, they came to the conclusion that perceived adaptive capacity and risk perception explain more the variation in adaptation efforts than economic, social, or political factors.

Hypothesis 6: Further research and effective communication on climate change increase awareness and understanding of climate change

A growing body of literature highlights the importance of effective communication of climate change impacts and possible adaptation options in order to increase awareness and understanding and to engage stakeholders and policy-makers (Moser and Dilling 2007; CRED 2009; Kahan 2010; Di Falco and Veronesi 2011). We analyze in Chapters 5 and 6 the relation between the channels of communication used and the degree of awareness of stakeholders. We shall also analyze the perceived lack of information, what kind of information stakeholders are asking for and where more research is needed.

Hypothesis 7: Participative processes are powerful instruments for ensuring the success of an adaptation process

Often in the literature the inclusion of stakeholders in the adaptation process was promoted as a good response to climate change (Adger 2003; Savard and Bourque 2010). It is stated that functional participative processes facilitate communication and the transfer of socio economic, environmental, technical, and scientific information among policy makers, researchers, and stakeholders. The research also suggests that participative processes should accelerate the implementation of adaptation solutions and strengthen the links among stakeholders. Some real examples of positive bottom-up processes in which stakeholders engage and take part in the adaptation process exist (Savard and Bourque 2010).

On the other hand, some authors criticize participative processes, stating that these are naturally problematic (Pennington and Rydin 2000; Few et al. 2007). For Bloomfield et al. (2001), Hillier (2003), and Few et al. (2007), it is difficult to establish that the selected or self-selected participants truly represent the whole set of people concerned; often not all social actors have the same access to the process. Moreover, as stated by Goodwin (1998) and Mitchell (2002), it is often difficult to determine during public meetings whether more active participants (including organized pressure groups) really represent the views of less active community members. We address this hypothesis in Chapters 5 and 6.

Hypothesis 8: Good leadership can help overcome barriers to adaptation, while lack of or ineffective leadership raises barriers

According to the Blackwell Encyclopedia of Political Science (Bogdanor 1991), leadership can be defined as '*the power of one or a few individuals to induce a group to adopt a particular line of policy*'. Leadership is particularly important in the initiation of the adaptation process and sustaining momentum over time (Moser and Ekstrom 2010). The lack of a leader can undermine the capacity and willingness of the community to take adaptation decisions (Tribbia and Moser 2008). We address this hypothesis in Chapters 5 and 6.

1.3 Structure of the thesis

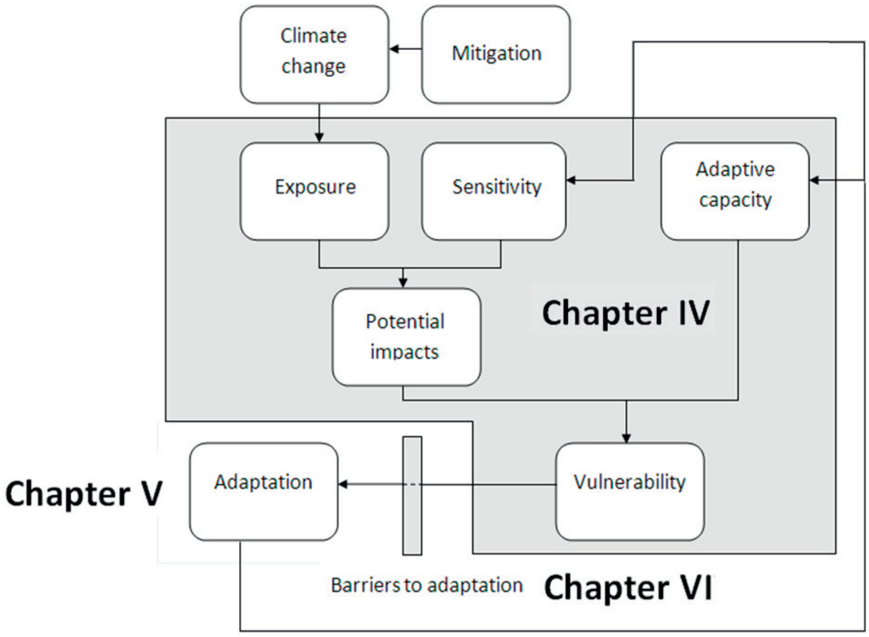

Figure 1.2: Structure of this thesis.

After this chapter, which introduced the thesis and presented the three goals and eight hypotheses we shall analyze, Chapter 2 presents the background that motivated this research and the questions posed (Figure 1.2). It therefore describes the tourism industry and its socio-economic importance in Switzerland. It also presents the available knowledge on the possible impacts of climate change affecting the sector.

Chapter 3 presents the methods, the data, and the different spatial scales chosen for the analysis. The subsequent thee chapters address in turn each of the three stated goals:

Chapter 4 examines vulnerability. Much importance was placed on developing a methodology for mapping the regional vulnerability of tourism in the country. The rest of the chapter presents three different methods we chose, along with the results and the limitations of the various approaches.

Another goal for the vulnerability mapping is to identify "hotspots", defined as regions in which adaptation measures are first and most needed. We present this analysis in Chapter 5, in which we also provide a precise definition of adaptation, show how it is already taking place in Switzerland, and suggest how it could be improved. That chapter will make use of face-to-face interviews and an online survey of stakeholders of the tourism industry. Moreover, we shall examine a real adaptation process more concretely in a case study region (Aletsch) analyzed in collaboration with the ClimAlpTour project. A participative adaptation process in this region met various barriers and did not lead to concrete actions up to now.

The 6th chapter aims therefore at assessing why adaptation processes could fail and at identifying possible barriers to the process. The chapter sets up a framework showing the barriers to adaptation and focuses on possible ways of overcoming them. In this framework, we shall use again the face-to-face interviews and the online survey. In addition, we shall use the results of a phone survey carried out among Swiss citizens in order to better understand the general population's position relative to adaptation.

In the last chapter we discuss the different outcomes obtained, we conclude on our eight hypotheses, we discuss the limitations of the various methods used, and finally we provide a conclusion to this thesis and suggest possible future research.

2 Background information

In this chapter, we describe the importance of tourism in Switzerland from a social and economic point of view. We also show that tourism is an important sector for climate change mitigation and adaptation and describe the likely impacts of climate change on the sector.

2.1 Tourism: an important sector for Swiss society and economy

Tourism is one of the sectors with the strongest effects on both the society and the economy since it is so strongly interlinked with other domains and since it is in fact a composite of activities, facilities, services and industries that deliver the travel experience. These are transportation, accommodation, eating and drinking establishments, entertainment, recreation, historical and cultural experiences, destination attractions, shopping, and other services available to travelers away from home (Goeldner and Brent Ritchie 2003). It is estimated that international tourism generated approximately 6% of worldwide exports of goods and services in 2003. This share increases to approximately 30% when considering service exports exclusively (UNWTO 2011). This does however not depict the revenues generated inside countries by domestic tourism. Moreover, tourism and travel are important employers, employing approximately 8% of the global workforce, either directly or indirectly (Pratt 2011).[3]

Tourism is also a relatively important sector for Switzerland, accounting in the 2005-2009 period for 2.8-2.9% of the Gross Domestic Product (GDP) (STV-FST 2011). In this case, direct income is principally generated by accommodation (25%), catering (17%), and passenger transport (16%) (STV-FST 2006). Of the 30.4 billions CHF_{2005} generated by the Swiss economy in 2005, domestic tourism directly generated 18.4 billion (61%). Meanwhile, foreign tourists spent 12 billion (39%), accounting for approximately 5.3% of the income generated by exports in Switzerland (STV-FST 2011). This places tourism in the 3rd position of Swiss exports.

Tourism in Switzerland is also an important employer: in 2009, 4.1 % of jobs were directly generated by this industry (STV-FST 2011). Generally, approximately one person out of every 11 is directly or indirectly employed by tourism in the country (Dayer 1998). In mountainous areas, this proportion is considerably higher. In Valais, for example, 1 person out of 3 works directly or indirectly for tourism, in particular during the winter season. Winter tourism provides thus an important contribution to the economy of the rural mountainous areas (König and Abegg 1997; Abegg et al. 2007; Bürki et al. 2007). Originally, however, the main income period of tourism in the Alpine region was summer. It is only since the early 1970s that winter tourism expanded significantly and overtook summer tourism (Agrawala 2007).

[3] Assuming that one job in the tourism industry generates around one and a half additional or indirect job.

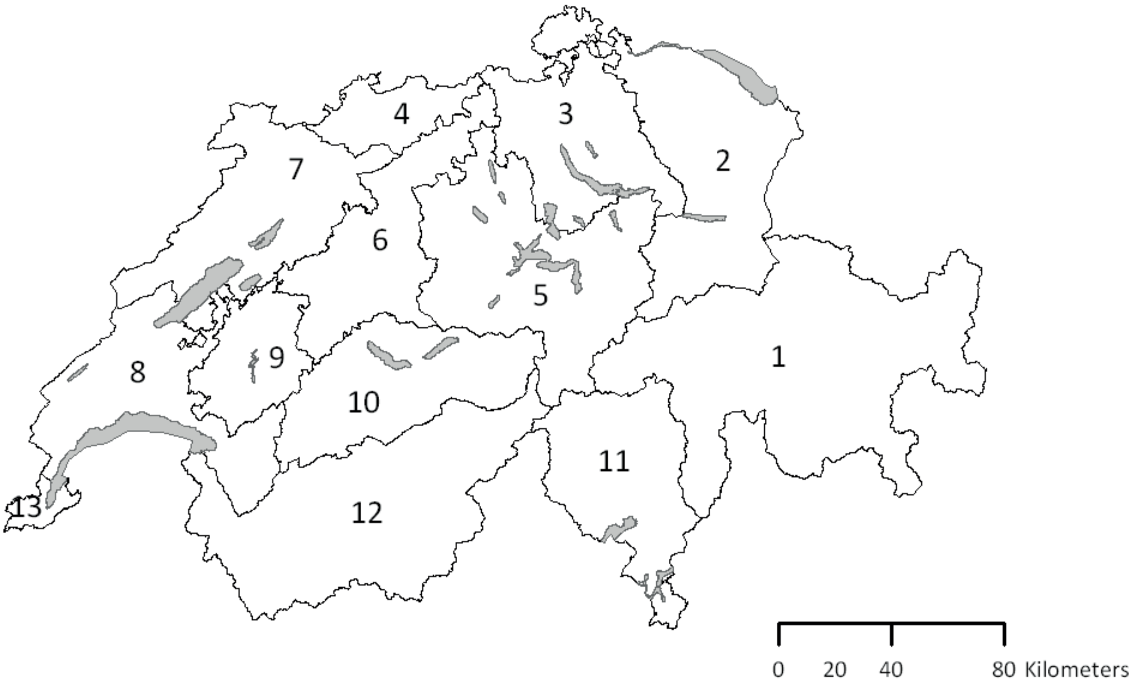

Figure 2.1: The 13 official Swiss tourism regions: 1. Grisons; 2. Eastern Switzerland; 3. Zurich region; 4. Basel region; 5. Central Switzerland; 6. Mittelland; 7. Neuchatel; Jura and Bernese Jura; 8. Lake Geneva region; 9. Fribourg region; 10. Bernese Oberland; 11. Tessin; 12. Valais; and 13. Geneva (STV-FST 2009). [4]

Structurally, Switzerland is divided into 13 tourism regions, each one distinguishable by its specific characteristics (Figure 2.1). About 240 000 touristic beds are available in the country, belonging to about 5 000 establishments (FSO 2009a) (Table 2.1). The highest number of establishments is located in the Grisons (13.7%), in Valais (12.1%), and in Eastern Switzerland (11.5%). On the other hand, Geneva and Fribourg count the lowest numbers of establishments, with respectively 2.7% and 2.4%.

Occupation rates of these establishments vary between 66.4% (Geneva in summer) and 23.7% (Neuchatel, Jura and Bernese Jura in winter). Grisons possess, by far, the highest tourism intensity, with 9 lodging nights per inhabitant, followed by the Bernese Oberland (5.5), and Valais (4.2). Small and medium-sized establishments account for the majority of the offer: almost 75% of the hotels do not possess more than 50 beds (STV-FST 2009).

With 54.4% of the stays, Swiss people generate the main tourist demand in the country. They are followed by Europeans, with Germans representing 15.4%, British 3.3%, Italians 3.1%, and French 2.9%. North-Americans account for 3.0% of the stays, Japanese 1.8%, Chinese 1.1%, and Australians together with New-Zealanders 0.8% (FSO 2009b). Reasons that foreign tourists come to Switzerland are many and varied. In winter, sporting activities represent the first reason for their visit, followed by resting and recreation (Dayer 1998). In summer, tourists principally come to Switzerland for resting and for recreation, as also for walking and hiking. A more complete summary of the tourism structure and of its economic importance can be found in the annual report publish by the Swiss

[4] http://www.myswitzerland.com/en/destinations/regions.html (Swiss tourism regions at the 2010 state). Last accessed 22.12.2011.

Tourism Federation (STV-FST), the umbrella organization representing the industry interests (STV-FST 2011).

Table 2.1: Number of establishments, beds, overnight stays, and occupation rates for the different tourism regions in 2008 (FSO 2009a).

	Region	Esta-blish-ments	Beds	Overnight stays	Tourism intensity[1]	Occupation rate in winter	Occupation rate in sum-mer	Annual occu-pation rate
1	Grisons	677	38 124	6 239 848	9	61.7%	52.9%	57.6%
2	Eastern Swit-zerland	566	18 153	2 035 033	0.7	36.8%	45.8%	41.5%
3	Zurich region	376	24 555	4 653 536	0.8	61.9%	70.0%	65.0%
4	Basel region	166	8 659	1 362 955	0.7	56.5%	58.6%	56.9%
5	Central Switzer-land	545	25 897	3 776 256	1.4	41.8%	58.3%	50.5%
6	Mittelland	354	13 080	1 818 271	0.4	46.1%	56.1%	50.8%
7	Neuchatel, Jura and Bernese Jura	183	4 711	361 417	0.3	23.7%	35.3%	29.9%
8	Lake Geneva region	316	17 230	2 636 535	1.1	49.6%	60.6%	55.5%
9	Fribourg region	119	4 044	403 761	0.4	31.1%	44.8%	37.9%
10	Bernese Oberland	461	25 202	3 904 926	5.5	49.6%	57.4%	53.4%
11	Tessin	438	17 935	2 667 093	2.2	35.1%	59.5%	49.0%
12	Valais	593	29 087	4 590 028	4.2	58.1%	49.8%	54.3%
13	Geneva	132	14 668	2 884 110	1.8	63.6%	71.6%	66.4%
	Total	4 924	241 345	37 333 769	1.3	51.6%	57.5%	54.4%

[1] Given as the ratio of lodging nights in relation to resident population. The ratio allows for the measurement of the relative importance of tourism to the local economy.

2.2 The contribution of Swiss tourism to climate change

By its nature, tourism contributes significantly to climate change. A conjoint study of the World Tourism Organization (UNWTO), the United Nations Environment Program (UNEP), and the World Meteorological Organization (WMO) (UNWTO-UNEP-WMO 2008) shows that the sector was accountable in 2005 worldwide for 4.9% of CO_2 emissions. The origins of the emissions do however highly depend on the type of tourism and on the choice of destination (near or distant locations), on the transport mode, and on the length of stay. Transport generates by far the largest proportion of emissions (75%), with air transport alone accounting for 40%. Accommodation follows with 21%. Finally, different tourism activities account for the remaining 4%.

In Switzerland, tourism in 1998[5] was directly responsible for 5.2% of GHGs emissions generated by the various economic sectors (including international aviation emissions), which places it in fourth position behind the transport sector, the manufacturing of energy intensive products, and agriculture (Perch-Nielsen et al. 2010b). Transport accounts for the highest proportion of emission in the Swiss

[5] 1998 was chosen for the analysis being the most recent year for which the Swiss Tourism Satellite Account (TSA) provided data at the time the study was carried out (Perch-Nielsen et al. 2010b).

tourism sector (87%), followed by accommodations (10%). The remaining 3% of the emissions come from different tourism activities. In comparison to other sectors, tourism possesses the fourth highest emissions rate, with 310 g CO_2-eq./CHF of gross added value (Perch-Nielsen et al. 2010b) (Figure 2.2). The Swiss average is about 80 g CO_2/CHF.

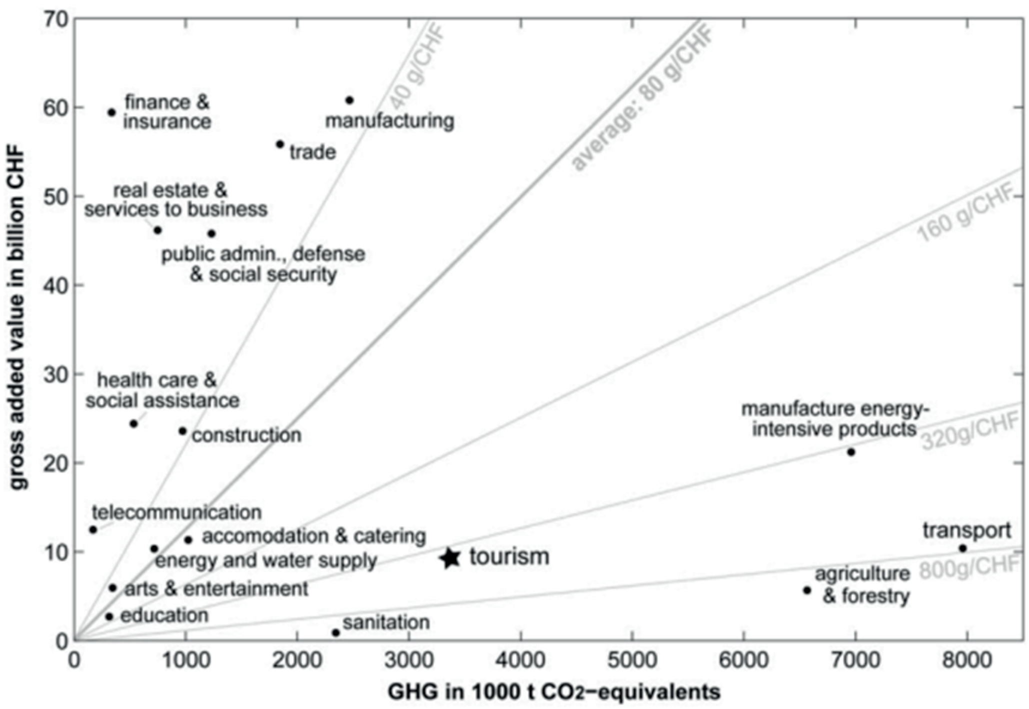

Figure 2.2: Comparison of the GHG intensities of tourism and selected economic sectors in Switzerland (FSO 2005). The gross value added of the sectors is plotted against their GHG emissions. The grey diagonal lines represent exemplary GHG intensities (Perch-Nielsen et al. 2010b).

2.3 The impacts of climate change on tourism in Switzerland

It is evident, therefore, that tourism contributes significantly to climate change. On the other hand, it is particularly exposed to its impacts. The greenhouse effect has been known since 1824, with the work of the French physicist Joseph Fourier (1824). This early study was then followed by a broad range of global and country-specific research on the human contribution to this effect and on climate change (Arrhenius 1896; Callendar 1938; Keeling 1960). It lead, between 1980 and 1988, to the worldwide recognition of the phenomenon and to a better understanding of its physical impacts, like the changes in average temperature and rainfall, and the melting of glaciers and of permafrost induced by these changes in temperature. The most recent summary of research on impacts can be found in the 4th IPCC report (IPCC 2007b).

As regards Switzerland, the most comprehensive assessment of the impacts of climate change was carried out at the end of the 1990s with the National Research Program 31 (NRP 31), 'Climate Change and Natural Hazards' of the Swiss National Science Foundation (SNSF). This program covered a wide range of possible physical impacts, including those that affect tourism. A summary of these impacts is provided by Badler and Kunz (2000) and Kunz (1999). Other studies on the topic were carried out in the following years, in particular under the NCCR Climate project. A list and description of these studies can be found in the 'SWIss Database of climate CHange Impacts' (SWIDCHI).[6]

Generally, three main reports presenting the climate impacts, their socio-economic consequences, and possible mitigation and adaptation strategies in relation to tourism have been made available to stakeholders so far: Müller and Weber (2007), Müller and Weber (2008), and Abegg (2011). Additional information can be found in Section 1.1 and in Matasci and Altamirano-Cabrera (2010a,b). Various studies analyzed some of these impacts in greater detail, sometimes considering the entire country, sometimes looking at a specific case study region. Serquet and Rebetez (2011) examined climate suitability and analyzed the effect of hot summer air temperatures on tourism demand. They found that alpine tourist resorts could benefit from higher temperatures at lower elevations under future climates. Abegg and Steiger (2011) critically analyzed the claim that Alpine summer tourism will benefit from climate change. They concluded that there does not yet exist sufficient scientific knowledge to verify the assertion. Bürki (1995), Elsasser et al. (1995), Abegg (1996), König and Abegg (1997), Bürki (2000), Elsasser and Messerli (2001), Elsasser and Bürki (2002), Abegg et al. (2007), Müller and Weber (2008), Uhlmann et al. (2009), Gonseth and Matasci (2011), Pütz et al. (2011), Rixen et al. (2011), Serquet et al. (2011), and Beniston (2012a) looked at winter tourism and at the effects of snowpack reduction. They all outlined the high vulnerability of lowland regions in relation to this impact. Some pointed out the relative benefits for higher locations. Beniston et al. (2011) and Beniston (2012b) studied changes in the amount and seasonality of precipitations and the frequency and intensity of natural hazards in the Swiss part of the Rhone catchment. They highlighted the fact that profound shifts in water availability and natural hazards events are likely, depending on seasons, as climatic change accelerates over coming decades. Researchers are now searching answers to social and economic issues linked to the topic. To our knowledge, the effects of other impacts of climate change on Swiss tourism specifically have not yet been studied. Nevertheless, some studies tried to quantify the economic impacts of climate change on tourism. Müller and Weber (2007) did so for the Bernese Oberland, whereas Meier (1998) and Ecoplan/Sigmaplan (2007) did it for the whole country. Even if they provide quite different values, they all agree that tourism will be one of the most affected sectors in the country.

The (positive or negative) impacts experienced by the tourism system come both from demand and supply (Figure 2.3). Indeed, climate change has an impact on tourism flows (i) and subsequently on monetary flows (ii). On the other hand, climate change has an impact on supply, which also affects monetary flows through additional infrastructure costs and investments and through changes in employment flows (iii). Adaptation measures can address both demand and supply and their outcome can be perceived on all of the three cited flows (i-iii). It should be pointed out that climate related changes could also bring positive outcomes to tourism in some regions of the country (at least in a given period).

[6] http://swidchi.epfl.ch/. This website hosts a project surveying and gathering the knowledge available in Switzerland on the actual and future impacts of climate change in the country. This inventory is a specific mandate given by NCCR Climate to the Research Group on the Economics and Management of the Environment (REME), financed by the SNSF, and maintained with the support of the FOEN. See also Annex A.19.

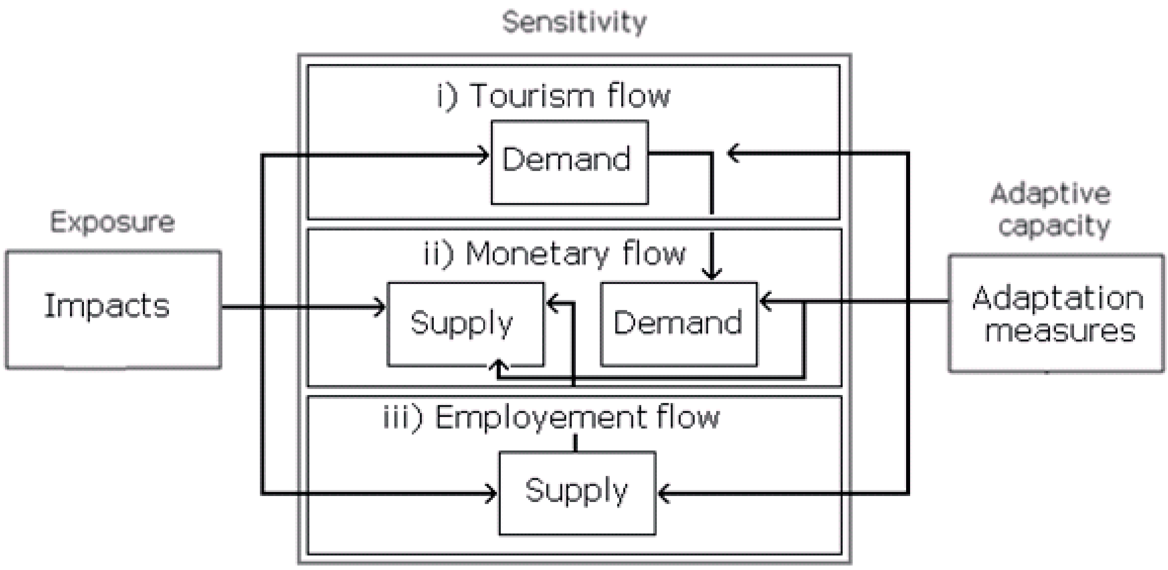

Figure 2.3*:* The flows in the system: impacts have both a positive and a negative effect on tourism flows (i), monetary flows (ii) and employment flows (iii). In the same way, adaptation measures have a positive effect on them.

Eleven impacts of climate change directly and/or indirectly influence tourism in Switzerland. In the following Table 2.2 and Table 2.3 we present possible consequences on demand and supply respectively. Boldfaced topics are particularly relevant due either to the strength of the impact, the low uncertainty about its existence, or the sensitivity of the tourism sector to it.

Table 2.2: 11 main impacts of climate change in Switzerland and their direct and indirect influence on tourism demand. ↑: increased and ↓: decreased tourism flow and subsequently monetary flow. In boldface impacts that are particularly relevant either because of their strength, because of the low uncertainty about their existence, or because of the sensitivity of the tourism sector to them. These will be addressed more specifically later in this section.

Demand		
Impact	Direct	Indirect
Positive or negative changes of weather patterns for tourism activities	**↓/↑ due to worse/better weather suitability for tourism activities**	**↑/↓ international tourism flow and subsequently monetary flow due to the worse/better climate suitability for tourism activities in other regions**
Snowpack reduction	**↓ mainly in the low-lying resorts due to the lower attractiveness of the region for winter sport activities**	**↑ in the higher resorts due to worse impacts in the lowlands and in other countries ↓ in higher ski resorts due to the lower number of people who learned skiing (lack of snow in the lowlands)**
Glaciers melting	**↓ due to the decreased scenic beauty**	↑/↓ due to the formation of glaciers lakes that could either increase or decrease the attractiveness of the region ↓ due to the increased risks for human lives caused by greater soil instability
Permafrost melting – rockfalls	↓ due to increased risks for human lives and closure of hiking trails	
Increase in the frequency and intensity of floods, debris flows, landslides, and falling rocks	↓ due to increased risks for human lives	
Increased water scarcity – drought		↓ because of changes in landscape beauty
Positive or negative changes in scenic beauty	**↑/↓ due to increased/decreased scenic beauty**	
Increase in the frequency of forest fires	↓ due to increased risks for human lives	
Increase in the frequency and intensity of wind- and winterstorms	↓ due to increased risks for human lives	
Increase in the frequency and intensity of heat waves	↓/↑ due to the worse/better climate suitability for tourism activities	
New pests	↓ due to the worse suitability for tourism activities and increased risks for human lives	

Table 2.3: 11 main impacts of climate change in Switzerland and their direct and indirect influence on tourism supply (≠: changes of monetary and job flows, ↑: increased costs). In boldface topics that are particularly relevant either because the strength of their impacts, because the low uncertainty about their existence, or because of the sensitivity of the tourism sector to them. These will be addressed more specifically later in this section.

Supply		
Impact	Direct	Indirect
Snowpack reduction	**≠ mainly in low-lying ski areas due to the worsening snow conditions, leading in extreme cases to the closure of the resorts. Among further possible consequences, the increased costs for ski resorts in which artificial snow is produced**	Changes in ecosystems characteristics due to snowpack reduction leading for example to seasonal lack of water for tourism activities
Glaciers melting	≠ due e.g. to changes in offers of glaciers-related tourism activities (e.g. skiing or ice cave sightseeing)	Increased costs for protective infrastructure against floods due to glacier lakes outbursts. Changes in ecosystems characteristics due to glaciers melting leading for example to lack of seasonal water for tourism activities
Permafrost melting – rockfalls	**↑ for repairing, restoring, or protecting infrastructure and human settlements**	
Increase in the frequency and intensity of floods, debris flows, landslides, and falling rocks	**↑ for repairing, restoring, or protecting infrastructure and human settlements**	
Increased water scarcity – drought	**Conflict for water with other sectors and lack of water for ensuring tourism activities**	Possible problems arising in relation to hydropower production for tourism activities
Positive or negative changes in scenic beauty	↑ for landscape management (e.g. in order to maintain alpine meadows)	
Increase in the frequency of forest fires	↑ for repairing, restoring, or protecting infrastructure and human settlements	
Increase in the frequency and intensity of wind- and winterstorms	↑ for repairing, restoring, or protecting infrastructure and human settlements	
Increase in the frequency and intensity of heat waves	≠ due to costs of interventions on buildings in order to adapt to the new climate conditions	

Hereafter, we discuss seven of these impacts in greater detail, which were selected either because of their strength, because of the relative certainty about their existence, or because of the strong direct or indirect consequences on tourism supply and demand. We noted aspects related to at least one of these three aspects in boldface in Table 2.2 and Table 2.3. Other impacts of climate change could also affect tourism, but they are either less important or the influence of climate change on them has not been clearly established yet. We did therefore not consider them any further. They include the increase in the frequency of forest fires, the increase in the frequency and intensity of wind- and winterstorms, and new pests appearing in the country. What was not additionally considered in this study are tipping points, possible non-linear, abrupt or step changes that can alter the state of the environment once a threshold has been reached (Lenton et al. 2008). Because of the high uncertainty surrounding them, they are difficult to take into account. They could however have a very important impact on the system.

2.3.1 Changes in weather patterns

Direct physical impacts of climate change include, for example, changes in patterns of temperature, precipitations, wind, humidity and sunshine hours. Figure 2.4 shows the deviation of the annual mean temperature from 1961 to 2010 in comparison to the reference period 1961-1990. It clearly appears that the second half of the period warmed significantly. In fact, in the last century the mean temperatures increased respectively by 1.0, 1.3, and 1.6°C for the southern, western and the eastern parts of the country (Frei et al. 2007). This is a far higher value than the average Earth temperature increase (0.6°C). Precipitations also became more frequent, with an increase of 8%. In relation to future evolution, most recently, the 'Swiss Climate Change Scenarios CH2011' (CH2011 2011) provided a new assessment of the possible paths of climate change for this century (2000-2100). The main conclusions of this research are:

- During this century, the temperature is very likely to increase in all seasons and regions compared to the mean observed temperature of the past decades; the magnitude of increase depends, however, on the pathway of future gas emissions;
- It is still difficult to assess precisely the evolution of precipitations because of the particular geographical location of Switzerland.[7] Nonetheless summer precipitation levels are likely to decrease in the different parts of the country. For spring, autumn, and winter the direction of the evolution is unclear (it can therefore either increase, decrease or stay constant). However, winter precipitation is likely to increase in southern Switzerland towards the end of the century;
- Extremes like summer warm spells and heat waves will very likely increase in frequency, duration and intensity by the end of the 21st century. Conversely, the number of cold winter nights and days is likely to decrease;
- Projections of the frequency and intensity of heavy rainfall events are uncertain, but a tendency toward more intense rainfall events in autumn and an increase in winter and summer is possible.

[7] The country lies between North Europe and the Mediterranean region. It lies thus at the intersection of two climate regions. This renders forecasts particular difficult. Moreover, the very complex Alps conformation makes the exercise even more complex.

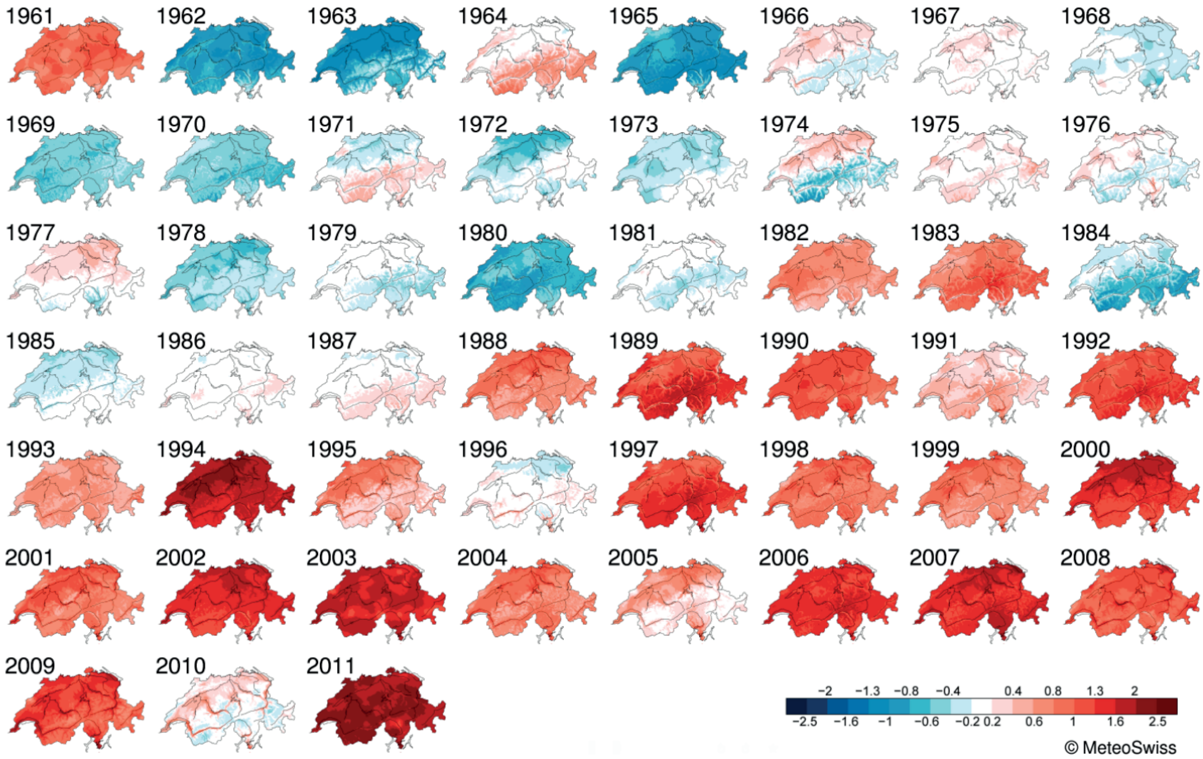

Figure 2.4: Climate evolution from 1961 up to 2011 for Switzerland. Represented are the deviations from the mean temperature (reference period 1961-1990). The bluer the map, the more Switzerland experienced a cold year, the opposite for red maps. It is clear that in the two last decades the country experienced an increase in average temperature (Scherrer et al. 2011).[8]

In Figure 2.5, past and future changes in seasonal temperature (°C) and precipitations (%) over Northeastern Switzerland (CHNE) are presented. The changes are relative to the reference period 1980–2009. Results for the other two regions (Western Switzerland CHW and South of the Alps CHS) are similar.[9] Taking for example the A1B emission scenario;[10] mean temperatures for the three Swiss regions considered could increase by 2.7-4.1°C and summer mean precipitations decrease by 18-24% in the end of the century compared to the past 30 years.

[8] Adapted from http://proclimweb.scnat.ch/portal/ressources/2162.pdf. Last accessed 22.12.2011.

[9] Regional differences in the warming signals are comparatively small, but become stronger at the end of the century, with temperature in CHS increasing more significantly than in the rest of the country.

[10] The A1B scenario describes a world in which fossil-intensive and non fossil energy sources roughly balance each other, and in which very rapid economic growth takes place, in which global population peaks in mid-century and declines thereafter and in which new and more efficient technology is rapidly disseminated.

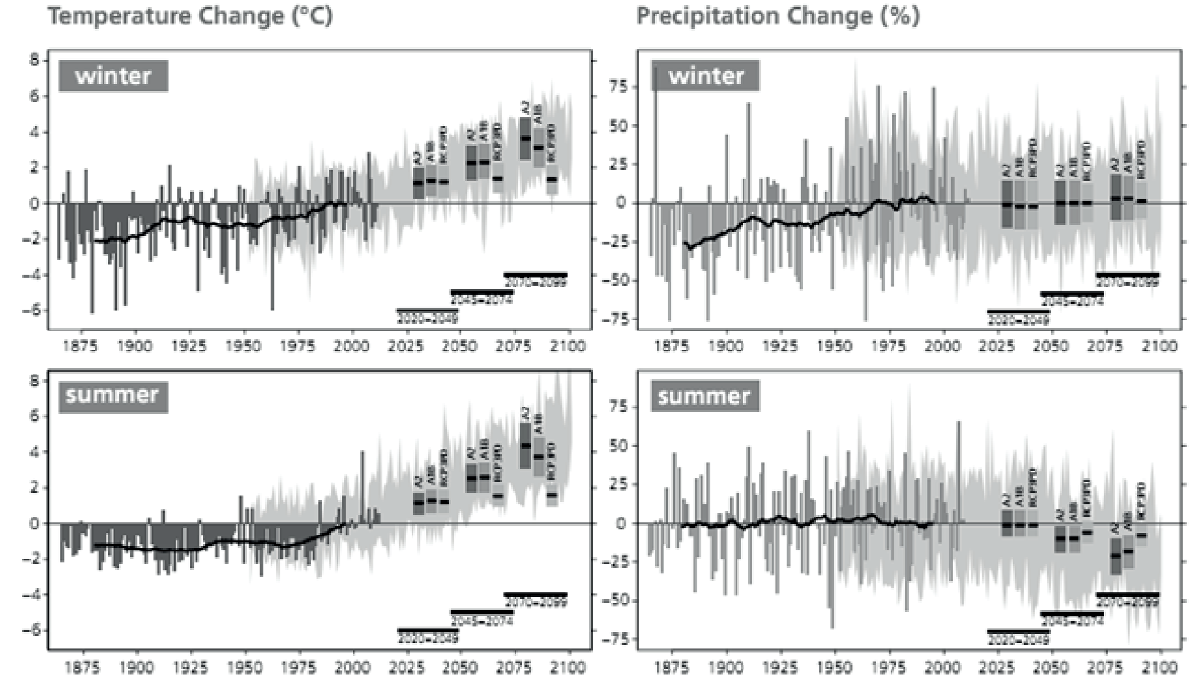

Figure 2.5*:* Past and future changes in seasonal temperature (°C) and precipitations (%) over Northeastern Switzerland (CHNE). Changes are relative to the reference period 1980–2009. The thin vertical bars represent the year-to-year differences with respect to the average of observations over the reference period. The heavy black horizontal lines are the corresponding smoothed 30-year averages. The grey shading indicates the range of year-to-year differences as projected by climate models for the A1B scenario (specifically, the 5-95 percentile range for each year across the available model set). The thick bars show best estimates of the future projections and the associated uncertainty ranges for selected 30-year time-periods and for three GHG emission scenarios (CH2011 2011).

2.3.2 Positive and negative changes of climate variability for tourism activities

As stated previously, climate change has and will continue to have consequences on several weather elements such as average, maximum and minimum temperature, precipitation, wind speed, humidity, and number of daylight hours.[11] All these elements form what is known as thermal comfort. Thermal comfort is an important resource for many types of tourism. Mieczkowski (1985) developed a Tourism Climate Index (TCI) of the suitability of climate for sightseeing activities (Annex A.1). TCI is a composite measure of the climate wellbeing of tourists. Although climate is only one of the variables that motivate tourists in their choice, it could play an important role in the final destination choice.

For Switzerland, it could be hypothesized that domestic tourist destinations, mainly at lakes and in the Alps, may become more attractive with increasingly hotter summers. This supposes that beach tourism in the Mediterranean region can be replaced by lake and mountain tourism, and that tourists

[11] For example, Frei (2004) predicts that the mean annual temperature in Switzerland will increase by 2.1°C until 2050 relative to 1990. Seasonally, the average temperature will increase by about 1.8°C in winter (ranging between +0.7 and +3.4) and fall (+0.8/+3.3), by 2.1°C in spring (+1.1/+3.5), and by 2.7°C in summer (+1.4/+4.7). Note that we used these values and not the CH2011 ones for our calculations. They are however very similar to CH2011 results for the A2 and A1B emissions scenarios.

go to those areas for summer coolness. Abegg and Steiger (2011) propose an interesting discussion on the topic, debating different elements of the hypothesis.

2.3.3 Snowpack reduction

With an increase in temperature, precipitations will fall increasingly in the form of rain instead of snow. This is particularly true during the springtime and for low-lying regions (Serquet et al. 2011). In a mountainous region, an increase of 1°C implies, on average, an upward shift of the snowline by 150 m (Haeberli and Beniston 1998). Assuming an average winter temperature increase of 1.8°C over 1990 levels (Frei 2004; OcCC/ProClim 2007), the lower snowline would rise by 270 m by 2050. In addition, with the increase in temperatures, the duration of snow cover will also decrease at low altitude (Agrawala 2007; Beniston 2009). These impacts are already visible in the recent evolution (Figure 2.6, Figure 2.7). Nonetheless, for future regional predictions, precise and reliable forecasts can hardly be made at the moment, especially considering the low predictability of rain- and snowfall in climate models. It can however be foreseen that many low-altitude ski domains will be particularly affected since by 2050 these resorts would not have enough snow to enable ski activity. Regions under 1700 m AMSL should be especially concerned. On the other hand, if winter precipitation increases, high altitude locations could enjoy more snowfall and could at least at the beginning benefit from the situation.

As pointed out in an Organization for Economic Co-operation and Development (OECD) report (Abegg et al. 2007) that analyzed the Alpine area of France, Switzerland, Italy, and Austria up to 2050, Switzerland will be less affected than neighboring countries if only natural snow is considered (Figure 2.8). Nonetheless, the more extensive use of artificial snow in the other Alpine countries must not be forgotten (Steiger and Abegg 2011).[12]

Finally, the effect of changes in snow quantity and snow cover periods on the availability of snow for skiing is not the only mechanism through which snow will affect tourism. There will also be an indirect effect, through the modification of the ecosystems' characteristics (changes in water flow modifying e.g. the vegetation) and the availability of water for other domains (Beniston 1994). They could also affect customer behavior (Gonseth and Matasci 2011).

[12] For example, 75% of the 900 hectares of slopes in Slovenia, 70% of the 22 500 ha in Italy, and 66% of the 25 400 ha in Austria can be artificially snowed in comparison to 36% of 22 000 ha in Switzerland (Abegg 2011). On the other hand, only 21% of the 25 000 ha of French slopes can potentially be snowed artificially.

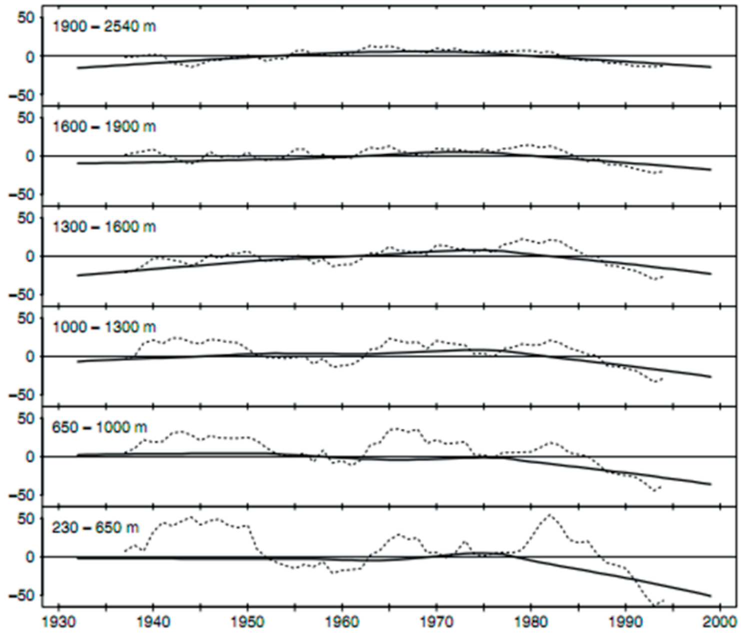

Figure 2.6: Relative daily, manually measured, snow depth deviation (in percent) of the annual winter mean (November - April) compared with the long-term mean. Drawn are the 11-year moving average and the lowess-smoothed long-term trend for different altitude zones, based on data of the entire Swiss Alps (1932 - 1999) (Laternser and Schneebeli 2003).

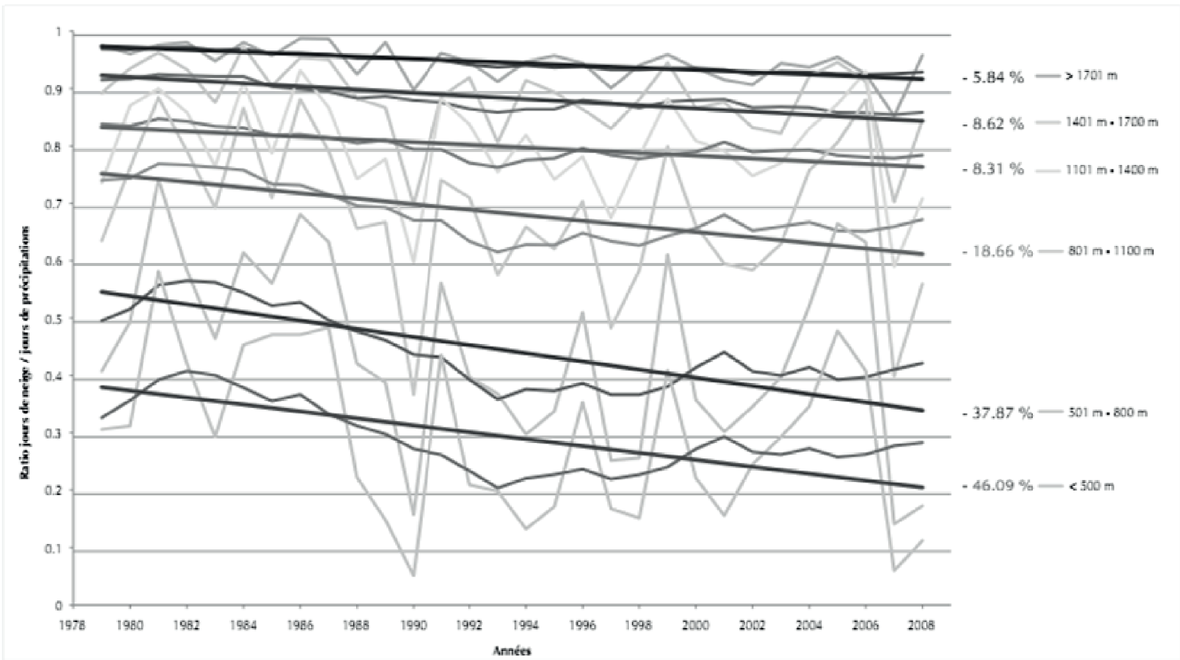

Figure 2.7: Winter (DJF) mean ratio of snowfall versus precipitation days by altitudinal categories from 1908 to 2008. Bold lines are unweighted moving averages with an 11-year window (with uncorrected 5-year edges using the available points) (modified after Serquet et al. 2011).[13]

[13] The Figure was taken from http://proclimweb.scnat.ch/portal/ressources/2171.pdf. Last accessed 04.04.2012.

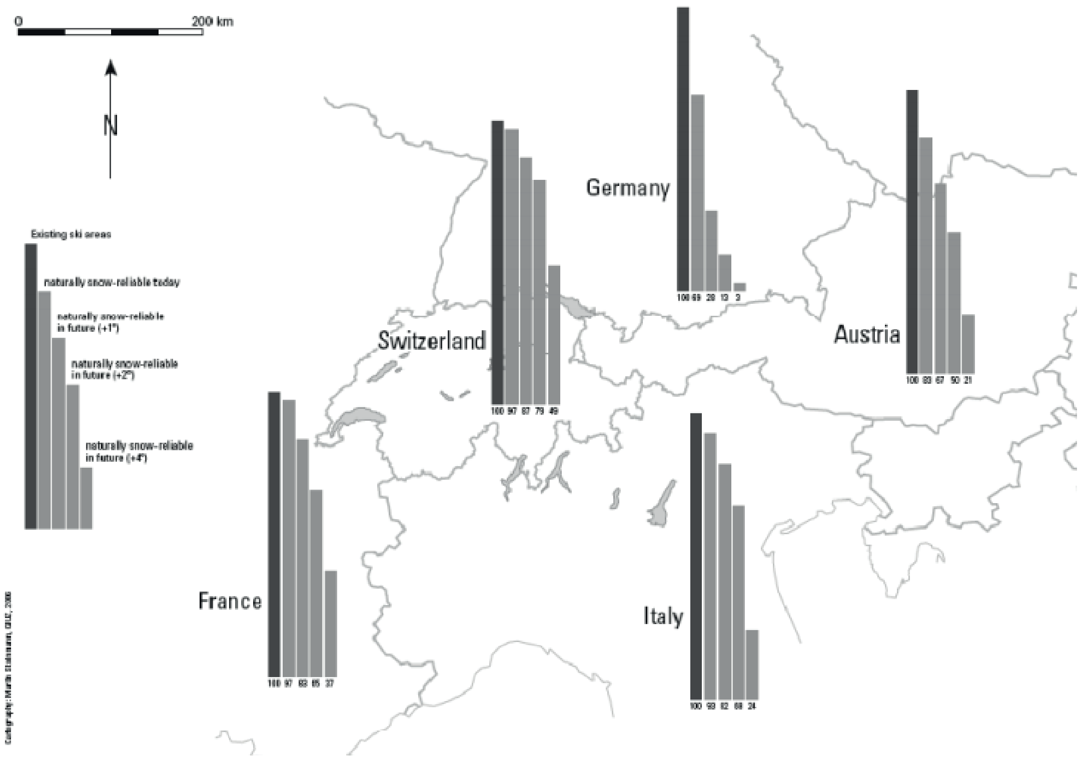

Figure 2.8: Percentages of existing ski areas for France, Switzerland, Italy, Germany, and Austria, respectively, that are naturally snow-reliable today (100%: dark gray bars) and in a +1°C, +2°C and +4°C scenario (light gray bars). As seen, Switzerland seems to be less affected than other Alpine countries in the future if only natural snow is considered (Abegg et al. 2007).

2.3.4 Melting glaciers

With respect to glaciers, many studies (e.g. Maisch 1992; Maisch et al.1998; Paul et al. 2007) predict an upward shift of the steady-state Equilibrium-Line Altitude (or ELA_0) for glaciers by 120 to 170 m for a 1°C temperature increase.[14] By 2030-2050, glacier surface in Switzerland will probably have shrunk by 54-80% compared to 1973, while glacier volume will have shrunk by 50-78% (Paul et al. 2007). Since 1850 Swiss glaciers have lost on average 33% and 35% respectively of their original volume and length (Maisch et al. 1998). Figure 2.9 presents results obtained by Maisch et al. (1998) with a rise of the glacier snow line by about 100 and 200 m respectively. The retreat of the glaciers in the near future will tend to accelerate rather than continue in a linear fashion (Bader and Kunz 2000).

[14] The ELA of a glacier defines the mean altitude of a line which connects points where accumulation equals ablation at the end of a specific balance year. The ELA_0 is the ELA for which the steady state of the glacier equals zero (Paul et al. 2007). The snow line at the end of the ablation season is roughly equal to the ELA for temperate glaciers (Paterson 1994).

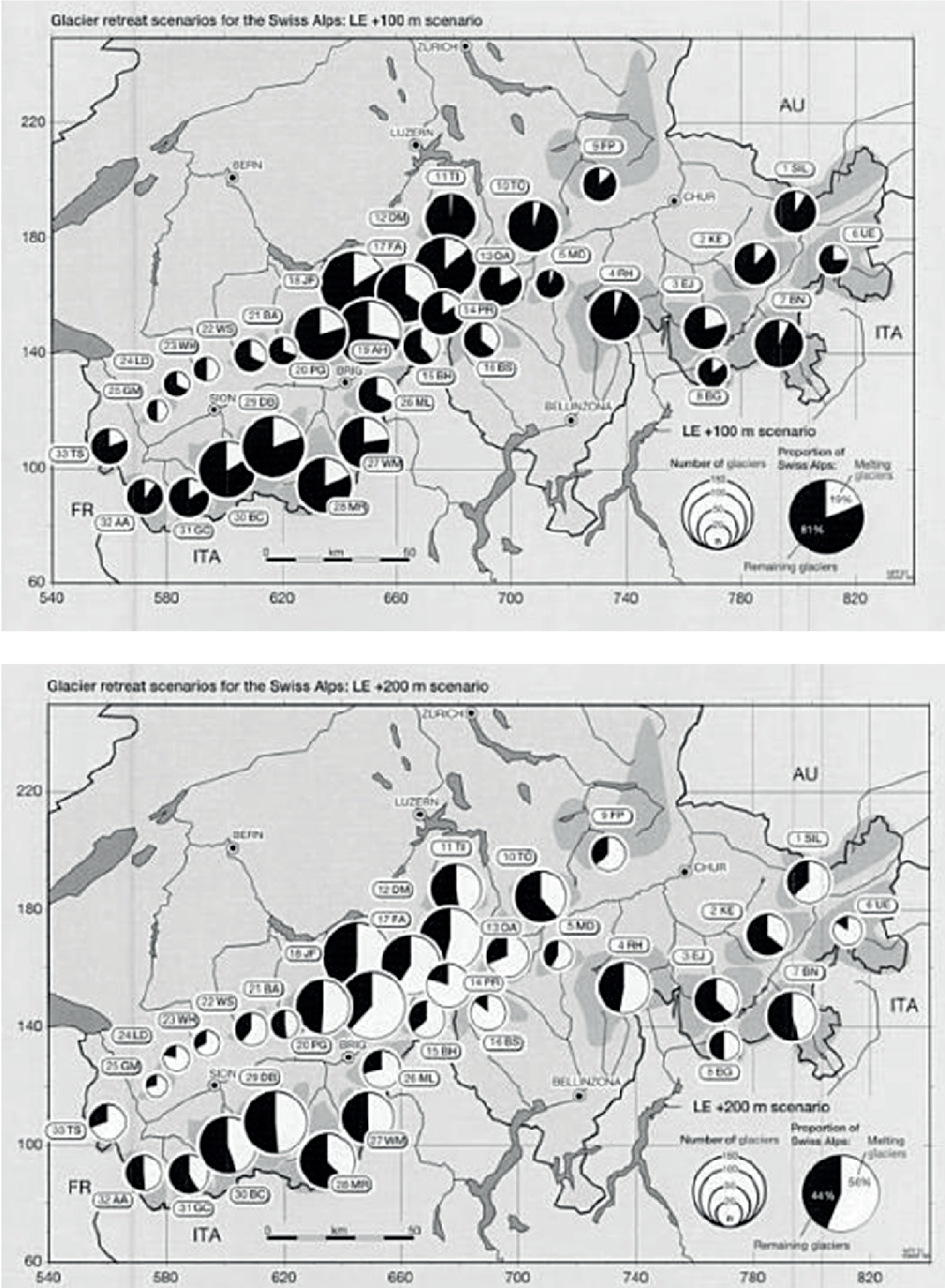

Figure 2.9: Map representing the glacier retreat for the Swiss Alps. Two scenarios are shown: in the upper part a +100 m and in the lower part a +200 m rise of glacier snow line. The percentages of lost glaciers (white sectors) and surviving glaciers (black sectors) are shown in both cases. The map covers 33 regions comprising 1923 glaciers (Maisch et al. 1998). Paul et al. (2007) gave similar results for an ELA_0 shift of +200 m.

Glacier melting will impact tourism in different ways. On the one hand, glacier retreat will alter the Alpine landscape and therefore will modify scenic beauty. A study by Scott et al. (2007b) on the Waterton Lakes National Park (Canada) showed that if glaciers and Alpine tundra disappear and occurrences of forest fires increase, more than 50% of visitors would visit the national park less frequently or stop visiting it altogether. It should nonetheless be kept in mind that new generations of tourists would not necessarily have a memory of the previous state of the landscape.

Glacier retreat will moreover affect soil stability and cause rockfalls, landslides as well as glacier lakes (Haeberli and Beniston 1998). These could have both positive and negative consequences on the tourism sector, as noted by Huggel et al. (2010).[15] Furthermore, as for snowpack reduction, it will modify water flow and availability (Huss 2011). Finally, resorts offering ski, hiking, ice cave sightseeing, and tubing on glaciers will also be negatively affected.

2.3.5 Permafrost melting – rockfall

Permafrost is defined as surface material whose temperature is constantly under 0°C. In the Alps, it is generally found over 2300 m AMSL. It is estimated that 4 to 6% of the Swiss territory is covered by permafrost (Keller et al. 1998) (Figure 2.10).[16] Permafrost also experiences the impacts of climate change. It is expected that the lower limit of permafrost will rise by 200-700 m if the temperature rises 1-2°C (Bader and Kunz 2000).

Melting of permafrost destabilizes soils. Engadine, Valais, Bernese Alps, and the Tödi region in Glarus are particularly affected. It is extremely likely that there will be problems related to infrastructure such as ski-lifts and protection against avalanches because these are fixed in the permafrost. For example, 15% of the Swiss mountain railways are built on permafrost (Noetzli and Vonder Mühll 2010). As a consequence, there will be a higher cost for repairs and restoration, in some cases causing the abandonment of the site. Moreover, hikers will be particularly affected by increased danger of falling rocks.

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[15] The 'New Lakes in Deglaciating High-mountain Areas: climate-related development and challenges for sustainable use' (NELAK) project (http://www.nfp61.ch/E/projects/cluster-hydrology/lakes_melting_glaciers/Pages/default.aspx, last accessed 22.12.2011) carried out under NRP 61 'Sustainable Water Management' is looking in particular at this topic.

[16] http://www.unil.ch/gse/page2743_fr.html. Last accessed 22.12.2011.

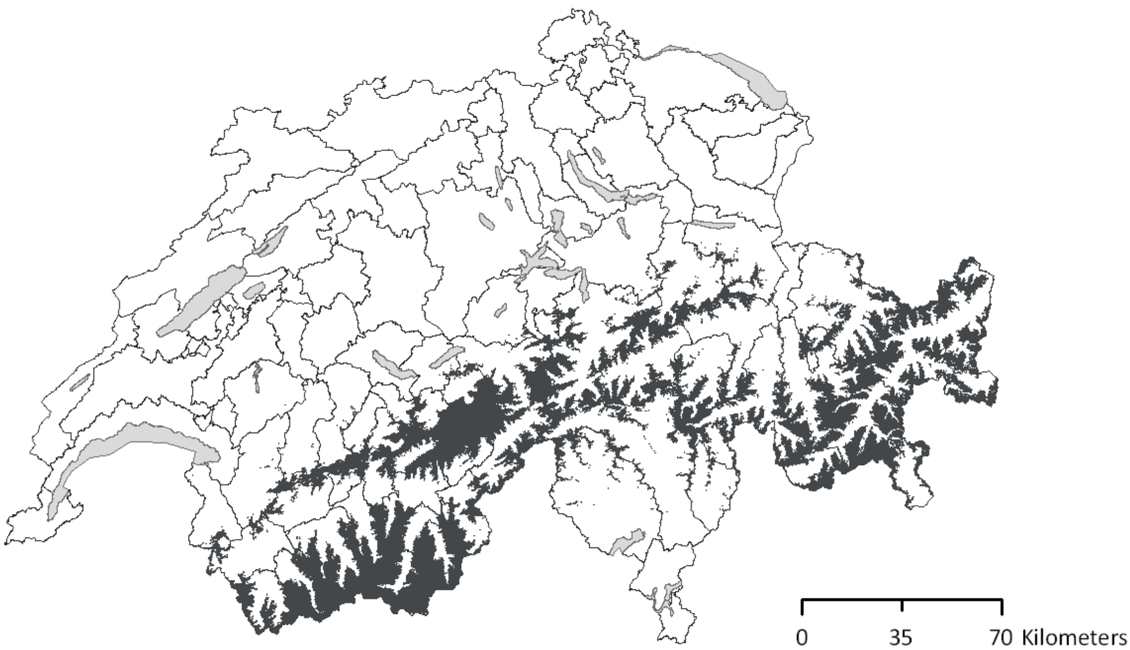


Figure 2.10: Possible and probable permafrost distribution in the Swiss Alps. About 15% of the Swiss alpine area or 4-6% of the total country area lies in permafrost territory. Models were generated using a Digital Height Model (DHM) 25 (adapted from FOEN 2006). In light grey, the limits of the 85 tourism regions presented in Section 3.1.2.1.

2.3.6 Increase in the frequency and intensity of floods, debris flows, landslides, and falling rocks

Natural hazards such as floods, debris flows, landslides, and falling rocks[17] will very likely change in frequency, intensity, and distribution in the future due to climate change (Bader and Kunz 2000). Until now, no statistically significant trend with regard to past increases in the annual cost of damage could be found. This nonetheless could be caused by the fact that observations only cover the 1972-2007 time-span and that 36 years are probably a too short period to identify a clear trend. Moreover, it is difficult to determine exactly the relative influence of factors such as the changing potential of loss (due to the spread of built areas and to more densely constructed regions), climate change, the effectiveness of protection structures and emergency measures in determining the severity and total cost of damages (Hilker et al. 2009).

We show in Figure 2.11 and Figure 2.12 respectively the costs and numbers of past events for the different Swiss communes. Figure 2.13 presents areas at risk of 100-year return floods (according to the Acquaprotect[18] project). If the frequency is effectively going to increase, floods in these areas would become more frequent.

If natural hazards indeed become more frequent, this will have consequences on both supply and demand: on the one hand, it will affect infrastructure and human settlements that serve at the base

[17] We will refer to this impact as 'Increase in the frequency and intensity of natural hazards' in the remaining of the thesis.
[18] http://www.bafu.admin.ch/naturgefahren/01916/06598/index.html?lang=en. Last accessed 22.12.2011.

for such activities (e.g. streets and accessibility, cable-ways, ski-lifts, and alpine huts). On the other hand, it could affect the public's perception of the destination's safety and would therefore decrease its attractiveness.

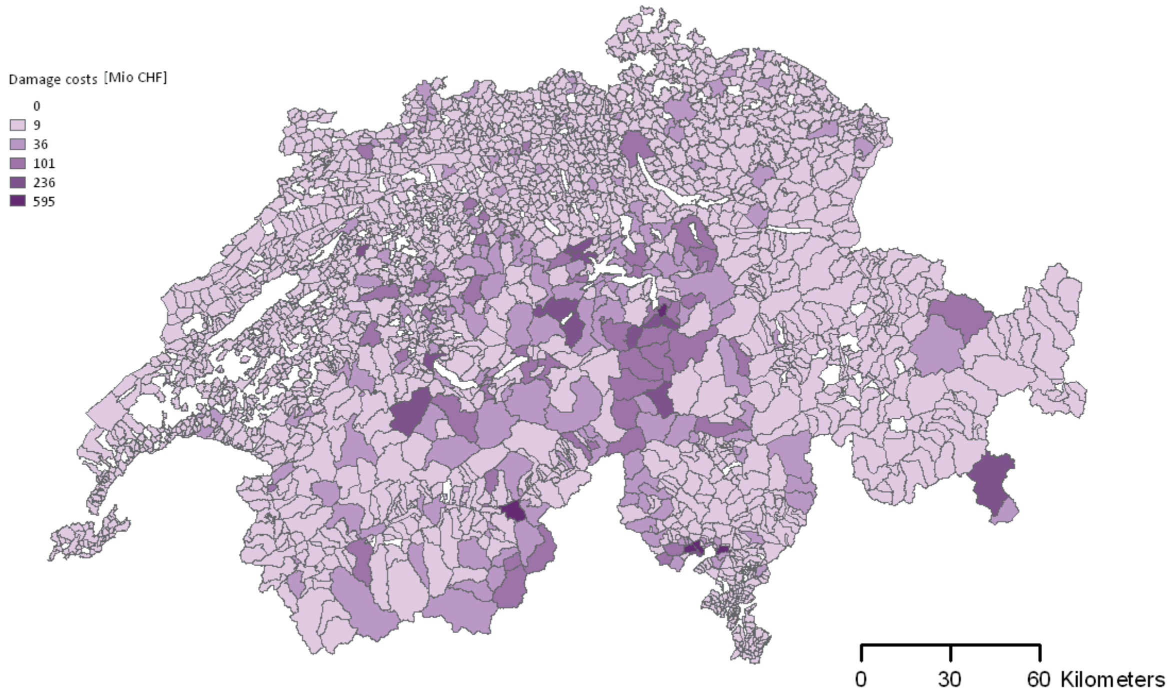


Figure 2.11: Map of Switzerland with the distribution of damage costs (CHF, taking into consideration costs increases) for 1972–2007 on the community level. We did not display here damages that could not be assigned to a local authority but these have been considered in the calculation. Source of data: WSL Storm Damage Database of Switzerland.

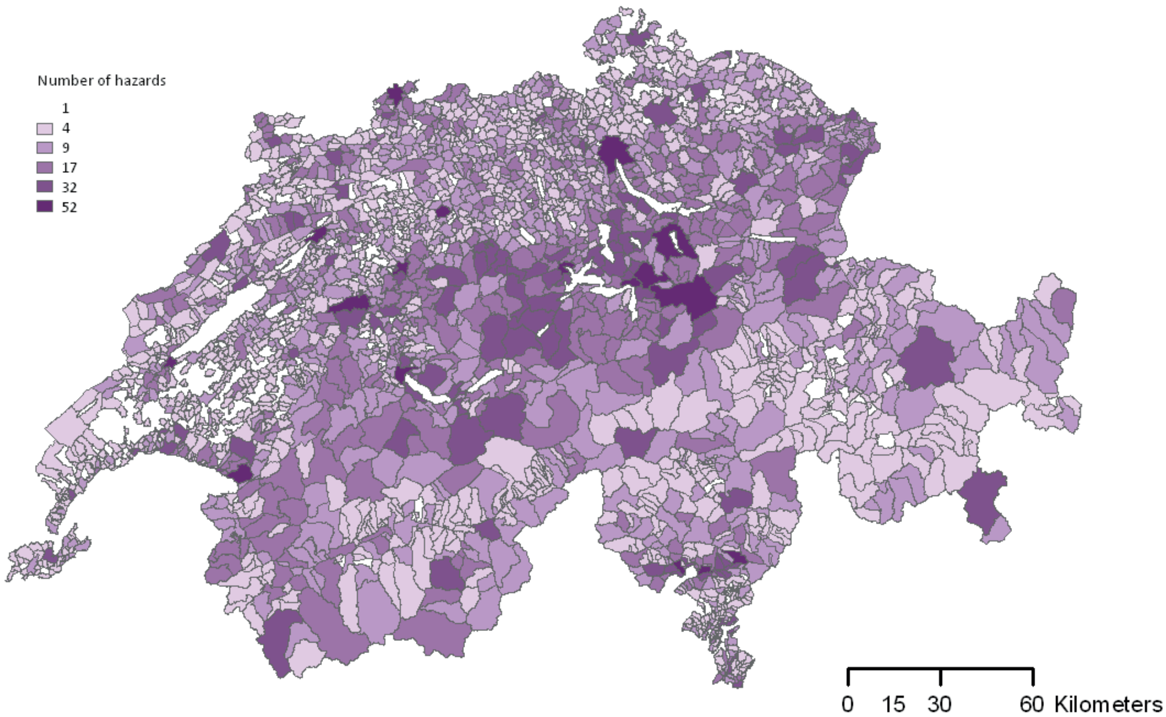


Figure 2.12: Map of Switzerland with the number of natural events at the community level in the different regions between 1972 and 2007. We did not display here damages that could not be assigned to a local authority but these have been considered in the calculation. Source of data: WSL Storm Damage Database of Switzerland.

Figure 2.13: In dark grey are areas at risk of 100-year return floods (according to the Acquaprotect project). In light grey are the limits of the 85 tourism regions presented in Section 3.1.2.1. Source: Swiss Flood Zones, developed by Swiss Reinsurance Company Ltd, Zurich (copyright), on behalf of BAFU, 2008.

2.3.7 Water scarcity – droughts

In the near future (2021-2050) the amount of annual water availability is not going to change significantly relative to 1980-2009, with the exception of higher regional water availability of short duration in regions covered by glaciers due to ice melting (the blue areas in Figure 4.14). Towards the end of the century (2070-2099), however, the amount of available water in the country will slightly decrease and the seasonal distribution is going to be modified, with more water available in the winter and less in the summer season (Bernhard and Zappa 2012).

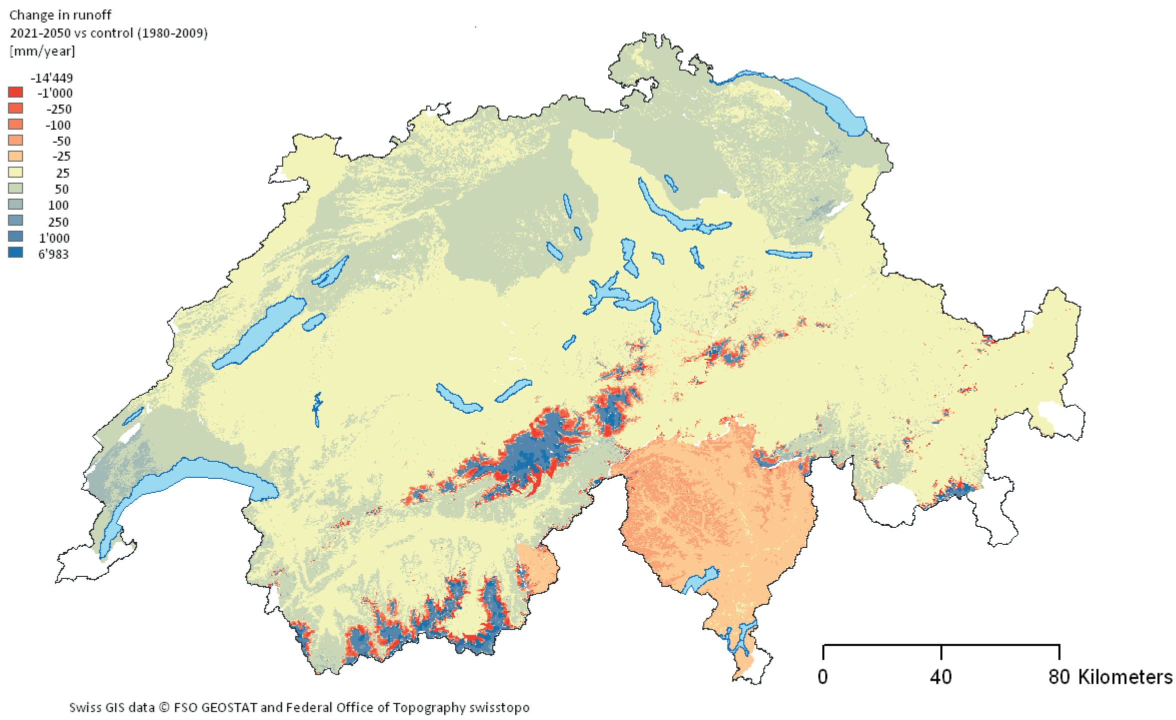
Because of the future increase in intense rainfall (Section 2.3.1), flooding will increase both in the summer and in the winter. Particularly affected will be Valais, Tessin, and the Mittelland. In the summer, while there might be fewer showers, rainfall will occur with greater intensity (Beniston 2004). Additionally, in the summer the combination of less abundant precipitation and more intense evapotranspiration could mean a regional decrease in water contained in soils along with an increase in water scarcity and droughts (CH2011 2011). Moreover, because of snowpack reduction in the Alps, rivers will dry more frequently, leading to a decrease in seasonal water accumulation. While approximately 40% of the water flow was fed by snow melting between 1980 and 2009, this percentage will decrease to almost 25% by 2085 (Bernhard and Zappa 2012).

Furthermore, the disappearance of glaciers could lead to more frequent droughts during the post-summer periods in these areas. As a result of the decrease of mean summer rainfall, snow and glaciers melting, and of the number of rainy days mentioned above, droughts (similar to the 2003 one) could last longer and be more frequent. In particular, this would likely occur during the summer (Frei 2004; Ecoplan/Sigmaplan 2007; CH2011 2011, Bernhard and Zappa 2012).

In Ticino the runoff will decrease considerably, particularly towards the end of the century. In Northern Switzerland the runoff will increase somewhat due to the predicted increase in precipitation in the winter and fall (Bernhard and Zappa 2012). It should also be pointed out that climate change will lower not only water quantity, but also water quality (e.g. warming and decrease in dissolved oxygen levels).

Tourism in Switzerland depends on water in many ways: in addition to basic needs, water is used to fill swimming pools and spas, irrigate golf fields and produce energy. Water is also essential for artificial snow production (Hahn 2004). If water becomes scarce, this could create conflicts with others sectors (Lebel et al. 2010), like agriculture or energy production, two sectors that strongly depend on it (OcCC/ProClim 2007; Freiburghaus 2009).[19]

[19] The AlpWaterScarce project within the Alpine Space Program was dedicated to this subject. http://www.alpwaterscarce.eu. Last accessed 22.09.2012.



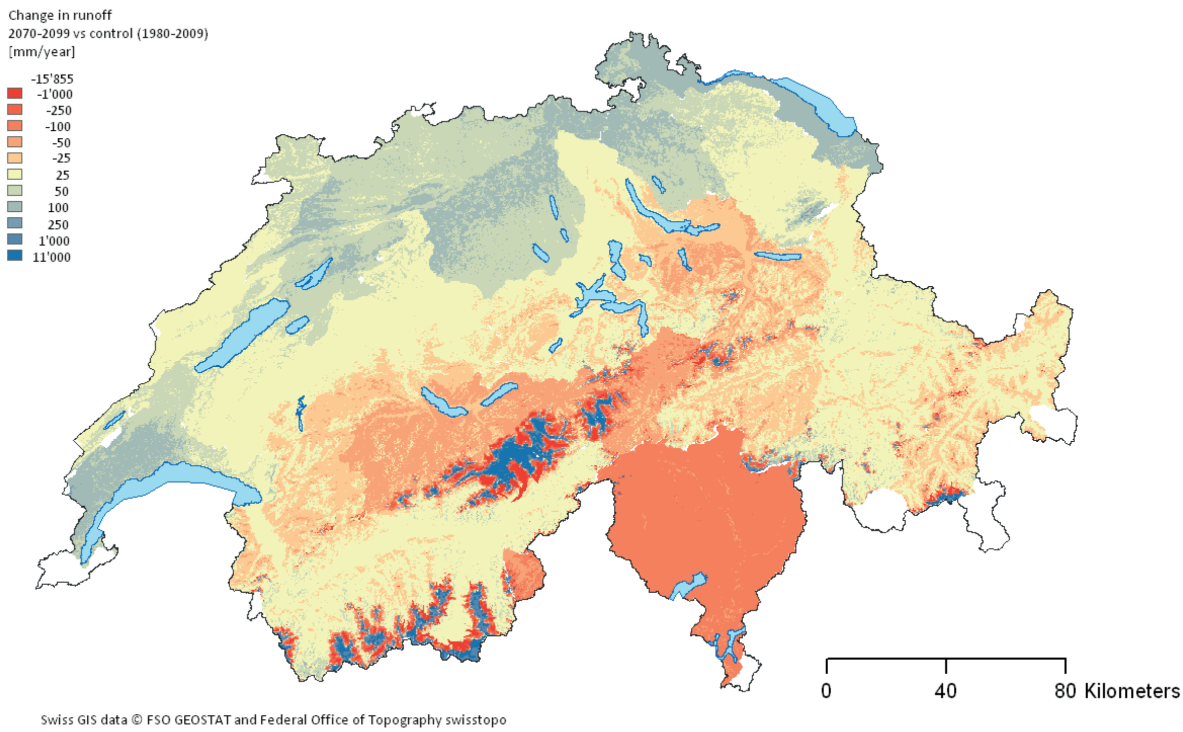


Figure 2.14: Pixel maps representing changes in natural runoff (mm/year) for respectively 2021-2050 (top) and 2070-2099 (bottom). Represented are average scores of the ten analyzed scenarios for the given period less the control period 1980-2009. FSO GEOSTAT and Swisstopo (copyright).[20]

[20] http://www.wsl.ch/fe/gebirgshydrologie/HEX/projekte/cchydro/index_DE. Last accessed 28.05.2012.

2.3.8 Positive and negative changes in scenic beauty

Higher temperatures will affect in particular the landscape of the High Alps. Many aspects of landscape, such as glaciers (already seen above), vegetation and soil, will be particularly affected. Flora and fauna will adapt to new conditions, but some natural processes, like forest growth and upward shift of the vegetation belts, only take place slowly. Therefore, many consequences will appear only after a considerable delay. The treeline could theoretically rise by 400 m, assuming the expected 2°C rise for 2050.[21]

Because of shifts to higher altitudes, low competitiveness, or inability to migrate, many species (in particular Alpine flora) are expected to disappear (Kienast 1998; Guisan and Theurillat 2000). Moreover, there will be an increased inflow of non-native species (OcCC/ProClim 2007; Pauchard et al. 2009) and changes in fauna's behavior. For example, bird species that were once migratory already now overwinter in Switzerland (OcCC/ProClim 2007). With high temperature increase and decrease in rainfall, desertification could occur in the inner Alpine dry valleys if no water resistant plants immigrate (Zimmermann et al. 2006). Valais, for example, could see some desertification by 2100. All this will affect the landscape and subsequently scenic beauty. Some regions could become more attractive, while others would be less so. Therefore, changes in scenic beauty could have both a positive and a negative effect on tourism flow.

[21] It has to be kept in mind, however, that in reality actual treeline advance is considerably time-lagged behind the evolution of the climatic treeline due to the slow regeneration process and to anthropogenic influences (mostly due to alpine farming activities) (Gehrig-Fasel 2007). For example, many alpine meadows exist not because of climate conditions and vegetation belts, but because of pasture. With a retreat of alpine exploitation by agriculture, these open spaces would disappear as well.

3 General methods and data

3.1 The chosen approaches

As seen in Section 1.1, this work has three general objectives: i) to assess the magnitude of impacts and the distribution of climate change vulnerability of tourism in Switzerland and the subsequent determination of vulnerability hotspots; ii) to analyze possible adaptation measures on regional and national scale; and iii) to identify and evaluate barriers to adaptation and how these can be overcome. We chose a composite of different methods to meet these three objectives: i) vulnerability mapping (Section 4.4.1), including Analytical Hierarchy Pairwise Multicriteria Analysis (AHP MCA) (Section 4.4.3), and cluster analysis (Section 4.4.5), ii) participative processes (Section 5.6.2), including also a SWOT[22] analysis (Section 5.6.3), and iii) finally phone (Section 3.1.3.2), online (Section 3.1.3.3), and face-to-face (Section 3.1.3.4) surveys among stakeholders and citizens.

With respect to the scope of the system under study, its boundaries, the attribute of concern, the hazard and the timeframe chosen, we note the following: the system refers to Switzerland and the attribute of concern refers to both Swiss and foreign tourism, to both supply and demand and to all the four seasons of activity. Hazards refer to the seven impacts presented in Section 2.3. The timeframe goes from the present up to 2050. An explanation of these choices can be found immediately below.

3.1.1 The choice of the timeframe

We selected 2010-2050 as our timeframe. The primary reason for this choice is that the period to 2020-2030 (and, to a lesser extent, to 2050) is the most relevant today for decisions about adaptation strategies (Allen Consulting Group 2005). This is due to the fact that most decisions that could be affected by climate change involve assets and business systems that have an economic life covered by this time horizon. On the contrary, the 2100 horizon is far beyond the productive life of capital and infrastructure investments. Moreover, it would involve a very high degree of uncertainty in the forecasting of socioeconomic, technological, and environmental changes. It is therefore extremely difficult to set-up accurate scenarios for such a long timeframe. We might consider, for example, how people at the beginning of the 20th century might have depicted e.g. the economic and demographic growth, technology advances, leisure time, and global security of the present days. Nevertheless, because adaptation measures are meant to be sustainable in the long run, the possible long-term evolution as e.g. the climate change predictions and demographic changes up to 2100 should be considered as well.

3.1.2 The system under study – the case study regions

As stated previously, the system refers to Switzerland, while tourism activities refer to both Swiss and foreign tourism taking place in the country, to both supply and demand and to all four seasons. Because of the multifaceted aspects of the topic, we choose three spatial levels to describe this system: i) a national, ii) a regional, and finally iii) a local level. On the first one, we shall analyse Switzer-

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[22] Strengths, Weaknesses, Opportunities, and Threats.

land as a whole, examining in particular its regional diversity by dividing the country into 85 tourism regions (3.1.2.1). On the second level, we shall carry out a more specific regional assessment, analyzing 16 case study locations (3.1.2.2). Finally, on the third level of analysis, we shall look more in depth at a specific case study (3.1.2.3).

3.1.2.1 The 85 tourism regions

In order to measure regional vulnerability, tourism regions had to be assessed. We defined these in such a way that tourism-related stakeholders could easily associate with one region and also in a way that each region was relatively homogeneous in its tourism structure. We made the selection of the regions by considering the 13 Swiss tourism regions defined by the Swiss Tourism Federation (STV-FST), presented in Section 2.1 (Figure 2.1). We further divided these regions into 85 smaller units by taking, when available, possible internal subdivisions suggested by the 13 regions themselves (Figure 3.1). We then asked people who participated in the MCA (Section 4.4.3) to provide feedback on the preliminary map that was generated. This allowed for further modifications of the subdivisions.

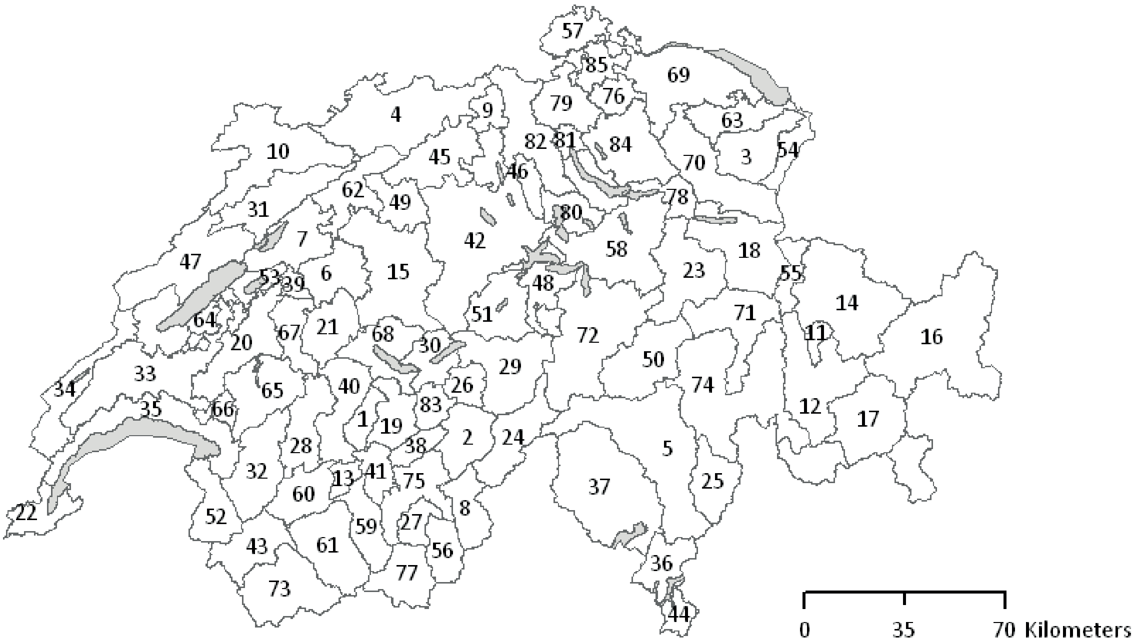

Figure 3.1: The 85 tourism regions considered in this study: 1. Adelboden; 2. Aletsch; 3. Appenzellerland; 4. Basel Region; 5. Bellinzona and Northern Ticino; 6. Bern; 7. Biel/Bienne Seeland; 8. Brig - Belalp; 9. Brugg Region; 10. Canton of Jura; 11. Central Graubünden - Arosa; 12. Central Graubünden - Lenzerheide, Savognin, Bergün; 13. Crans-Montana; 14. Davos, Kloster, Prättigau; 15. Emmental; 16. Engadin Scuol; 17. Engadin St. Moritz; 18. Ferienregion Heidiland; 19. Ferienregion Lötschberg; 20. Fribourg and the Centre; 21. Gantrisch Region; 22. Geneva Region; 23. Glarnerland; 24. Goms; 25. Graubünden - Italian-speaking area; 26. Grindelwald; 27. Grächen-St. Niklaus; 28. Gstaad-Saanenland; 29. Haslital; 30. Interlaken; 31. Jura Bernois; 32. Lake Geneva Region - Alps; 33. Lake Geneva Region - Countryside; 34. Lake Geneva Region - Jura; 35. Lake Geneva Region - Towns and Lakes; 36. Lake Lugano; 37. Lake Maggiore and Valleys; 38. Lauchernalp - Lötschental; 39. Laupen Region; 40. Lenk - Simmental; 41. Leukerbad; 42. Luzern Region; 43. Martigny Region; 44. Mendrisiotto; 45. Mittelland I; 46. Mittelland II; 47. Neuchâtel; 48. Nidwalden; 49. Oberaargau; 50. Obere Surselva; 51. Obwalden; 52. Portes du Soleil - Chablais; 53. Region of Lake Murten; 54. Rheintal; 55. Rhine Valley, Bündner Herrschaft, Chur; 56. Saas-Fee/Saastal; 57. SchaffauserLand; 58. Schwyz; 59. Sierre - Anniviers; 60. Sion Region - Anzère; 61. Sion Region - Les 4 vallées and Evolène; 62. Solothurn and Region; 63. St. Gallen - Bodensee; 64. The Lakes Region; 65. The Pre-Alps - Gruyères - Moléson; 66. The Pre-Alps - Les Paccots; 67. The Pre-Alps - Schwarzsee; 68. Thunersee; 69. Thurgau - Bodensee; 70. Toggenburg; 71. Untere Surselva; 72. Uri; 73. Verbier St-Bernard; 74. Viamala; 75. Visp Region; 76. Winterthur and its region; 77. Zermatt Matterhorn; 78. Zürichsee; 79. Züri-Unterland; 80. Zug Region; 81. Zurich; 82. Zurich Mittelland; 83. Wengen-Mürren-Lauterbrunnental; 84. Zürcher Oberland; 85. Zürcher Weinland.[23]

3.1.2.2 The case study regions of the face-to-face interview

In the vulnerability map, we analyzed the topic starting from the national level and broke it down into smaller regions. In order to have a more bottom-up approach and evaluate the regional specifications more thoroughly, we chose 16 locations for face-to-face interviews (Figure 3.2). We selected these locations either because stakeholders had already initiated adaptation processes or measures in the region, because the regions were particularly affected by climate change, or because stake-

[23] The Entlebuch district might have been separated from the Luzern Region, having its specificities.

holders there recently changed their business strategies in a way that was interesting from the perspective of climate change adaptation. Hereafter we provide a brief description of these locations and of the reasons for their selection.

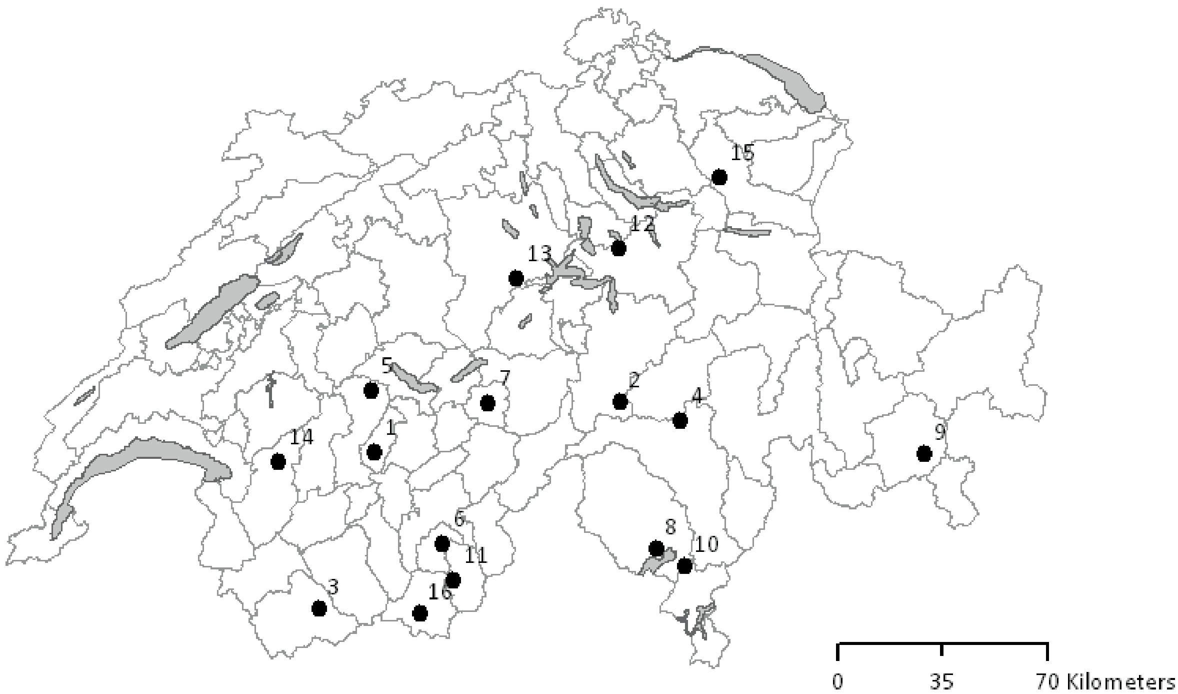

Figure 3.2: The 16 case study regions in which we carried out interviews: 1. Adelboden; 2. Andermatt; 3. Bagnes (Verbier); 4. Campo (Blenio); 5. Erlenbach im Simmental (Stockhorn); 6. Grächen; 7. Grindelwald; 8. Locarno (Cardada); 9. Pontresina and St. Moritz; 10. Rivera (Monte Tamaro); 11. Saas Fee; 12. Sattel; 13. Schwarzenberg; 14. Vaud Alps; 15. Wattwill (Obertoggenburg); and 16. Zermatt. In light gray, the limits of the 85 tourism regions presented in Section 3.1.2.1.

1. Adelboden – part of the Adelboden tourism region

Adelboden is a municipality located in the canton of Bern. Since 2003, it decided to focus its tourism more on health and wellness, and less on developing the winter season. However, because of the financial crisis, the main investor of the planned wellness center (the backbone of the new strategy) abandoned the project. We decided to contact stakeholders in order to investigate snowpack reduction, the adopted strategy and the barriers hindering it.

2. Andermatt – part of the Uri tourism region

Andermatt is a village possessing a ski resort of 1575 hectares and 125 km of slopes. Work is currently underway to convert the village into a comprehensive resort town as part of the Orascom project.[24] The project plans to offer 490 new apartments, 25 to 30 private villas, and 6 hotels classified as 4 and 5 stars with a capacity of 844 rooms.

[24] http://www.orascomdh.com/en/projects/projects-under-development/andermatt.html. Last accessed 22.12.2011.

We initially chose to contact stakeholders because of snowpack reduction, changes in climate suitability for tourism activities, and problems associated with glacier melting and changes in landscape beauty. We also contacted them because of the new resort being constructed and to enquire about its relation to climate change. Moreover, we contacted them because the region is part of the ClimAlpTour[25] research project (Alber et al. 2011). Finally, we contacted the stakeholders as well because of their decision to cover the glaciers with 2500 m^2 of plastic sheets during the summer of 2005.

3. Bagnes (Verbier) – part of the Verbier St-Bernard tourism region

Verbier is an internationally renowned ski resort in the lower Valais, at 1500 m AMSL. We initially contacted the stakeholders in the region to inquire about snowpack reduction and their utilization of JusteNeige, a tool intended to optimize artificial snowmaking launched in 2009-2010 (Loubier et al. 2010).

4. Campo (Blenio) – part of the Bellinzona and Northern Ticino tourism region

This 3.5 km ski resort lies at relatively low altitude (1215 m AMSL). Since 1996 artificial snowmaking provides snow security in the resort. We contacted them to inquire about their strategies with snowpack reduction.

5. Erlenbach im Simmental (Stockhorn) – part of the Lenk - Simmental tourism region

Stockhornbahn offered until 2004 ski-related activities. Since then, they decided to modify their strategy, to close the ski resort, and to focus on summer activity, on snowshoeing and other non ski-related winter activities. Nonetheless, summer was already previously the prevalent season. We contacted them to inquire about their strategies with snowpack reduction and because of the strategy chosen.

6. Grächen – part of the Grächen-St. Niklaus tourism region

Grächen hosts a ski resort with 42 km of slopes. In 1997 - 1998, it became evident that the terrain at a midway station of a chairlift was instable because of the presence of permafrost. As a consequence, and in the interest of the safety of the passengers, the original midway station had to be destroyed and a specially developed new one was built in 2003. In 2011 another chairlift had to be demolished because of problems generated by permafrost. We initially included the region in the analysis because of their experience adapting to melting permafrost.

7. Grindelwald – part of the Grindelwald tourism region

Grindelwald is a popular municipality with strong ties to the tourism industry, situated in the Berner Oberland. It is internationally known for its landscape beauty and for its mountains, but also as a ski resort. In 2005 a glacier lake formed above the village, putting the valley in danger of a large flood. Large investments were made with the construction of a drainage tunnel in order to catalyze this water and thus mitigate the danger.

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[25] The ClimAlpTour project aimed at dealing with the effects of climate change on alpine tourism, with reference both to winter tourism and sports and to alpine all-seasons tourism. This project addressed the need to provide both a sound knowledge of the different aspects of the impact of climate change on alpine tourism and concrete adaptation strategies to apply in selected areas. http://www.climalptour.eu. Last accessed 27.12.2011.

We contacted stakeholders to inquire about the melting of glaciers and the consequent formation of a glacier lake, but also because the region created an organization aimed at adopting and initiating appropriate measures for counteracting climate change (the Jungfrau Climate CO2Operation), and also because it created an I-phone climate guide.[26]

8. Locarno (Cardada) – part of the Lake Maggiore and Valleys tourism region

Cardada-Cimetta is a ski resort with 5.4 km of slopes and 4 lift facilities lying between 1340 and 1869 m AMSL. In the 1990s, part of the ski resort was dismantled. In 2005, the mountain cableway sold the skiing-related infrastructure to the ski school in order to focus on the summer season. We contacted them to inquire about their strategies with snowpack reduction and about changes in climate suitability for tourism activities.

9. Pontresina and St. Moritz – part of the Engadin St. Moritz tourism region

The Engadin St. Moritz region is well known for its tourism offer. Pontresina, a village in the region, is a pioneer in Switzerland in the area of permafrost melting and landslide protection. In 2003, the village embarked on an ambitious project to build protection dams. It also created a walking trail related to climate change.

We contacted stakeholders to inquire about the melting of permafrost, the construction of the dams and the didactic path. We contacted stakeholders from St. Moritz too, to inquire about their strategies with snowpack reduction and about changes in climate suitability for tourism activities.

10. Rivera (Monte Tamaro) – part of the Lake Lugano tourism region

Until 2003, Monte Tamaro was one of a dozen of ski resorts in the southern part of Switzerland (Ticino). Then, because of many years of bad snow conditions, they specifically changed their strategy and focused exclusively on summer activities. The choice appeared to be profitable, since the number of visits is now around 110 000/year.

We contacted them to inquire about their strategies with snowpack reduction and about the declared adaptation strategy to abandon skiing-related activities in favor of summer tourism.

11. Saas Fee – part of the Saas-Fee/Saastal tourism region

Saas Fee is a ski resort with 100 km of slopes and 23 lift facilities stretching from 1800 to 3500 m AMSL. We contacted stakeholders to inquire about their strategies with snowpack reduction and if they feel water scarcity or changes in climate suitability for tourism activities. In addition, we were interested in the region because the valley was the subject of an Econcept study (Bättig et al. 2011) on the impacts of climate change in the area. We discussed with them their possible adaptation strategy in relation to tourism, water management, biodiversity, settlements, and infrastructure.

12. Sattel – part of the Schwyz tourism region

Sattel is a small municipality located at approximately 9 km North of Schwytz and 30 East of Luzern. By 1992, the municipality and the cableway company had already completely changed their strategy, focusing less on winter activities in favor of better and more diverse offerings in the summer. The choice has proven to be an economic success, with yearly revenues of around 4.5 Mio CHF and 70

[26] http://www.jungfrau-klimaguide.ch/en/#/en/klimaguide/6656/. Last accessed 22.12.2011.

people working for the company, making it the biggest employer of the region. We initially contacted stakeholders because of snowpack reduction related investigations, because of the chosen strategy and because they took part in an internal Ernst Basler + Partner study.[27]

13. Schwarzenberg – part of the Luzern Region tourism region

Schwarzenberg was a small ski resort composed of only one ski lift. It was in service only when natural snow was available and thus did not make use of snow machines. In 2010 it closed its operations because of lack of snow. We contacted them to inquire about their strategies with snowpack reduction.

14. Vaud Alps – part of the Lake Geneva Region - Alps tourism region

The Vaud Alps region is composed of 5 main ski resorts (Chateau-d'Oex, les Diablerets and Glaciers 3000, Leysin-Les Mosses, Rougemont, and Villars-Gryon). We contacted them to inquire about their strategies with snowpack reduction, because of the early studies on the subject carried out by the region (Serquet and Rebetez 2010), and also because of the strategy prepared to address specifically the topic.

15. Wattwill (Obertoggenburg) – part of the Toggenburg tourism region

The Obertoggenburg region lies in Eastern Switzerland. It possesses around 60 km of slopes, ranging from 1090 to 2262 m AMSL. We contacted stakeholders to inquire about their strategies with snowpack reduction because they took part in the internal Ernst Basler + Partner study.

16. Zermatt – part of the Zermatt Matterhorn tourism region

Zermatt is a municipality in the canton of Valais located at 1608 m AMSL with a very large volume of tourists. It possesses 350 km of slopes, 57 lift facilities, and an astonishing landscape. We contacted stakeholders to inquire about their strategies with snowpack reduction, possible changes in climate suitability for tourism activities, permafrost and glacier melting, but also because of the high dependency on tourism of the region and the hi-tech environmentally friendly Monterosa mountain house built in 2009.

3.1.2.3 The case study region of the participatory adaptation process

Finally, we decided to choose a case study region in order to assess possible adaptation strategies in a vulnerable area. Due to time constraints and the needs of the ClimAlpTour project, it was not possible to select one of the focal areas of vulnerability identified by the vulnerability mapping. We chose the Aletsch region instead. The delimitation of the region differs slightly from the one presented in Section 3.1.2.3; we did not include here Lax, Martisberg, Bitsch and the old municipality of Mörel[28] because tourism is not a major part of the local economy in those areas.

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[27] http://www.ebp.ch/files/f%20e/rp_anpassung-klimawandel-tourismus.pdf. Last accessed 22.12.2011.
[28] Now being part of Mörel-Filet.

Figure 3.3: In dark grey, the Aletsch case study region, in light gray the limits of the 85 tourism regions presented in Section 3.1.2.1.

The region studied is situated in the Upper Valais, above Brig and on the right side of the Rhone River. It is part of the Valais canton, in the South-West of Switzerland (Figure 3.3). The altitude ranges from 668 (the lower side of Naters) to 4193 m AMSL (the Aletschhorn, which belongs to the same municipality). The area is 347 km^2 and includes 6 municipalities: Naters, Riederalp, Betten, Fiesch, Fieschertal and Bellwald. The total resident population (as of 2007) comprises 10 345 inhabitants.

The study area partly embraces the perimeter of the Swiss Alps Jungfrau-Aletsch (SAJA) UNESCO world heritage region.[29] This site was inscribed in 2001 and then expanded in 2007. It is considered of great value due to its beauty and the information it contains about the formation of mountains and glaciers, as well as ongoing climate change. All the municipalities in the UNESCO area signed the Konkordiaplatz Charter (Hill 2007), committing to preserve the aesthetic beauty of the SAJA landscape for future generations and to maintain a sustainable use of the countryside in the core zones of the UNESCO site.[30]

In addition, from 1977 to 1986, the Aletsch region was part of the Man And Biosphere (MAB) Project (Mattig and Zeiter 1984; Messerli 1989). This study generated a significant amount of information and valuable data on the region. To summarize this data, the case study region was almost self-sufficient and lived nearly in autarchy until the 1940s (at least the villages without communication with the valley floor) (Theurillat 1992). More than 80% of the working force was then employed in the primary sector. With the construction in 1950 of the cableways to Riederalp and Bettmeralp, the Aletsch region opened itself to modern tourism and a large proportion of its population switched to the tertiary sector and to the newly-created and more attractive jobs in tourism. Since then, tourism has become the dominant economic factor in the region (with a high dependence on the hotel and

[29] Fiesch is however not part of the UNESCO world heritage region.
[30] http://whc.unesco.org/en/list/1037/. Last accessed 22.12.2011.

the restaurant industry), with related major changes within the original agricultural system (Messerli 1983). Contrarily to the Bernese side of the SAJA region, in which summer and winter tourism are about even (see also Section 4.5.8.1), winter tourism prevails on the Valais side (Wallner et al. 2008).

Presently, the Aletsch plateau offers a total of 104 kilometers of slopes and 35 lift facilities, 11 km of cross-country ski field and 75.5 km of winter hiking trail.[31] There is at the moment no project for new ski-lifts on the South slope since the plateau is already well-equipped. Development projects for the North side of the slope are not allowed since the region is part of the UNESCO site.

3.1.3 The collected data

The data used for this study come from a variety of sources. They can mainly be divided in two categories: quantitative (hard) and qualitative (soft) data. Hard data can be described with some specificity. This means that they can generally be quantified (Kiritz 1997). This is for example statistical information or results of simulations. Soft data are on the other hand illustrative. They are usually gathered in informal communication. They are therefore often based on subjective perception and lack the rigor of statistical data. Nevertheless, we utilize soft data for this study when no hard quantitative data are available. This is explained in this section.

3.1.3.1 Quantitative data: Swiss federal statistics and impacts scenarios

We selected seventy indicators to depict the vulnerability of the 85 tourism regions. Data were mainly supplied by or calculated from information delivered by research groups and projects working on simulating future scenarios (ENSEMBLES,[32] the Projection of Economic impacts of climate change in Sectors of the European Union based on boTtom-up Analysis (PESETA),[33] and the Global Land Ice Measurements from Space (GLIMS)[34] projects), the Federal Office for the Environment (FOEN), the Federal Office of Topography (Swisstopo), the Federal Statistical Office (FSO), the Swiss Federal Institute for Forest Snow and Landscape (WSL), Laurent Vanat (Consulting on winter tourism for Switzerland), and by the Urban and Regional Planning Community (CEAT) at the Swiss Federal Institute of Technology of Lausanne (EPFL). A comprehensive description of the seventy indicators can be found in Annex A.3.

3.1.3.2 Qualitative data: the Univox phone survey

We developed a first survey as part of a larger study, the Univox environment monitoring 2011, conducted by the gfs-Zürich research institute on behalf of the Aduno group.[35] Our main objective was to obtain an overview of the Swiss population's general views on climate change and its willingness to support adaptation measures.

We asked six questions in relation to this subject:

1) Will climate change have an impact in Switzerland?

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[31] http://www.skiresorts-test.com/skiing-holiday/aletsch-arena-riederalp-bettmeralp-fiesch-eggishorn.html. Last accessed 22.12.2011.
[32] http://www.ensembles-eu.org. Last accessed 22.12.2011.
[33] http://peseta.jrc.ec.europa.eu. Last accessed 22.12.2011.
[34] http://www.glims.org/. Last accessed 22.12.2011.
[35] General results can be found at http://www.gfs-zh.ch/. Last accessed 08.03.2012.

2) What is the relative importance of each of the 6 proposed short-term measures of the Swiss climate policy for addressing climate change?
3) Accepting that the climate is changing, should adaptation measures be taken already now or should they be carried out step by step when the impacts have clearly emerged?
4) Who among the population, private and public stakeholders should bear the main responsibility for these actions?
5) What is your personal opinion on future snowpack reduction?
6) How do you evaluate the effectiveness of artificial snowmaking to combat climate change in the tourism industry?

This phone survey was run by gfs-Zürich between August 29 and September 17, 2011, collecting the opinion of 1007 people living the German and French-speaking parts of Switzerland.

3.1.3.3 Qualitative data: the online survey

We elaborated a second survey in collaboration with the WSL in order to gather respondents' perception concerning present and future impacts of climate change on the tourism sector in the country and to fill data and information gaps of the vulnerability map. It was also meant to investigate adaptation actions already taking place in Switzerland and assess their effectiveness. Additionally, it was meant to evaluate barriers to adaptation and possible ways of overcoming them. It finally aimed at testing the robustness of the vulnerability map and/or at revealing differences between the results of this map and stakeholders' perception.

We developed the online survey following a review of the literature (in particular based on Foddy (1993)) and discussions with workers in the tourism industry and in the research field. It was partly based on a previous survey carried out by Kruse et al. (personal communication) at the WSL. It contained 33 questions, of which 6 were open ones; the interviewees had then the possibility to freely express themselves on the subject.

The survey ran from November 2, 2011 to January 4, 2012. We first tested it for 20, then 500 email addresses. After this initial phase, we finally sent it on November 24, 2011, to 7896 email addresses of Swiss tourism stakeholders either related to food and beverage serving services, passengers and transport services, accommodation, travel agencies, cultural services, or to communal and cantonal administrations (for a total of 8416 email addresses). After the first round of testing and collection of feedback, we decided to send an introductory email to explain the reasons of the survey one week before sending it out to all 7896 stakeholders. Moreover, because of the length of the questionnaire and the complexity of the questions, we decided to split the survey and to send vulnerability map-related questions to half of the set and barriers-related ones to the second half. This obviously implied a loss of potential respondents, but we hoped it would increase the number of people completing the survey. Finally, we emailed a reminder on December 13, 2011, asking people again to fill the form. The survey was available in German, French, Italian, and English. The complete English version of the survey can be found in Annex A.13. The German, French, and Italian ones are available in the wiki (Annex A.18). We used FeedbackServer™ 5 for generating it.

We wrote to almost all Swiss municipalities, cable car companies, tourism guides, tourism offices, and hotels with available email address. 566 people answered. We partly expected the low response rate (6.72%) from the beginning because we also sent the survey to stakeholders (e.g. a hotel in Geneva or a small municipality of the Plateau) not directly concerned with the topic. We wanted nonetheless to give every person related to the sector the possibility to express her/his opinion. Other reasons for the low response rate could be that receptionists in hotels filtered some mails and they thus never reached the relevant persons; some stakeholders had difficulties in accessing the survey because of the web browser they used, while yet others found it too long.

In the reminder sent in December, we allowed respondents to explain why they chose not to participate in order to better understand the reasons for the low response rate. 166 persons chose to do so (multiple answers possible). The main reasons for not taking part seemed to be the lack of time (46%), followed by the estimation that the region in which the person works and its tourism are not affected by climate change (16%). 15% of these respondents felt that they were not personally affected or competent enough to answer. For 7% of the respondents the questionnaire was too complicated and/or badly organized. For 6%, tourism was not important in the region. Only 2 persons (1%) indicated that they did not take part in the survey because they did not believe in climate change. We present other reasons in the wiki (Annex A.18).

3.1.3.4 Qualitative data: the face-to-face interviews

We developed face-to-face interviews in order to gather information on various aspects of adaptation. These included the existing adaptation measures, the triggering factor and path that brought about these measures, the type of actors involved, the level of development, the effectiveness, and possible barriers that hindered or still hinder the process. We identified stakeholders according to the following criteria: i) the person is closely related to tourism and/or has a considerable power of decision and power of action in the region; ii) the region in which she/he works is known as being highly exposed to climate change impacts in relation to tourism (Section 4.5.2); and/or iii) the region is well known for either its changes in strategy and supply, its proclaimed adaptation measures to the impacts of climate change, or its efforts to reduce GHGs emissions. We sought moreover examples of different classes of adaptation measures as presented in Section 5.3.1 (e.g. autonomous and planned, anticipatory and reactive, short term and long term adaptation measures and strategies), in particular localized measures.

We covered 13 of the 16 regions presented in Section 3.1.2.2. We conducted all interviews between July 27, 2011, and October 12, 2011. We interviewed face-to-face or by phone 17 people related to the 13 tourism resorts with semi-structured interviews. When people were not available for a direct interview due to distance or scheduling problems or that information was missing, both phone discussions and email exchanges allowed us to gather the missing information. We recorded almost all of the discussions (15). We carried out 9 interviews in English, 4 in French, 3 in Italian, and 1 in German. They lasted between 18 (phone interview - Andermatt) and 99 minutes (face-to-face interview - Cardada). We transcribed main parts of the discussions. Moreover we double-checked information given by asking interviewed persons confirmation of our interpretation of their answers.

4 Assessment of the regional vulnerability of tourism in Switzerland

The main findings of this chapter could be expressed as follows:

- Climate change affects Swiss tourism in many ways. According to experts, the most important impacts are snowpack reduction, glaciers melting, and water scarcity;
- In experts' opinion, the adaptive capacity of a region considerably determines its degree of vulnerability; the most exposed regions are then not necessarily the most vulnerable ones;
- Based on our calculation, patterns of vulnerability could be found inside the country, with the lake regions of the Plateau possibly benefiting from climate change and high Alpine regions (mainly in Valais, Ticino, and Uri) appearing as areas particularly vulnerable for the 2030-2050 time horizon;
- Stakeholders' perception of regional vulnerability and the generated map differ noticeably. In stakeholders' opinion, focal areas of vulnerability are mainly on the Plateau and in the Rhine valley. This is perhaps due to the fact that stakeholders mainly assumed that already visible impacts such as snowpack reduction and the increase in frequency and intensity of floods are signs of vulnerability;
- Stakeholders' perception of both present and future potential impacts and vulnerability are positively and significantly correlated. The correlation among perceived adaptive capacity and vulnerability is on the other hand weaker and U-shaped;
- Data gaps on which more research must be carried out still exist, even if some are being filled (e.g. concerning the potential impacts of climate change on future water availability);
- The concepts of vulnerability and vulnerability mapping have their limitations, and these should not be forgotten.

4.1 Abstract

In this chapter, we investigate the vulnerability of tourism to climate change in 85 Swiss regions. We analyze in particular the impacts generated by changes in climate suitability for tourism activities, specifically snowpack reduction, glaciers melting, permafrost melting, changes in the frequency and intensity of natural hazards, changes in water availability, and in landscape and scenic beauty. We select 70 indicators describing the exposure, the sensitivity, and the adaptive capacity of Swiss tourism to climate change. We collect simulations on the possible impacts and statistical data on these indicators for the various regions. Where quantitative data are not available, we fill gaps with qualitative data generated by an online survey. This allows identifying the most important determinants of vulnerability. It will reveal spatial heterogeneity in vulnerability and hotspots, i.e. areas in which the implementation of adaptation measures is more crucial. Finally, we compare calculated (objective) and perceived (subjective) vulnerability.

4.2 Introduction

Climate change is happening, and the tourism industry is particularly affected by it as a result of its dependency on climate and weather. In addition, this economic sector is exposed to natural hazards, particularly in the Alpine region. Tourism is an important pillar of the Swiss society and economy

(Section 2.1), providing significant employment and generating substantial income. Therefore, it is essential to reduce its vulnerability and to start implementing adaptation measures. In order to do so, it is necessary to define which areas face what problems. With limited resources, it is furthermore of essence to spot priority areas of vulnerability.

Past studies partially addressed the topic, mainly relating to snowpack reduction. König and Abegg (1997), Elsasser and Messerli (2001), Elsasser and Bürki (2002), Priceputu and Greppin (2005), Abegg et al. (2007), Uhlmann et al. (2009), Serquet et al. (2011), Beniston (2012a) all outlined the high exposure or vulnerability of lowland regions to snowpack reduction and the relative gains for higher locations. In addition, Serquet and Rebetez (2011) looked at changes in climate suitability for tourism activities. They found a correlation between domestic tourist demand and hot summer temperatures in the Swiss Alps, with Alpine resorts nearest to major cities benefitting the most. Very few studies looked at other climate impacts affecting the sector, such as permafrost melting or changes in scenic beauty. To our knowledge, only Müller and Weber (2008) investigated simultaneously the set of most relevant of these impacts. They looked at a multitude of possible impacts, including changes in climate suitability for tourism activities, snowpack reduction, glaciers melting, changes in frequency and intensity of natural hazards, and changes in scenic beauty. They qualitatively assessed risks and opportunities for tourism in four different geographic areas of Switzerland (Alps, Prealps, cities, and lakes regions) by surveying 11 experts. They found that benefits are predominant for almost all regions, with the exception of the Prealps (Figure 4.1). These are seen as losers mainly due to snowpack reduction.

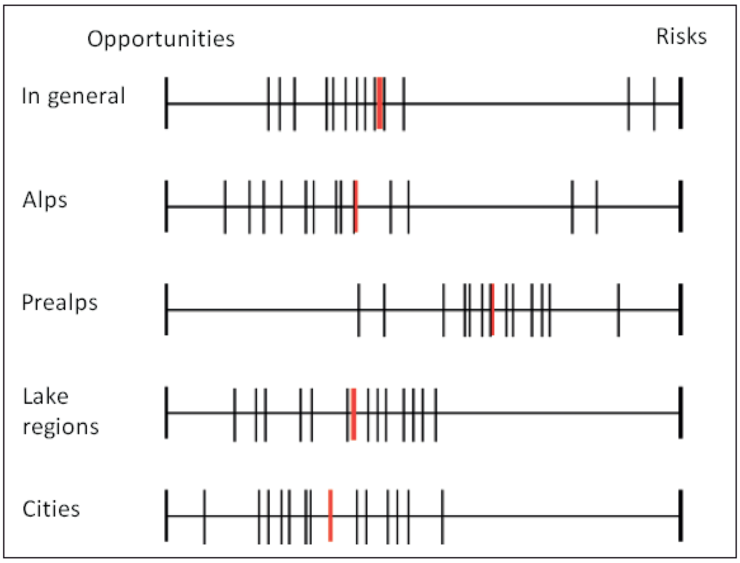


Figure 4.1: Evaluation by the support group of the Müller and Weber (2008) report on opportunities and risks for the tourism sector in different geographic regions of Switzerland due to climate change. Black lines represent the evaluation of experts, the red line the average. Adapted from Müller and Weber (2008).

The report does, however, not mention some important impacts as permafrost melting or water scarcity and drought. Neither does it look at internal variability in the four regions studied. The aim of this chapter is hence to build on Müller and Weber's results and to describe the vulnerability of Swiss tourism to climate change, to analyze its causes, its magnitude, and its spatial heterogeneity.

Stakeholders often anticipate the large transformations that climate change could bring to the current tourism structure. They are the first to detect landscape and climate transformations and changes in tourism behavior. However, they frequently place climate change impacts on a lower priority level than other, more direct, threats to their business. This study does not aim at providing a precise estimation of the dangers that the different regions are going to face. Doing this is still too difficult due to data gaps and the lack of an objective assessment of the relative importance of the impacts. We aim on the contrary at raising stakeholders' awareness of and attention to the many challenges that the tourism sector is already facing and will face in the future due to climate change. Higher awareness of the problem, together with higher awareness of the environmental impacts of the sector, could be first steps towards the beginning of a sustainable adaptation process in the different, and in particular in the more affected, regions. Results should then suggest what could be:

i) The most important drivers influencing vulnerability;
ii) Spatial heterogeneity in vulnerability;
iii) Hotspots, i.e. areas where the implementation of adaptation measures is more crucial;
iv) Data gaps and fields where more research should be carried out; and
v) Differences between perceived and assessed vulnerability.

We shall, therefore, develop a tool that allows stakeholders to compare results with their own subjective perceptions of vulnerability in their region, and that encourages them to discuss and share such information.

This chapter is organized as follows: Section 4.3 provides background information on vulnerability. Section 4.4 presents respectively the data and methods exploited. Section 4.5 displays the results and Section 4.6 discusses the results obtained. Section 4.7 mentions the limitations encountered. Finally, Section 4.8 concludes.

4.3 Background on vulnerability

Vulnerability has a multitude of definitions across interconnected research fields, with scholars from different knowledge domains using often different conceptualizations of this term or using the opposite term of resilience[36] instead (Luers et al. 2003; Turner II et al. 2003; Metzger et al. 2005; Janssen and Ostrom 2006; Füssel 2007; Ionescu et al. 2009; Malone 2009; Miller et al. 2010; Costa and Kropp 2012). For example, the IPCC defines vulnerability as "*the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change, including climate variability and extremes. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity*". In other words, in the IPCC definition, the concept of vulnerability describes the degree to which a system is likely to experience harm due to exposure to climate change, the extent to which it is susceptible to sustain damage and to adapt to it (Benioff et al. 1996; Turner II et al. 2003; IPCC 2007a; Perch-Nielsen 2008). Damage from climate change could affect segments of the natural environment, elements of the economy, of welfare, and of human health.

[36] Resilience can be defined as the '*tendency to maintain integrity when subject to disturbance*' (Burton et al. 2005). Other definitions can be found in OECD (Levina and Tirpak 2006).

4.3.1 Exposure, sensitivity, and adaptive capacity

According to the IPCC Report (2007a), vulnerability to climate change is a function of three components (Figure 4.2): i) exposure, ii) sensitivity, and iii) adaptive capacity. First, it is a function of **exposure**. This is defined by the IPCC (2007a) as the '*nature and degree to which a system is exposed to significant climatic variations'*. A system could be exposed both to direct impacts (such as changes in temperature and rainfall average, increased risk of natural hazards, or snowpack reduction generated by changes in climate conditions) and indirect impacts (e.g. worse/better climate suitability for tourism activities in other regions).

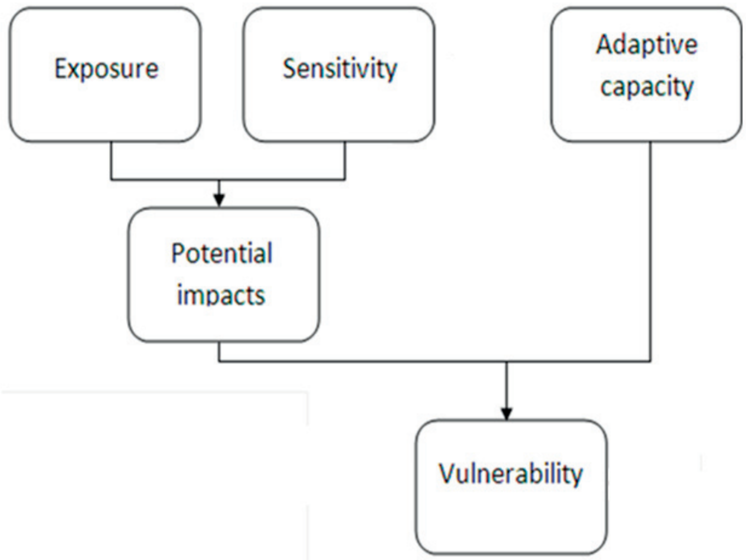


Figure 4.2: Components of vulnerability (adapted from Allen Consulting Group (2005)).

Secondly, vulnerability is a function of the regional **sensitivity** to them, where sensitivity is '*the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli'*. Sensitivity could be environmental (e.g. linked to water availability or landscape quality), human (e.g. social structure), and/or economic (e.g. economic structure of the region).

Finally, vulnerability depends on the (e.g. biophysical, social, technological and economic) **adaptive capacity** of the system. Adaptive capacity can be defined as the '*ability of a system to adjust to climate change (including climate variability and extremes) to moderate potential damages, to take advantage of opportunities, or to cope with the consequences'* (IPCC 2007b).

The first two components – exposure and sensitivity – provide an indication of the potential susceptibility of a system (as a region or process) to adverse impacts (or **potential impacts**). On the other hand, the third component, adaptive capacity, reflects the ability of the system to manage those adverse impacts, and thereby reduce, gross vulnerability (Preston et al. 2008).

4.3.2 Possible vulnerability assessment methods and tools

Different methods and tools exist to assess vulnerability. The range of choice is large (even if often methods overlap) and it depends on the type of results that are sought. Shall they be qualitative or quantitative? Participative or data-driven? Use complex models or transparent processes? Be adapted to local or global analysis? Be dynamic or static? A list of possible methods and tools is given in Füssel (2007), in Downing and Ziervogel (2004), Winograd (2004), and in the United Nations Framework Convention on Climate Change (UNFCCC) compendium (UNFCCC 2008). We considered here the more relevant ones for our objectives, namely to assess the magnitude of impacts and the distribution of vulnerability of tourism to climate change in Switzerland and the subsequent determination of focal areas of vulnerability.

Expert judgment is an approach for soliciting informed opinions from individuals with particular expertise. One issue of these studies is that special attention should be given to the choice of experts, in order to cover the full range of opinions. This method is particularly useful to obtain a rapid assessment of the state of the knowledge about an aspect of climate change, when, for example, there is insufficient time to undertake a full study. It is also interesting because it provides different perceptions, which could be discussed and analyzed. It is nonetheless important to enclose a large spectrum of experts, in order to avoid biased results. The main disadvantages of the method, in contrast to the other participatory methods presented hereafter, are that it relies on subjective perceptions and not on quantitative assessments. This method was used among others by Brooks et al. (2005b) and Müller and Weber (2008, Section 4.2).

Participatory Geographic Information System (PGIS) uses local people's direct experience or historical 'folk memories' of e.g. floods, water-logging, landslides, avalanches, storm damage, and coastal inundations in order to determine the amplitude and likelihood of these hazards (McCall 2008). Maps are useful for representing people's perceptions or to emphasize relative results. As stated by Forrester et al.(2003), the clearness and conciseness of 'citizen maps' allow decision makers to take into account citizen inputs, which used to be ignored. This method is particularly suitable for regional studies. It is however less appropriate for analyses carried out on a national or higher level. More information can be found in PPgis.net.[37]

Multicriteria Analysis (MCA) also relies on peoples' judgment and is often a participative method, which allows for the inclusion of different types of actors in the decision process. It generally consists of collecting data on the region and in using Geographic Information System (GIS) tools in order to manage, produce, analyze, and combine them. Criteria generally cover political, economic, social, and environmental aspects (Bell et al.2003; UNFCCC 2008). The family of criteria used, to which actors assign a weight, allow us to consider different consequences and provide the basis for comparison of choices and therefore facilitate the selection of a satisfactory one. Multicriteria Analysis is a method that is particularly applicable to cases where purely economic approaches (such as cost-benefit analysis) would fall short, in particular where significant environmental and social impacts cannot be assigned monetary values. It is nonetheless a quite complex method, which is sometimes felt as counter-intuitive by participants (Section 4.7).

Another method is the **livelihood-sensitivity matrix** described in the weADAPT website.[38] The matrix is useful, whether to synthesize existing knowledge on climate vulnerability in a fairly rapid participatory exercise with stakeholders, to provide a vulnerability assessment based on expert judgment, or to integrate results from a variety of quantitative and qualitative methods. It is however less suitable when a more in-depth analysis is needed. It consists in first listing livelihoods and their productive activities in the case study region (e.g. crop production, livestock production, forestry, or health tour-

[37] http://ppgis.iapad.org/pgis.htm. Last accessed 22.12.2011.
[38] http://www.weadapt.org. Last accessed 22.12.2011.

ism). In a second step, the possible impacts are enumerated (the list is set starting from stakeholders' perceptions) and given a score. By weighing and summing the sensitivity scores of each type of climate impact, it is possible to prioritize actions and identify the variables possessing relative importance in determine vulnerability. The method does not consider future scenarios.

Cluster analysis (Kropp et al. 2006; Prettenthaler et al. 2006; Holsten et al. 2012) is a typological method which groups region with similar values on a set of indicators with the help of clustering methods. It has the advantage of providing a quick overview of regions lying in a similar situation. On the other hand, the method does not allow the ranking of different regions by their vulnerability.

Finally, **vulnerability mapping** is a spatial assessment technique that partially includes some of the above-mentioned methods. It is by far the most common method to assess vulnerability, even if carried out in different ways. Often political, economic, social, and environmental data of the given region are collected and analyzed using GIS tools. It is an attractive approach to analyze the different possible impacts, and the interrelations between them. It also allows for the creation of a general view of the areas where, according to the climate scenarios, the effects of climate change can have a major socio-economic impact (the hotspots of vulnerability) and ultimately decide where the implementation of adaptation measures is particularly important. Moreover, as pointed out by Preston et al. (2008), it generates a powerful tool to interest and motivate stakeholders to participate in the adaptation process, to overcome barriers and to grasp related opportunities.

Worldwide, a broad array of attempts have been made to standardize the methodological framework (Benioff et al. 1996; Kelly and Adger 2000; Füssel 2007; UNFCCC 2008) or the choice of indicators for the three components: exposure, sensitivity, and adaptive capacity (e.g. Brooks et al. 2005b). Nonetheless, vulnerability is a complex variable that depends on the spatial amplitude of the region studied (a set of nations vs. a single country) and on the choice of the selected sector (e.g. tourism, agriculture, biodiversity). Therefore, it is difficult to create *ex ante* a standardized method, a set of indicators or of indices that could be prescribed for conducting vulnerability research in any area.[39] A more critical discourse on the method can be found in Hinkel (2011).

A growing number of studies deal with mapping vulnerability to climate change, often focusing on a particular impact such as floods (Hebb and Mortsch 2007) or heat waves (Lissner et al. 2011). Some studies moreover focused on a particular sector or field such as the ecosystem (Priceputu and Greppin 2005; the EU LIFE+ VACCIA project).[40] Generally, researchers analyze a specific region such as the coastal zone of Poland in Zeidler (1997), Scandinavia in the CARAVAN project,[41] Tajikistan in Heltberg and Bonch-Osmolovski (2011), India in O'Brien et al. (2004), Germany in Schröter et al. (2005), the Sakai Sub location (Kenya) in Mutua (2006), the Yaqui Valley in Mexico in Luers et al. (2003), global cities in de Sherbinin et al. (2007), the Sydney Coastal Councils Group in Preston et al. (2008), Southeast Asia in Yusuf and Francisco (2009), or Europe both in the MOVE[42] project (MOVE 2011, Vinchon et al. 2011)[43] and in the ESPON 2013 Program[44] (ESPON 2011). Other researchers fo-

[39] http://www.vulnerabilitynet.org/. Last accessed 22.12.2011.
[40] Vulnerability Assessment of ecosystem services for Climate Change Impacts and Adaptation. http://www.ymparisto.fi/default.asp?node=24015&lan=en. Last accessed 22.12.2011.
[41] Climate change: A Regional Assessment of Vulnerability and Adaptive capacity for the Nordic countries. http://www.environment.fi/default.asp?contentid=380099&lan=EN. The site provides also a very interesting online mapping tool http://www.iav-mapping.net/CARAVAN/CARAVAN.html. Last accessed 09.03.2012.
[42] Methods for the Improvement of Vulnerability Assessment in Europe.
[43] http://www.move-fp7.eu/. Last accessed 09.03.2012.

cused on the Alpine space (e.g. Kruse et al. 2011), or on the North Rhine-Westphalia (Kropp et al. 2006; Holsten et al. 2011; Holsten et al. 2012; Klaus et al. 2011; Lissener et al. 2011), these last two studies being also part of the ESPON 2013 Program. For Switzerland, we can cite the study of Priceputu and Greppin (2005) on biosphere and human activities, which also mentions tourism.

Very few studies dealt specifically with vulnerability in relation to tourism: Prettenthaler et al. (2006), Perch-Nielsen (2010), Holsten et al. (2011, 2012). Prettenthaler et al. (2006) analyzed the regional economic impacts of climate change on winter tourism in Austria in order to help implement adaptation policies. The output of their research was an economic and climatologic cluster analysis. Perch-Nielsen (2010), on the other hand, presented an index approach to assess the global vulnerability of beach tourism to climate change. Aggregate results on an annual level showed that the large developing countries and small islands might be among the most vulnerable. Holsten et al. (2011, 2012) looked at the vulnerability in North Rhine-Westphalia of various sectors among which was winter tourism. Results for this sector indicated that the higher elevated areas of Sauerland are the most affected, as they strongly depend on skiing activities.

4.4 Data and methods

As seen in Section 4.3, vulnerability has a multitude of definitions across interconnected research fields, with scholars from different knowledge domains using often different conceptualizations of this term or using the resilience[45] term instead (Luers et al. 2003; Turner II et al. 2003; Metzger et al. 2005; Janssen and Ostrom 2006; Füssel 2007; Ionescu et al. 2009; Malone 2009; Miller et al. 2010; Costa and Kropp 2012). As Füssel (2007), we do not assume a single 'correct' or 'best' conceptualization of vulnerability or resilience that would fit all assessment frameworks. We think that each definition reflects different contexts and research frames. We use here the definition given by the IPCC (2007a, Section 4.3), which is most generally used in the climate change discourse. We shall nonetheless discuss the limitations of our choice in Section 4.7.

The number of methods available to assess vulnerability is high and varied, and this probably because vulnerability is a concept which is so difficult to define. After reviewing the different methods, we choose the last one, namely vulnerability mapping, in the context of this work. Reasons for this choice are that it appears to be by far the most complete of the set, encompassing both people's perception and quantitative and objective evaluations. Other methods, in particular expert judgment, multicriteria analysis, and cluster analysis are also included in the process. They are presented in Sections 4.4.3 and 4.4.5. In addition, an online survey and face-to-face interviews with stakeholders will allow us to gather stakeholders' perceptions on the topic.

We used here the 85 tourism regions presented in Section 3.1.2.1 in addition to the case study regions of the face-to-face interviews presented in Section 3.1.2.2. Quantitative data used in this chapter are presented in Section 3.1.3.1. When statistical and quantitative information was lacking, we collected information by means of the online survey (qualitative data) presented in Section 3.1.3.3. In

[44] European Observation Network for Territorial Development and Cohesion. http://www.espon.eu/main/. Last accessed 09.03.2012.

[45] Resilience can be defined as the '*tendency to maintain integrity when subject to disturbance*' (Burton et al. 2005). Other definitions can be found in OECD (Levina and Tirpak 2006).

addition to allowing us to gather information meant at filling data gaps, the survey addressed the following subjects (Annex A.13):[46]

- the respondents' ranking of relative importance of exposure, sensitivity, and adaptive capacity;
- their impression of past and future changes in their region due to climate change (the exposure of the region);
- their perception on the global and regional problems generated by climate change (the potential impacts);
- their perception on respectively the adaptive capacity and the vulnerability of their region as well as an evaluation of their willingness to act.

As discussed above (Section 4.3.1), vulnerability V is a function of exposure E, sensitivity S, and adaptive capacity AC, with the relation between exposure and sensitivity determining the potential impacts. These were mentioned in the online survey as 'problems to the sector'. We refer to them as PI. We asked respondents to evaluate the degree of present and future potential impacts, adaptive capacity, and vulnerability in the region. We asked the following questions:

- PI: We are interested in your opinion. Please indicate to what extent you agree with the following statements. The impacts of climate change are already causing problems in the tourism sector in my region today/The impacts of climate change will lead to problems in the tourism sector in my region in 2030-2050.
- AC: How do you assess the ability of tourism to cope with climate change impacts in your region? E.g. its ability to moderate potential damages, take advantage of opportunities, or cope with the consequence of climate change?
- V: In your opinion, how vulnerable is the tourism sector in your region regarding climate change? By 'vulnerable', we mean a region that is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes.

If the above-mentioned relation is true for the perceived vulnerability ($V_{perceived}$), this could be expressed as follows (Equations 1 and 2):

$$V_{perceived} = f\,(E_{perceived}, S_{perceived}, AC_{perceived}) \qquad (1)$$

or

$$V_{perceived} = f\,(PI_{perceived}, AC_{perceived}) \qquad (2)$$

If, according to stakeholders' perception, vulnerability really is a function of the different components, a significant correlation should exist between perceived vulnerability, perceived potential impacts, and perceived adaptive capacity. On the other hand, no correlation should exist between the potential impacts and the adaptive capacity, as they are two independent features.[47]

[46] More information on the organization of the interviews and of the online survey can be found in Sections 3.1.3.4 and 3.1.3.3.
[47] This could be discussed because the present adaptive capacity can be triggered by past impacts, as for example in relation to already implemented adaptation measures. We discuss this in Section 4.6.2.

4.4.1 The vulnerability mapping method

Research on vulnerability is becoming increasingly widespread, with a growing number of studies that emerged in the last years (Section 4.3.2). A common methodology for vulnerability mapping does not, however, (and perhaps could not) exist since each case study faces different problems and research questions. We define as follows the four dimensions that describe a vulnerability situation and which allow, as stated by many authors, to meaningfully use the term 'vulnerability' (Luers et al. 2003; Metzger et al. 2005; Füssel 2007; Füssel 2009):

- System: Switzerland as described in Section 3.1.2.1;
- Attribute of concern: the tourism sector as described in Section 2.1;
- Hazard: the seven impacts described in Section 2.3;
- Temporal reference: 2030-2050 as described in Section 3.1.1.

We then used combination of several methods: in a first step, a literature review and a follow-up discussion with experts and stakeholders[48] allowed us to define the most relevant impacts and indicators depicting the vulnerability of tourism in Switzerland in relation to climate change (Section 4.4.2). Once indicators were selected, we questioned experts using a Pairwise Comparison Multicriteria Analysis (AHP MCA) (Section 4.4.3) in order to assess the relative weights of these indicators and impacts. This is a subjective assessment, depending on experts' judgment and not an objective evaluation. We then collected information on the indicators for the 85 different tourism regions considered in our study. We mainly obtained data from offices of Swiss federal administration and from research groups working on simulating future impacts (Section 3.1.3.1). When quantitative data was missing, we used qualitative data generated by an online survey (Section 3.1.3.3). In order to check if the data collected were sound, we compared the results of the survey with the ongoing research (often carried out at the regional scale). We did not employ data that appeared to be inconsistent or unreliable. Next, we treated, aggregated, and presented data as maps using GIS tools (ArcGIS 9.3) (Section 4.4.4). Finally, we performed a cluster analysis (Section 4.4.5) and a robustness analysis (Section 4.4.6) in order to establish both similarities among tourism regions and the robustness of the results.

4.4.2 The choice of indicators

Because vulnerability is a complex and variable characteristic, depending on the spatial amplitude of the region and on the sectors studied, it is difficult to create *ex ante* a standardized set of indicators or of indices that could be prescribed for conducting vulnerability research.

In the context of this study, we selected the main climate change impacts of particular importance for tourism in Switzerland, in addition to the indicators depicting exposure, sensitivity, and adaptive capacity based on the published literature on climate change impacts (using the SWIDCHI[49] database) and on vulnerability assessment (Brooks al. 2005b; Perch-Nielsen 2008; Preston et al. 2008). The

[48] Please note that the difference of definition between the terms 'stakeholders' and 'experts' lies is in the fact that we consider as 'experts' persons who examine climate change and estimate its impacts at the Swiss level (top down), whereas the term 'stakeholders' designates persons linked to the sector, who might be directly affected by the impacts of climate change at the local and regional level (bottom up perspective). A list of the 13 experts interviewed and their areas of activity can be found in Annex A.9.
[49] See http://swidchi.epfl.ch/ and Annex A.19 for more information.

choice of the indicators underwent a continuing process. Discussions with experts and stakeholders (in particular in the frame of the ClimAlpTour project) allowed us to improve the choice by, for example, eliminating less appropriate indicators or selecting better ways to depict some of them.

Finally, we selected 70 indicators, grouped in 20 families (Figure 4.3). 13 indicators measure exposure, 40 measure sensitivity, and 17 measure adaptive capacity.[50] Some of the indicators characterize negative exposure or sensitivity. For example, high climate suitability for tourism activities or an elevated percentage of mountainous or lake areas most likely have a positive effect on the development of summer tourism in the region as an alternative to the heat of the lowlands and of the urban centers (OcCC/ProClim 2007; Serquet and Rebetez 2011). Similarly, ski resorts at high elevation have an advantage compared to ski resorts located in the lowlands, which are affected by snowpack reduction. These indicators were marked with a (-) in the following text. More general information on the various indicators, the reasons of their choice, and their sources can be found in Annex A.3.

Because indicators selection and weighting is fraught with uncertainties, we decided to be as transparent as possible in our description of the process, the methodology, and the selected data. We therefore documented each step of the method (see Annexes A.2 - A.6). We took care to choose indicators that were well-founded, accurate, non-ambiguous, comprehensible for stakeholders, relevant, responsive to changes, with high information content, available, and based on homogeneous data (after Perch-Nielsen 2008; based on Atkins et al. 1998, OECD 2002, Kaly et al. 2003, and Esty et al. 2006). The evaluation and information on criteria we used for it can be found in Annex A.2. Some of the indicators may have an ambiguous effect on vulnerability. The list of desirable indicators is certainly not complete. We are aware of the drawbacks, but decided to use this set of indicators nonetheless because we believe that they carry important information.

Finally, in considering the choice of indicators, it is clear that adaptive capacity is the most critical of the three components of vulnerability, even though it is not directly measurable (Adger and Vincent 2005; Brooks and Adger 2005, Engle 2011). The choice of its indicators is therefore particularly subjective. In addition, trustworthy information was often difficult to obtain.

We classified adaptive capacity in the following six classes: i) social acceptability; ii) social feasibility; iii) economic feasibility; iv) environmental feasibility; v) institutional feasibility; and vi) technological feasibility. *Social acceptability* can be understood as stakeholders' willingness to adapt, as well as the local population's acceptability of the measures taken. It is related to both cognitive and normative aspects (Jones and Boyd 2011), and is often strictly linked to psychological intrapersonal, interpersonal, and decision making factors (Gifford 2011). *Social feasibility* corresponds to the '*information and skills*' of Smit and Pilifosova (2001). It depends, for example, on local stakeholders' knowledge on and familiarity with the scientific research on climate change impacts for their region or with possible adaptation measures. It also depends on social capital and on the capability of local stakeholders to collaborate and create a participative process (Huang et al. 2011).

Economic feasibility portrays the possibility to act in relation to the company and to the communal, regional, and cantonal finances. It also depicts aid provided in the form e.g. of subsides. *Environmental feasibility* stands for the quality of the environment. This could include, for example, ecosystem resilience, geographic, and geological characteristics as well as future resources availability. *Institu-*

[50] Examples of other indicators used in similar studies can be found in ESPON 2013 (ESPON 2011) and in the MOVE project indicator database. http://www.gi4drr.org/move/move_query/. Last accessed 09.03.2012.

tional feasibility measures both the ability to make appropriate decisions and to implement them on the communal, cantonal, and national political level and also at the local tourism organizations level. It depends on institutional arrangements, institutional structures, and the strength of these institutions, as in the case of flexibility (e.g. existing policies) and the structure of the administration in place. It also depends on internal and external destination communication, such as communication among different partners in the region, with other regions confronted with similar problems or with experts. Berkhout et al. (2006) provide an interesting insight on adaptation in business organizations. In particular, they show that organizations enact routines that can be carried out repeatedly in response to recognized situations and that they match their available routines to the situations they face. They also show that changes to new situations take places either by repetition (learning by doing) or through a process of search and planned modification of routines to suit the new situation. Nonetheless, the organizations themselves often do not experience the stimuli, and the interpretation of signals frequently depends on the advice of external specialists who are not able to provide clear and definitive answers.

Finally, *technological feasibility* measures the capability to act and to adapt with the help of technologies, such as self-greening development, solutions for protective structures, or a dense transport network. Technological feasibility embraces therefore also the 'infrastructure' aspect cited by other authors (Engle and Lemos 2010). Lastly, we did not consider here equity (Smit and Pilifosova 2001), the equal access to resources, considering it to be homogeneous and very high in all the regions considered (e.g. all stakeholders have equal access to resources).

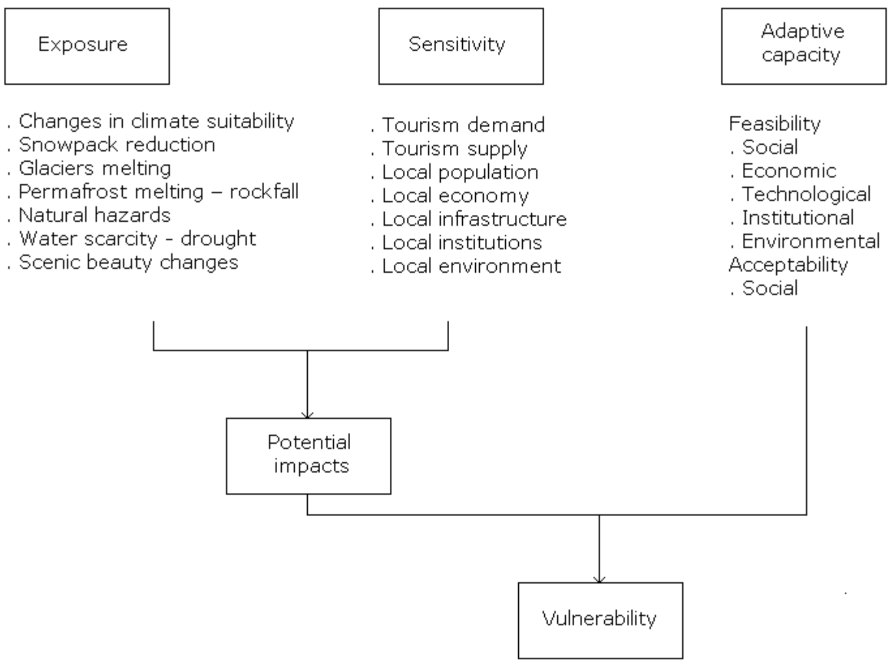


Figure 4.3: Vulnerability is made of three components: exposure, sensitivity, and adaptive capacity. These three categories can be split further into the families of indicators presented in the figure. Each of them contains various indicators.

4.4.2.1 Exposure-related indicators

Various climate impacts affecting Swiss tourism were depicted in the different studies carried out on the subject. After considering the published literature on climate change impacts, on vulnerability assessment (Brooks et al. 2005b; Perch-Nielsen 2008; Preston et al. 2008), and after considering the discussion with experts, and feedback from stakeholders, we selected a set of main climate change impacts considered to be of particular importance. It includes seven impacts, the ones we already presented in Section 2.3, together with the reason for their selection: (i) changes in climate suitability for tourism activities; (ii) snowpack reduction; (iii) glaciers melting; (iv) permafrost melting and rockfalls; (v) natural hazards; (vi) water scarcity and drought; and (vii) landscape changes and scenic beauty. For some impacts and for the time horizon considered, we considered the effects as beneficial (e.g. in relation to changes in climate suitability). These are noted in Table 4.1 with a (-). More information on the choice of the various indicators representing these impacts can be found in Annex A.3.

Table 4.1: The list of the 13 indicators depicting exposure. The sign (-) next to the indicator represents an impact bringing beneficial effects to the region. We then substracted the value from exposure and vulnerability. When no sign is given, the indicator implicitly increases exposure.

	Description of the indicator used	Quantitative data
Changes in climate suitability		
Changes in climate suitability for light outdoor activities 2011-2040 vs. control (1961-1990) (-)[51]	[Δ average pondered TCI score for spring, summer, and fall]	X
Share of mountainous area in the region (-)	[hectares/hectares tourism region]	X
Share of lakes in the region (-)	[meters of lake perimeter/hectares tourism region]	X
Snowpack reduction		
Share of the region located between the current and the future snow reliability line	[hectares/hectares tourism region]	X
Share of the region located above the future snow reliability line (-)	[hectares/hectares tourism region]	X
Glaciers melting		
Future glacier surface loss	[hectares/hectares tourism region]	X
Permafrost melting – rockfall		
Share of the region surface with potential permafrost melting	[hectares/hectares tourism region]	X
Natural hazards[52]		
Number of past natural hazards (1972-2007)	[number of past natural hazards/hectares tourism region]	X
Cost of past natural hazards (1972-2007)	[Mio CHF/hectares tourism region]	X
Cost on infrastructure of past natural hazards (1972-2007)	[Mio CHF/hectares tourism region]	X
Share of the region with 100-year flood probability	[hectares/hectares tourism region]	X
Water scarcity - drought		
Future water availability	[Δ mm/year 2021-2050 vs. 1980-2009]	X
Scenic beauty changes		

[51] More information on this indicator can be found in Annex A.1.
[52] The choice of the second and the third indicators describing natural hazards, namely the costs generated both on the whole and on infrastructure, is disputable, seeing that it partially encloses elements linked to sensitivity. Reasons for the choice of these proxies can be found in Annex A.3.

	Description of the indicator used	Quantitative data
Share of the region which will be conquered by forest because of climate change	[hectares/hectares tourism region]	X

4.4.2.2 Sensitivity-related indicators

As seen in Section 4.3.1, sensitivity refers to "*the degree to which a system is affected, either adversely or beneficially, by climate variability or change*". The effect may be direct or indirect (IPCC 2007b). It depends here on tourism structure, population, economy, infrastructure, institutions, and the environment (Figure 4.3, Table 4.2). For some indicators, quantitative data were not available. This is the case of the added value generated by tourism (for which values exist only at the Swiss level or for some regions), job seasonality, water availability, water storage capacity, and energy use. We then replaced the first indicator, perhaps one of the most relevant, by proxies (data on tourism demand and supply structure). For other data (the ones marked as 'qualitative' in Table 4.2), we collected information via the online survey presented in Section 3.1.3.3. However, we did not include in the vulnerability map results on water availability and financial health because of their low consistency. Concerning the energy use in destination in the tourism sector and current water storage capacity, the required data were currently not available. This prevented us from collecting a relevant aspect of vulnerability, but proxies could not be found. Moreover, it has been decided not to consider land use complexity because every result obtained with the available data would have been too approximate.

Table 4.2: The 40 selected indicators describing sensitivity. The sign (-) next to the indicator represents an element bringing beneficial effects to the region. We then substracted the value from sensitivity and vulnerability. When no sign is given, the indicator implicitly increases sensitivity and we therefore summed it. The ● denotes that we did finally not consider the indicator in the calculations because of inconsistencies. More information on the indicators can be found in Annex A.3.

		Quantitative data	Qualitative data	Missing data
Tourism demand				
Tourism intensity	[guest nights in hotels, health resorts,[53] and in the 'parahotel industry'[54]/inhabitants]	X		
Guest nights/one-day[55] tourists ratio				X
Length of the stay	[guest nights in hotels and health resorts/arrivals in hotels and health resorts]	X		
Skiers visits	[sum of skiers visits/hectares tourism region]	X		
Winter seasonality	[guest nights in hotels and health resorts in winter (DJF)/total guest nights in hotels and health resorts]	X		
Summer seasonality	[guest nights in hotels and health resorts in summer (JJA)/total guest nights in hotels and health resorts]	X		

[53] FSO statistics on guests' nights do not differentiate if these were spent in hotels or health resorts.
[54] The term 'parahotel industry' includes youth hostels, camping places, guest houses, and Bed and Breakfast establishments.
[55] One-day tourists are visitors that do not sleep in the region.

		Quantitative data	Qualitative data	Missing data
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry'	[guest nights/(number of bed-places*365)]	X		
International attractiveness (share of foreign tourists)	[guest nights of foreign tourists/total guest nights]	X		
Tourism supply				
Density of beds in hotels, health resorts, and in the 'parahotel industry' (warm beds)	[beds available/hectares tourism region]	X		
Tourism supply structure (big vs. small hotels and restaurants)	[(1*very small scale + 2* small scale + 3*medium scale + 4*big scale)/(total+1)]	X		
Secondary homes (cold beds)	[number of rooms in homes temporarily inhab-ited/total number of rooms in homes]	X		
Proximity to substitute ski destina-tions	[average number of ski resorts in a 25 km-radius]	X		
Length of activity of ski resorts	[average number of open days with at least 50 cm of snow on the upper part of the resort pondered on the capacity of the stations]	X		
Artificial snow production	[average km of slopes that can be potentially covered by artificially snow on a resort pon-dered on the capacity of the stations]	x		
Total capacity of ski domains locat-ed under the future snow-reliability line	[hourly flow rate/(altitude difference*hectares tourism region)*1000]	X		
Total capacity of ski domains locat-ed over the future snow-reliability line (-)	[hourly flow rate/(altitude difference*hectares tourism region)*1000]	X		
Length of infrastructure located on possible/probable permafrost melt-ing	[meters of length of infrastructure/hectares tourism region]	X		
Media and communication on snow conditions				X
Local population				
Density of resident population	[resident population/hectares tourism region]	X		
Share of the population born on place (collective knowledge on areas subject to natural hazards)	[people born on the same municipality/total number of inhabitants]	X		
Age structure (age-dependency ratio)	[(kids (<15 years) + elderly people (>64 years))/(people between 15 and 64 years old)*100]	X		
Local economy				
Share of jobs (full-time equivalents) in the hotel and catering sector	[jobs in the hotel and catering sector/total num-ber of jobs]	X		
Share of jobs (full-time equivalents) in the transportation sector	[jobs in the transportation sector/total number of jobs]	X		
Job seasonality				X
Share of jobs in the agriculture sector	[jobs in the agriculture sector/total of jobs]	X		

		Quantitative data	Qualitative data	Missing data
Average net income pro person in private dwellings	[average annual income per person in 10^3 CHF]	X		
Average financial health of municipalities	[from bad (1) to very good (5)][56]		●	
Average per capita cantonal income	[average annual per capita cantonal income in CHF]	X		
Local infrastructure				
Accessibility	[average minutes of travel from the nearest urban center (public transports and personal mobility) pondered on the population]	X		
Accessibility to services	[average meters of travel from nearest service pondered on the population]	X		
New or renovated buildings (after 1990)	[number of new or renovated buildings/total of buildings]	X		
Density of transport network (existence of replacement routes)	[log of kilometers of road and rail networks/hectares tourism region]	X		
Current water storage capacity				X
Energy use in destination in the tourism sector				X
Local institutions				
Left vs. right	[average score of a Principal Component Analysis (PCA) for the opposition left vs. right in federal votes]	X		
Ecologists vs. liberals	[average score of a PCA for the opposition ecologists vs. liberals in federal votes][57]	X		
Size of the municipalities - municipalities aggregation	[average number of inhabitants of the municipalities/total number of inhabitants of the region]	X		
Local environment				
Land use protection	[hectares of protected land/hectares tourism region]	X		
Landscape beauty	[from very attractive (1) to very unattractive (5)]		X	
Water availability	[from no problems (1) to very strong problems (3) in water availability]		●	

4.4.2.3 Adaptive capacity-related indicators

Adaptive capacity reflects the ability of the system to manage, and thereby reduce, gross vulnerability. It depends both on feasibility and acceptability and on social, economic, technological, institutional, and environmental aspects. Selected indicators are presented in Table 4.3. As stated before, quantitative information is sometimes not yet available or is missing. Information often exists, but is still too fragmentary and difficult to collect rigorously. We then decided to ask stakeholders for their perception. This is the case, for example, of indicators related to public participation, past adaptation action taken in the region, average financial health of municipalities, and subsidies. As before, we did not ultimately integrate all the qualitative data in the calculations because of low quality of the re-

[56] Data points are calculated for the main Swiss cities by the Swiss Graduate School of Public Administration (IDHEAP) institute. They are, however, not available for all Swiss municipalities (Soguel and Ziehli 2011).

[57] Some indicators are found both among sensitivity and adaptive capacity-related indicators (e.g. both results of the PCA on left vs. right and ecologists vs. liberals). For adaptive capacity they relate to the choices done before, for sensitivity to choices taken at the time horizon chosen.

sults obtained. We did then not include results on subsidies and on the average financial health of municipalities (Annex A.3). For other indicators, such as the possibility of self-green energy development actions in the region and the affiliation to an official tourism region, information is still lacking. However, these indicators of vulnerability were given only small weights by the experts in the MCA (Section 4.5.1).

Table 4.3: The selected indicators describing adaptive capacity. The ● sign denotes that we did not finally consider in the calculations the indicator. More information on the indicators can be found in Annex A.3.

		Quantitative data	Qualitative data	Missing data
Feasibility				
Social				
Existence of studies on climate change impacts for the region	[number of studies carried out in the region]	X		
Public participation actions in the region	[from frequent (1) to inexistent (3) public participation actions]		X	
Economic				
Average net income pro person in private dwellings	[average annual income per person in 10^3 CHF]	X		
Average financial health of municipalities	[from bad (1) to very good (5)]		●	
Average per capita cantonal income	[average annual per capita cantonal income in CHF]	X		
Subsidies	[from very (1) to not helpful (4) communal, cantonal, or federal subsidies]		●	
Technological				
Density of transport network (existence of replacement routes)	[log of km of rail and road networks/hectares tourism region]	X		
Possibility of self-green energy development				X
Institutional				
Past actions taken from the tourism sector in this direction	[number of actions cited pondered on the number of answers]		X	
Part of an official tourist region (Swiss tourism)				X
Destination communication				X
Left vs. right	[average score of a PCA for the opposition left vs. right in federal votes]	X		
Ecologists vs. liberals	[average score of a PCA for the opposition ecologists vs. liberals in federal votes]	X		
Environmental				
Land use protection	[hectares of protected land/hectares tourism region]	X		
Water availability	[from not existing (1) to very strong (6) risk of water scarcity and/or drought]	X		
Acceptability				
Social				
Political framework: results of a vote on right of appeal of organizations[58]	[negative votes/total of voting]	X		

[58] *«Droit de recours des organisations: Assez d'obstructionnisme - Plus de croissance pour la Suisse!»,* (Right of appeal of organizations: enough obstructionism - more growth for Switzerland!), 30.11.2008.

		Quantitative data	Qualitative data	Missing data
Past actions taken from the tourism sector in this direction	[number of actions pondered on the number of answers]		X	

4.4.3 The Multicriteria Analysis (MCA)

Even though we believe that all the 70 indicators carry important information, they certainly do not have the same importance in defining vulnerability. We shall let experts weigh them in a Multicriteria Analysis (MCA).

MCA is a participative method that was originally designed to help decision-makers investigate the different options to attain a specific goal. In vulnerability assessment, this method has the advantage of considering social, political, and environmental indicators that would otherwise be difficult to translate in monetary terms like in a cost-benefit analysis. Moreover, it has the advantage of being particularly reliable and quite precise in comparison with others (Thill 1999). In the context of this study we used the Pairwise Multicriteria Analysis developed by Saaty (1977) and Saaty (1987) in order to assess the relative importance of each indicator in depicting vulnerability. Concretely, the method developed by Saaty and Saaty consists in asking specialists, once the indicators have been chosen, to compare them pairwise and to weigh their relative importance on a scale from 1 to 9. With our 70 indicators, this would have meant 2 415 comparisons.

Because of the high number of indicators, and the subsequent high number of choices, we additionally selected the Analytic Hierarchy Process (AHP) (Annex A.7) (Saaty 1987). AHP is a general theory of measurement used in MCA, which decomposes the set of indicators into a hierarchy of more easily comprehended categories, each of which can be analyzed independently. We therefore broke down the pairwise comparisons into thematic categories between the 70 selected indicators, and classified them into 5 different levels. This generated 21 matrices and 204 pairwise comparisons (see Annexes A.8 - A.10).

We then performed a MCA by carrying out face-to-face interviews with 13 Swiss experts between January 18 and March 11, 2011.[59] We chose experts on these criteria: i) very good knowledge of Swiss Tourism; ii) good knowledge of climate change related topics; iii) working at the Swiss level (in order to obtain a general view of the situation and not a view restricted to the problems faced by a region); iv) working on the subject at the present time; and v) willing to participate. Care was also taken in selecting people from different horizons (e.g. scientists, tourism operators, directors and members of the administration of tourism- and nature-related corporations and organizations) in order to include different perspectives of the problem. We chose face-to-face interviews in order to better explain the method and the meaning of the indicators. This had however the disadvantage to let less time for reflection to the interviewed people. We therefore decided to send the list of indicators in advance to experts together with their explanation (Annex A.3), and to give them the possibility to comment and criticize this list.

Because of the high number of pairwise comparisons requested by the MCA, we asked each expert to fill only some of the matrices. We took care in ensuring that there were always at least 3-4 answers for each matrix in order to have a minimum variety of opinions. We checked the consistency of

[59] More information can be found in Annex A.9.

the results, and when necessary we asked experts to rethink and modify their results in order to avoid inconsistency (e.g. A > B > C > A). We considered results as consistent when we obtained a Consistency Ratio (CR) lower than 0.1 (Saaty 1987) (Annex A.7). When experts did not modify a matrix, we excluded it from the analysis.

4.4.4 The treatment and aggregation of the indicators

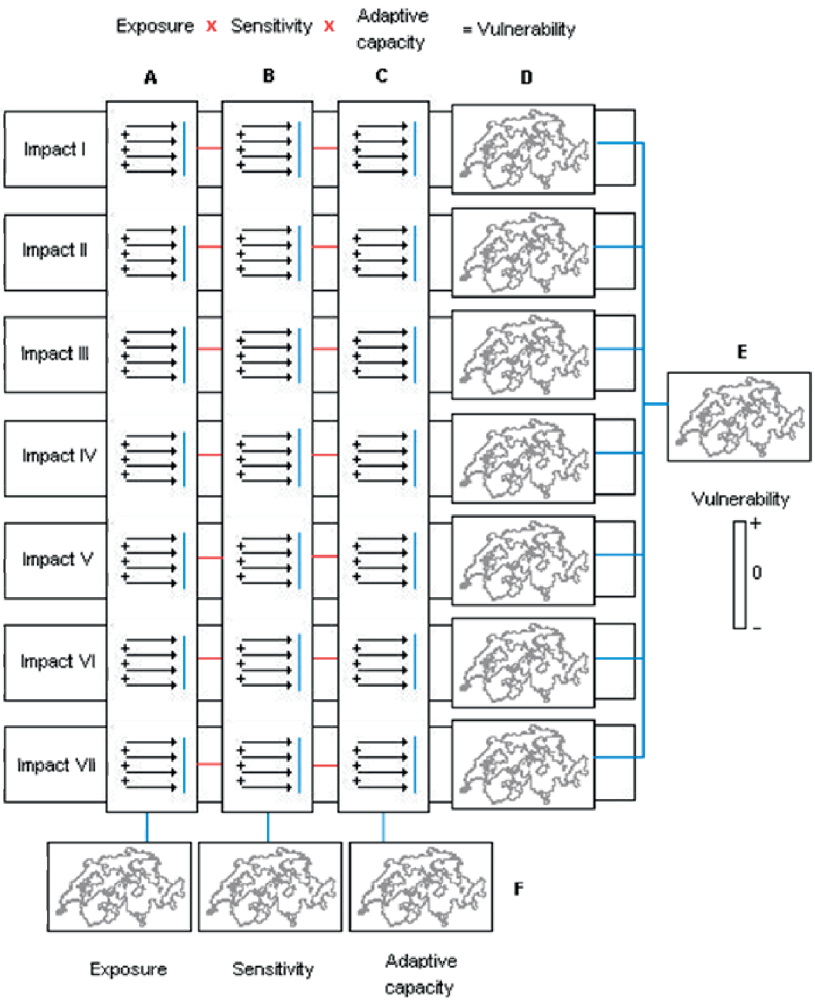


Figure 4.4: Conceptual model for assessing vulnerability. Indicators (arrows) are weighted and summed to create, respectively, a map of exposure (A), sensitivity (B), and adaptive capacity (C) for each impact. For each impact theses three maps are multiplied to obtain a vulnerability map (D). Each vulnerability map is weighted and summed to the other ones to develop the final map of general vulnerability of the tourism sector (E). The weighting and summing of the maps for respectively exposure, sensitivity, and, adaptive capacity of the 7 impacts gives the total value of these aspects (F). Red lines indicate multiplications and blue lines weighting and summing.

Once indicators were collected and their relative importance defined (Sections 4.4.2 and 4.4.3), we used GIS tools (ArcGIS 9.3) to treat and aggregate the information (Figure 4.4). We took inspiration from the methods developed by Preston et al. (2008) and Holsten and Kropp (2012). First, and in order to make indicators comparable among each other, each indicator I_i was rescaled on a scale from 0 to 10: 0 for the least exposed/sensitive/most able to adapt region among the 85 tourism region and 10 for the most exposed/sensitive/least able to adapt region. For intermediate results, Equation (3) was used. For indicators with negative exposure or sensitivity the scale ranged from -10 to 0.

$$I_{rescaled}= 10*(I_i-I_{min})/(I_{max}-I_{min}) \quad (3)$$

Then, for each indicator, we weighted the obtained score with the results of the MCA. We did not retain all the indicators for all the impacts. For example we used the indicator 'Infrastructure on permafrost at risk of melting' only for the assessment of 'Permafrost melting', or the indicator 'Transport capacity installed over the future snow reliability line' only for 'Snowpack reduction'.

We then calibrated the weights of the remaining indicators in consequence. More information can be found in Annex A.6. Next, we summed indicators to create components of vulnerability (A: exposure, B: sensitivity, and C: adaptive capacity in Figure 4.4) for each of the chosen impacts. As mentioned before, for exposure and sensitivity, regions can show either positive or negative values. We then multiplied the results thus obtained to create a vulnerability map for each of the seven impacts (changes in climate suitability for tourism activities, snowpack reduction, glaciers melting, etc.) (D). Next, we weighted these vulnerability maps by the importance of each impact and summed them in order to obtain a map of net vulnerability to climate change for Switzerland (E). In addition, we weighted and summed the seven impacts components of vulnerability for respectively exposure, sensitivity, and adaptive capacity, in order to obtain the total value of these components (F). Final we again rescaled scores (S_i) for (E) and (F) using Equation (4), this time considering negative values (after Holsten and Kropp (2012)) due to the fact that scores for the different regions can be either positive or negative (Figure 4.5):

$$S_{rescaled}= 10*S_i/|S_{max}| \quad (4)$$

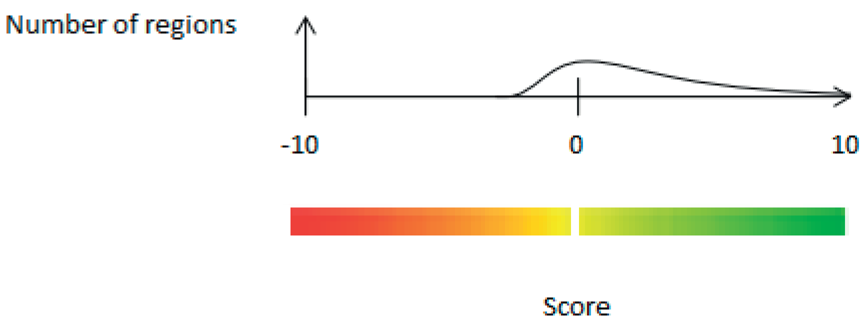


Figure 4.5: Rescaling procedure for vulnerability variables: schematic distribution of climatic changes over the regions (adapted from Holsen and Kropp (2012)).

When we used multiplication, we did so because of the non-substitutability of the three components of vulnerability. Vulnerable regions are regions that are highly exposed AND sensitive AND not able to adapt. Summing the three would have led little exposed region with concommitent low adaptive capacity to be considered as vulnerable (Figure 4.6). No region had negative values for both exposure and sensitivity, which could have led to absurd results.

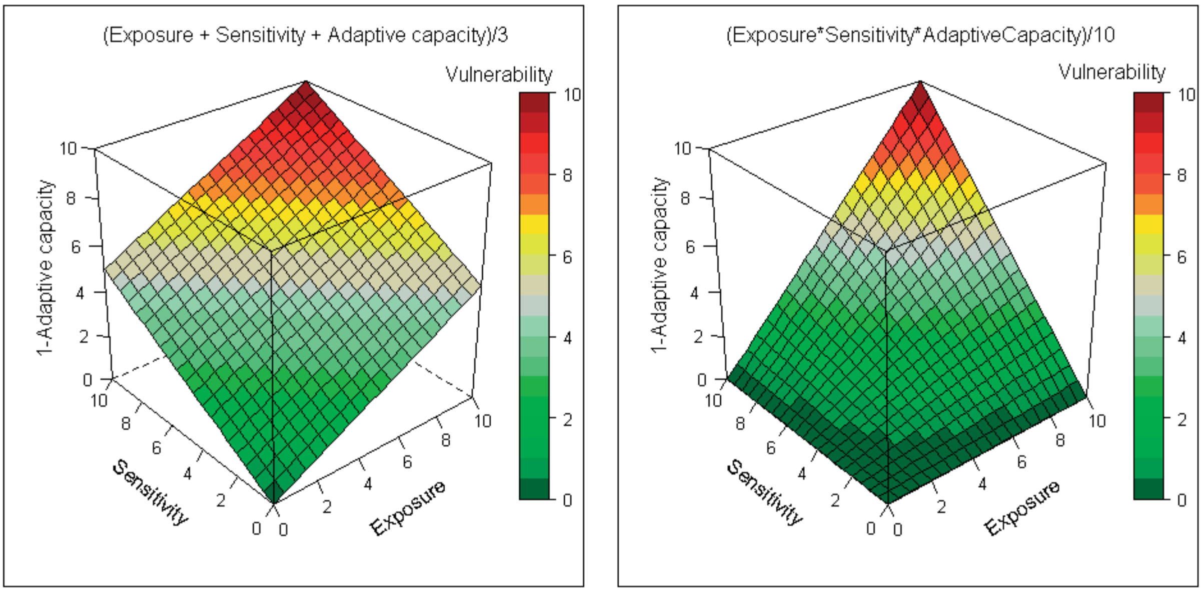


Figure 4.6: Representation of vulnerability as a function of exposure, sensitivity, and the inverse of adaptive capacity (with the three components possessing the same weight). The left box shows the result of averaging of the three factors, while the right box shows the result of multiplication. The greener the area, the lower and the redder the higher the vulnerability (adapted from Holsten and Kropp 2012). Only positive values of exposure and sensitivity are shown, even though sensitivity and exposure can also reduce vulnerability. The higher the score for the inverse of the adaptive capacity, the less the region is able to adapt.

4.4.5 Cluster analysis

Cluster analysis is a method that allows '*exploring data sets to assess whether or not they can be summarized meaningfully in terms of a relatively small number of groups or clusters of objects or individuals which resemble each other and which are different in some respects from individuals in other clusters'* (Everitt et al. 2011). In the context of this study, we used it in order to assess if and which regions have similarities concerning vulnerability. We performed a hierarchical cluster analysis using R v2. 11.1 (2010). The results are shown in Section 4.5.3.

4.4.6 Robustness analysis

During the MCA, only 13 experts could be interviewed. Moreover, not all filled all the matrices because of the high number of choices. As a consequence, some of the matrices received only 3-4 assessments and sometimes these went in different directions (Annex A.10). For the calculations of the vulnerability map, we took the average of these assessments. In order to analyze the strength of the results, we carried out a robustness[60] analysis by randomly choosing one of the answers for each of the 21 matrixes generated by the MCA analysis. We then carried out the calculation with the new obtained set of weights and recalculated the final vulnerability map. This was reiterated 100 times and displayed in a boxplot (Section 4.5.6).

[60] We use here the term 'Robustness' instead of 'Sensitivity' in order to avoid confusion with the homonym component of vulnerability.

4.5 Results

4.5.1 The most important drivers influencing vulnerability

Discussions with experts and the Multicriteria Analysis allowed us to establish the most important drivers influencing vulnerability based on their opinions (Figure 4.7, Table 4.4, and Annex A.10). Almost all of the people interviewed on the subject agreed in assigning the highest score to issues related to adaptive capacity (55/100), followed by sensitivity (29/100), and exposure (16/100). In the adaptive capacity category, acceptability clearly appeared to play the most important role (79/100 versus 21/100 for feasibility). In the feasibility sub-category, the economic (30/100) and the technological (23/100) aspects appeared to play the largest part. In the sensitivity group, the local environment (23/100) and institutions (20/100) obtained the highest scores, followed by tourism demand and supply (both 14/100), local infrastructure (13/100), population (9/100), and economy (7/100). In the exposure category, snowpack reduction received the highest score (25/100), followed by glaciers melting (17/100), water scarcity - drought (15/100), changes in climate suitability, natural hazards and scenic beauty (all 12/100), and finally permafrost melting - rockfall (7/100). Generally, two indicators, namely the past actions taken by the tourism sector in this direction (29/100) and the political framework (results of a 2008 vote related to the right of appeal of organizations) (14/100) (both in the adaptive capacity category) account for 43/100 of the total vulnerability score (Table 4.4). Other indicators followed with a far smaller grade. In experts' judgment, 24 indicators (over the 70) accounted for 80/100 of the score. We could have restricted ourselves to them, but nonetheless included all the indicators for which data were available.

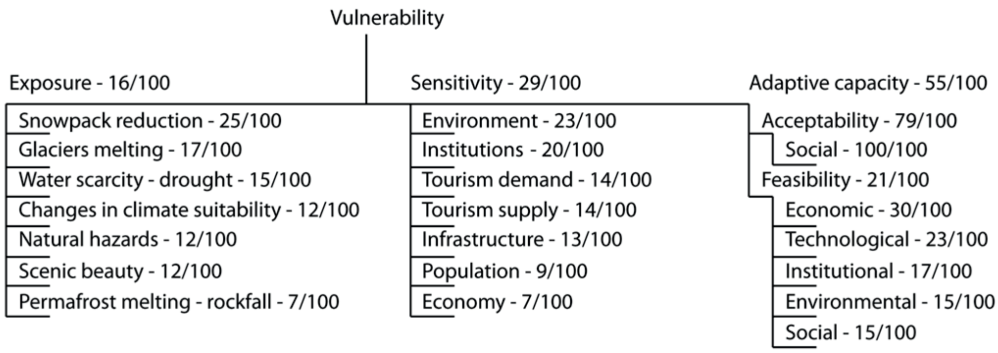


Figure 4.7: Scores generated by the MCA for the different families of indicators.

The experts tended to agree on the relative scores of exposure, sensitivity, and adaptive capacity and of the two components of adaptive capacity (feasibility and acceptability). They did, however, sometimes diverge in the other categories (Annex A.10). The robustness analysis presented in Section 4.4.6 allowed us to consider this point. Interestingly, scores are very similar to those found by Greiving in the Delphi analysis for the ESPON Climate - Climate Change and Territorial Effects on Regions and Local Economies project (Greiving 2010; ESPON 2011).[61]

[61] http://www.espon.eu/. Last accessed 30.12.2011. For the first round of the Delphi analysis: exposure 22/100; sensitivity: 28/100; adaptive capacity: 50/100. Sensitivity: environmental: 31/100; economic: 23/100; physical: 19/100; social: 16/100; cultural: 11/100. Adaptive capacity: technology: 24/100; knowledge and awareness: 22/100; economic resources: 20/100; institutions: 18/100; and infrastructure: 16/100.

Table 4.4: Scores obtained in the MCA. In square brackets, the score obtained by the family of indicators. Indicators for which data are missing are indicated by a star (*). The sign (-) next to an indicator represents an impact bringing beneficial effects to the region. This was then subtracted for vulnerability. When no sign is given, the indicator increases vulnerability.

Indicator		Score [/100]
Exposure		
Changes in climate suitability [1.92]		
	Changes in climate suitability for light outdoor activities 2011-2040 vs control (1961-1990) (-)	0.54
	Share of mountainous area in the region (-)	1.11
	Share of lakes in the region (-)	0.27
Snowpack reduction [4.11]		
	Share of the region located between the current and the future snow reliability line	2.20
	Share of the region located above the future snow reliability line (-)	1.91
Glaciers melting [2.85]		
	Future glacier surface loss	2.85
Permafrost melting – rockfall [1.15]		
	Share of the region surface with potential permafrost melting	1.15
Natural hazards [1.94]		
	Number of past natural hazards (1972-2007)	0.33
	Cost of past natural hazards (1972-2007)	0.72
	Cost on infrastructure of past natural hazards (1972-2007)	0.55
	Share of the region with 100-year flood probability	0.34
Water scarcity - drought [2.55]		
	Future water availability	2.55
Scenic beauty changes [1.96]		
	Share of the region which will be conquered by forest because of climate change	1.96
Sensitivity		
Tourism demand [4.00]		
	Tourism intensity	0.35
	Guest nights/one-day tourists ratio	0.40 (*)
	Length of the stay	0.36
	Skiers visits	0.72
	Winter seasonality	0.84
	Summer seasonality	0.39
	Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry'	0.66
	International attractiveness (share of foreign tourists)	0.28
Tourism supply [4.00]		
	Density of beds in hotels, health resorts, and in the ‘parahotel industry' (warm beds)	0.35
	Tourism supply structure (big vs. small hotels and restaurants)	0.30
	Secondary homes (cold beds)	0.21
	Proximity to substitute ski destinations	0.24
	Length of activity of ski resorts	0.36
	Artificial snow production	0.40
	Total capacity of ski domains located under the future snow-reliability line	0.60
	Total capacity of ski domains located over the future snow-reliability line (-)	0.42
	Length of infrastructure located on possible/probable permafrost melting	0.40
	Media and communication on snow conditions	0.72 (*)
Local population [2.62]		

Indicator		Score [/100]
	Density of resident population	0.89
	Share of the population born on place (collective knowledge on areas subject to natural hazards)	1.32
	Age structure (age-dependency ratio)	0.41
Local economy [2.29]		
	Share of jobs (full-time equivalents) in the hotel and catering sector	0.15
	Share of jobs (full-time equivalents) in the transportation sector	0.12
	Job seasonality	0.27 (*)
	Share of jobs in the agriculture sector	0.17
	Average net income pro person in private dwellings	0.44
	Average financial health of municipalities	0.67
	Average per capita cantonal income	0.47
Local infrastructure [3.75]		
	Accessibility	0.44
	Accessibility to services	0.47
	New or renovated buildings (after 1990)	0.59
	Density of transport network (existence of replacement routes)	0.71
	Current water storage capacity	0.70
	Energy use in destination in the tourism sector	0.84 (*)
Local institutions[5.61]		
	Left vs. right	1.27
	Ecologists vs. liberals	2.00
	Size of the municipalities - municipalities aggregation	2.34
Local environment [6.51]		
	Land use protection	1.37
	Landscape beauty	2.73
	Water availability	2.41
Adaptive capacity		
Feasibility		
Social [1.71]		
	Existence of studies on climate change impacts for the region	0.30
	Public participation actions in the region	1.41
Economic [3.43]		
	Average net income pro person in private dwellings	0.30
	Average financial health of municipalities	1.41
	Average per capita cantonal income	0.49
	Subsidies	1.23
Technological [2.63]		
	Density of transport network (existence of replacement routes)	1.83
	Possibility of self-green energy development	0.80 (*)
Institutional [1.87]		
	Past actions taken from the tourism sector in this direction	0.30
	Part of an official tourist region (Swiss tourism)	0.29 (*)
	Destination communication	0.41 (*)
	Left vs. right	0.30
	Ecologists vs. liberals	0.57
Environmental [1.75]		
	Land use protection	0.43
	Water availability	1.32

Indicator	Score [/100]
Acceptability	
Social [43.32]	
Political framework: results of a vote on right of appeal of organizations	14.44
Past actions taken from the tourism sector in this direction	28.88

4.5.2 Spatial heterogeneity in vulnerability

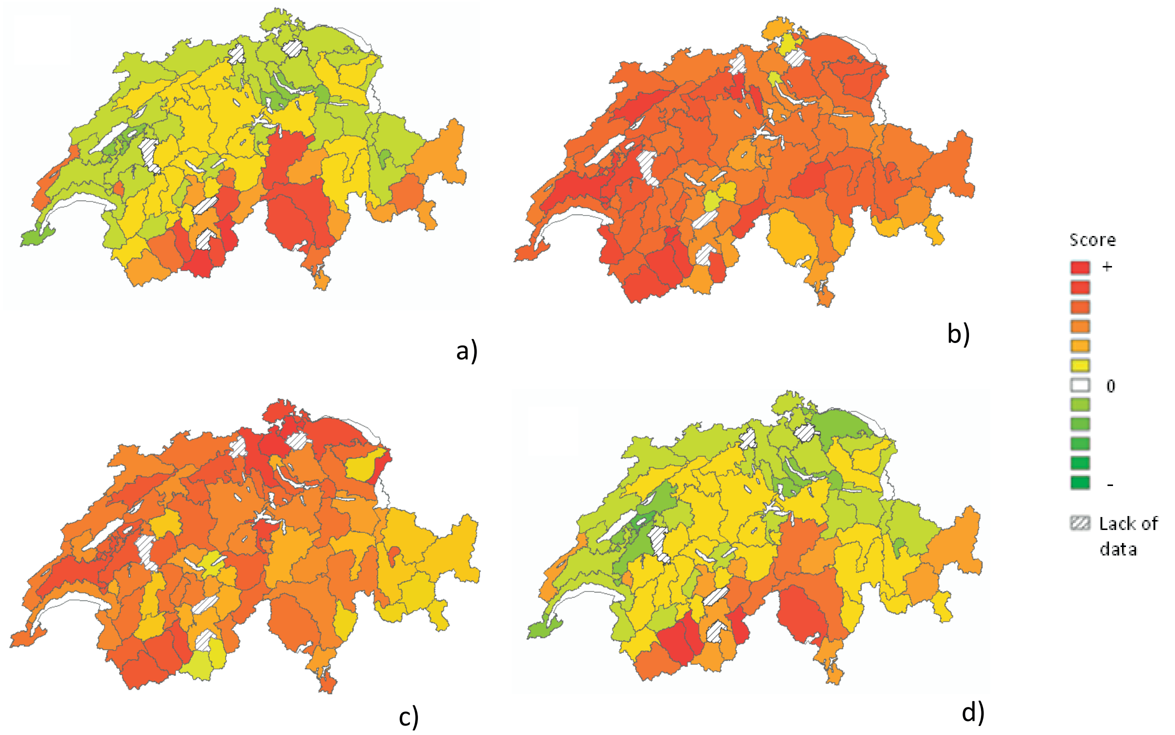


Figure 4.8: Representation of a) exposure, b) sensitivity, c) adaptive capacity, and d) vulnerability of the 85 regions analyzed for the 2030-2050 time horizon. The higher the score (and redder the region), the higher the exposure, the sensitivity, and the vulnerability and the lower the adaptive capacity. The lower and more negative the score, the greener the region. Hatched areas indicate regions with lack of data. Maps refer to the aggregation levels F and E presented in Figure 4.4.

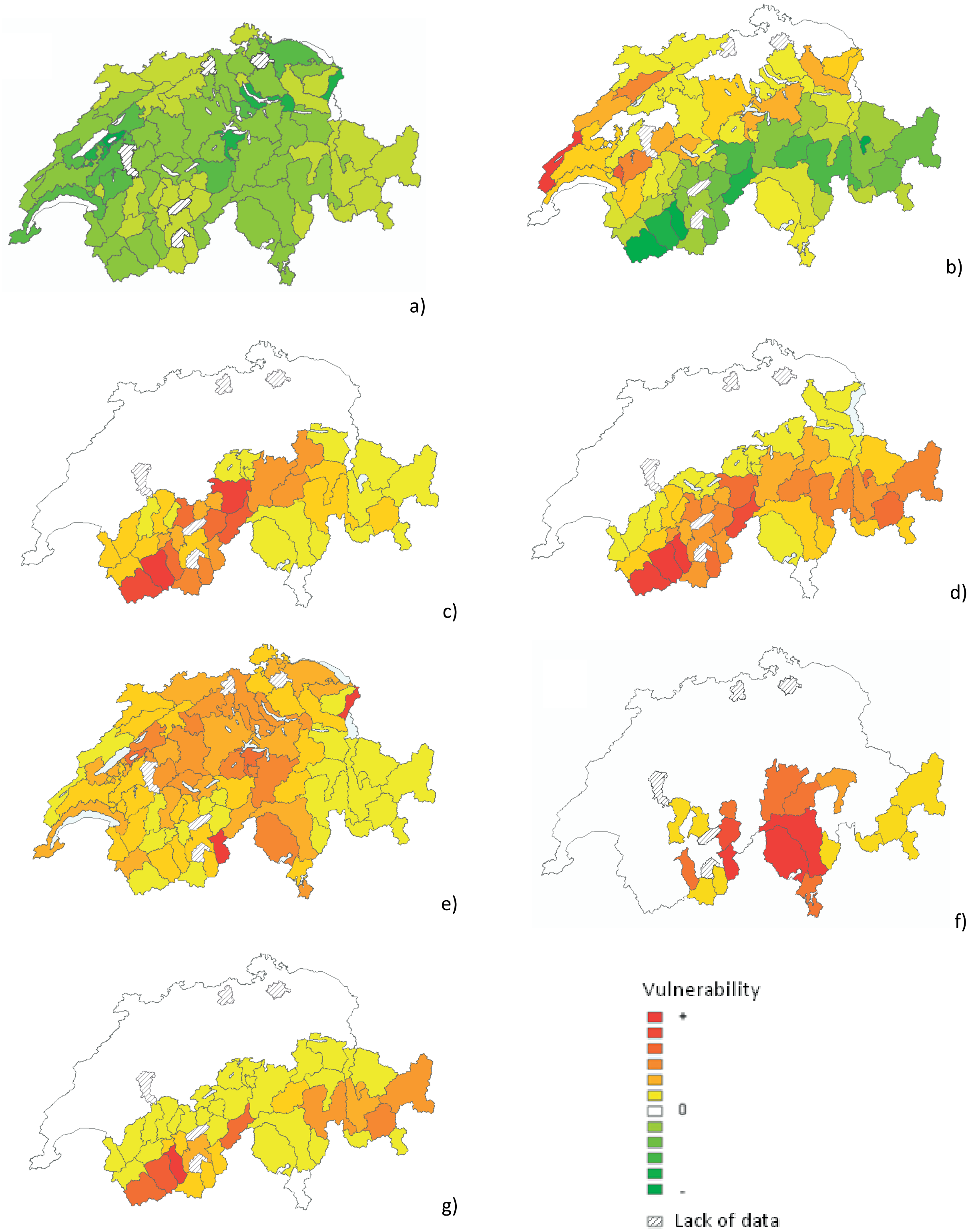


Figure 4.9: Representation of vulnerability at the 2030-2050 horizon due to a) changes in climate suitability for tourism activities, b) snowpack reduction, c) glaciers melting, d) permafrost melting - rockfall, e) natural hazards, f) water scarcity – drought, g) scenic beauty changes. The redder the region, the more vulnerable; the greener the region, the more it will presumably benefit from the impact. Hatched areas indicate regions with lack of data, white areas, regions with nul vulnerability. Maps refer to the aggregation level D presented in Figure 4.4.

Alpine region and in particular the territory located at high-elevations in Valais, Ticino, and Uri appeared to be most exposed. Brig - Belalp, Zermatt Matterhorn, Lake Maggiore and Valleys, and Aletsch came out as the four most exposed regions. This is mainly due to the combination of future glacier surface loss, increased water scarcity and drought, changes in scenic beauty, and potential permafrost melting. Also regions at mid-elevation like The Pre-Alps - Les Paccots, and the Lake Geneva Region - Jura appeared to be particularly affected. This is primarily due to snowpack reduction. Other regions, such as the Region of Lake Murten, the Lakes Region, Zürichsee, the Geneva, and the Zug regions appeared to be less affected by these changes due mainly to their relatively good climate suitability for tourism activities (with the presence of lakes and their relative attractiveness during heat days) and the inexistence of typically mountainous impacts (glaciers and permafrost melting for example).

With regards to sensitivity, the Valais regions (Crans-Montana, Sierre - Anniviers, Sion Region - Les 4 vallées and Evolène, les Portes du Soleil - Chablais), the countryside of the Lake Geneva, the Mittelland II, and the Jura Bernois appeared to be among the most sensitive, as seen in Figure 4.8.b. Reasons are mainly due to a combination of various aspects of the local environment, institutions and tourism structure. Less sensitive regions are Wengen-Mürren-Lauterbrunnental, Zurich, and the Zürcher Weinland.

In relation to adaptive capacity, the region between Zurich and Schaffhausen but without enclosing Zurich (Zürcher Weinland, Züri-Unterland, Zurich Mittelland, SchaffauserLand, Thurgau - Bodensee), the Rheintal, the canton of Nidwalden, the countryside behind the Lake Geneva region (Lake Geneva Region - Countryside and Region of Lake Murten), and lower and central Valais (Sierre - Anniviers) get the lowest scores (Figure 4.8.c). Reasons are primarily due to the fact that in these regions adaptation in relation to tourism has not been undertaken in the past (which is not surprising, considering that they are mostly not affected by climate change and/or dependent on tourism). Higher adaptive capacity was on the other hand attributed to Zermatt Matterhorn, Saas-Fee/Saastal, and Interlaken, where much has already been done in the past in this direction.

Looking at the vulnerability for the different impacts, it appears that the greatest beneficiaries for the 2030-2050 time horizon due to changes in climate suitability for tourism activities should be the Region of Lake Murten, the Zürichsee, Nidwalden, the Lakes Region, and the Rheintal (Figure 4.9.a). In relation to snowpack reduction, Lake Geneva Region - Jura appears to be the most vulnerable region. It is followed by The Pre-Alps - Les Paccots, The Pre-Alps - Gruyères - Moléson, and the Jura Bernois. Four regions stand to benefit from changes in snowpack: the Central Graubünden - Arosa, Verbier St-Bernard, Sierre - Anniviers, and Sion Region - Les 4 vallées et Evolène (Figure 4.9.b). This last region appears, however, to be the most vulnerable to glaciers melting, followed by Haslital, Verbier St-Bernard, Goms, the Ferienregion Lötschberg, and Aletsch (Figure 4.9.c). Sierre - Anniviers is the most vulnerable to permafrost melting, followed by Sion Region - Les 4 vallées et Evolène, Verbier St-Bernard, and Goms (Figure 4.9.d). When considering natural hazards, the most vulnerable regions are Brig - Belalp and the Rheintal (Figure 4.9.e). In relation to the increased water scarcity and drought, it is mainly the northern part of Ticino (Lake Maggiore and Valleys, Bellinzona and Northern Ticino), Brig - Belalp, and Aletsch that appear to be most affected on the 2030-2050 time horizon. Others regions, mainly in the North, get more runoff at this time horizon (Figure 4.9.f). Finally, in relation to changes in scenic beauty, Sierre - Anniviers stands out once again as one of the most vulnerable, followed again by Sion Region - Les 4 vallées et Evolène, Goms, and Verbier St-Bernard (Figure 4.9.g).

In relation to the combination of the vulnerability for these seven impacts (Figure 4.8.d), it appeared that the most vulnerable regions are located in the Valais Canton: Sierre - Anniviers, Brig - Belalp, and Sion Region - Les 4 vallées et Evolène are the three tourism regions that obtained the highest vulnerability scores. They are followed by Lake Maggiore and Valleys, Bellinzona and Northern Ticino, and Aletsch. On the other hand, Saas-Fee/Saastal, Zermatt Matterhorn, and Engadin St. Moritz (which were among the most exposed) rank only after those regions. Their vulnerability is reduced by their low sensitivity and/or high adaptive capacity.

The regions with the strongest negative vulnerability, i.e which could benefit the most from climate change until 2030-2050, are mainly the lake regions (Region of Lake Murten, The Lakes Region, Zürichsee, Geneva Region) and Central Graubünden - Arosa. This last one is less affected than other regions; its vulnerability mainly relates to permafrost melting and changes in scenic beauty. It should be noted that for some regions we could not carry out calculations due to the lack of information. These are the Brugg Region, Grächen-St. Niklaus, Lauchernalp - Lötschental, the Pre-Alps - Schwarzsee, and Winterthur and its region for which information on landscape beauty and public participation actions could not be collected during the survey. General scores can be found in the wiki (Annex A.18).

4.5.3 Similarities among regions

The cluster analysis presented in Section 4.4.5 allowed for the assessment of similarities among regions. Clustering was made in relation to exposure, sensitivity, adaptive capacity, and vulnerability (Figure 4.10; Annex A.11). We made cuts respectively at a value of the root of 15, 25, 13, and 30, generating respectively 4, 6, 6, and 6 clusters. We gave the same weight to all indicators.[62]

For exposure, classes retrace altitudinal regions, with clusters grouping low, middle and high areas. One cluster additionally groups Brig - Belalp and Uri. Roughly speaking, the first cluster (in white in Figure 4.10.a) groups regions that are not negatively exposed by climate change, the second groups regions mainly affected by snowpack reduction (light green), the third (green) groups regions affected by glaciers and permafrost melting and changes in scenic beauty. The last one (dark green) additionally groups regions particularly exposed to natural hazards and in particular regions that encountered high past costs on infrastructure due to the natural hazards (see for a comparison the maps depicting the various impacts in Annex A.5).

The clustering relative to sensitivity groups regions showing similar tourism structures (Figure 4.10.b). Regions are depicted in white where tourism demand and supply are not so relevant. In light orange are regions which depend on tourism and in which supply is found. In orange, we have regions in which demand is particularly high. There is an additional cluster which groups important alpine ski domains such as Zermatt Matterhorn, Saas-Fee/Saastal, Grindelwald, Wengen-Mürren-Lauterbrunnental, Central Graubünden - Arosa, and Engadin St. Moritz (red). Moreover, a last cluster is formed by Zurich (light brown).

In the adaptive capacity clustering (Figure 4.10.c), distinctions appeared among the Northern, Southern, Eastern and Western parts of the country. The clear origin of this subdivision was however difficult to define, and could be partly due to institutional and social characteristics depicted by both the

[62] As a result, the clustering is clearly influenced by the number of indicators chosen to depict the various families (e.g. 18 indicators on the 40 chosen to describe sensitivity are related either to tourism supply or demand).

average scores of the PCA (e.g. ecologists vs. liberals) and the political context represented by the results of the vote on the right of appeal of organizations.

Finally, the vulnerability cluster map (Figure 4.10.d) showed differences among Northern Switzerland (white), the Jura, Plateau, and the Prealps (light purple), the Eastern and Western- (light yellow), the Central- (pink), and the Southern Alps (light pink). Moreover, a sixth cluster includes Verbier St-Bernard, Saas-Fee/Saastal, Grindelwald, Wengen-Mürren-Lauterbrunnental, and Engadin St. Moritz (deep purple). These five tourism regions enclose important tourism domains. Northern Switzerland, on the contary, encloses regions least affected by climate change both because of their little exposure and little dependence on tourism.

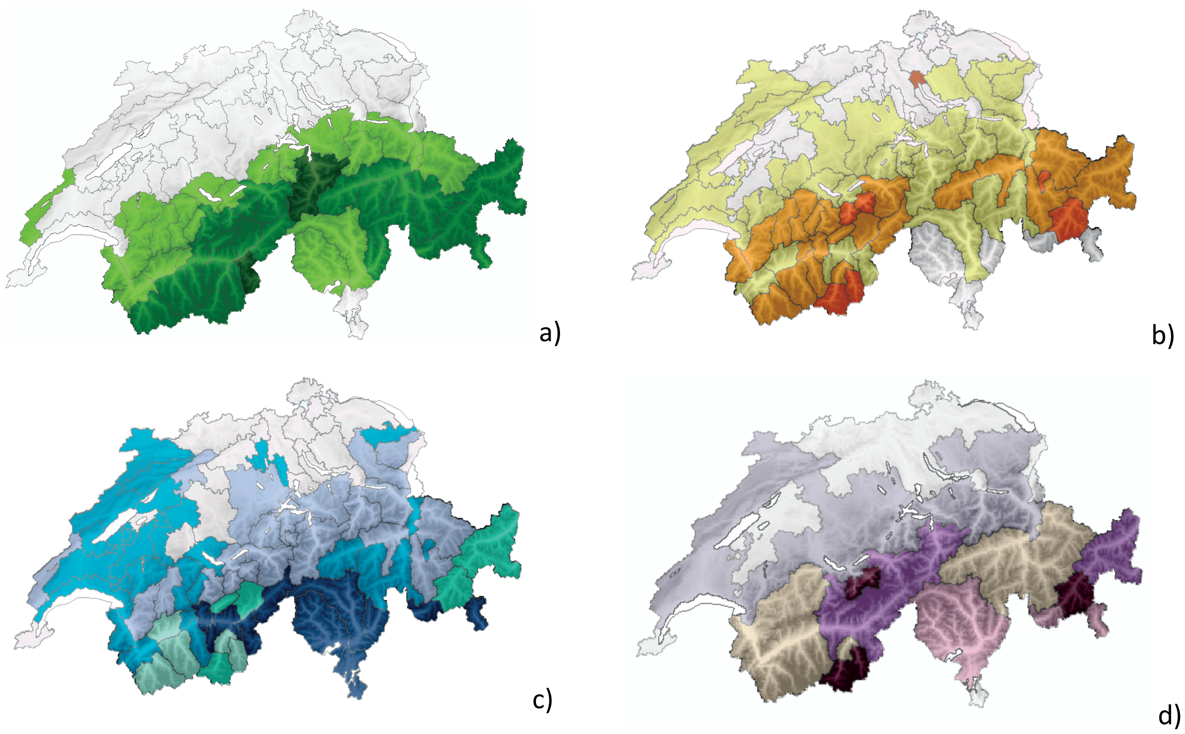


Figure 4.10: Result of the cluster analysis: for exposure (a) with 4 clusters and for sensitivity (b), adaptive capacity (c), and vulnerability (d) with 6 clusters.

4.5.4 Hotspots – regions in which the implementation of adaptation measures is more crucial

Figure 4.11: Hotspots of vulnerability with respectively in light and dark grey the ninth and the tenth decile of the vulnerability distribution. Hatched areas indicate regions with lack of data.

We defined strong and very strong focal areas of vulnerability as respectively the ninth and the tenth deciles of the vulnerability distribution among the regions (Figure 4.11). As mentioned in Section 4.5.2, Sierre - Anniviers and Brig - Belalp are the two tourism regions that obtained the highest vulnerability scores. Sion Region - Les 4 vallées et Evolène appears also particularly vulnerable.

4.5.5 Data gaps and fields where more research should be carried out

Data gaps indicate to researchers where more investigation should be carried out or where more information should be gathered. As mentioned previously, not all the indicators could be described quantitatively. Among the 70 indicators selected, quantitative data were not available for 16 of them. Of these lacking indicators, some would require greater means of collection (e.g. past actions taken from the tourism sector in this direction, public participation actions in the region, media and communication on snow condition, current water storage capacity), while for some this would be necessary but unfeasible (missing statistical data on e.g. guest nights/one-day tourists ratio, job seasonality, average financial health of municipalities, as also on the added value generated by tourism).

Concerning the added value generated by tourism, this would have perhaps been the most needed information in relation to sensitivity[63] that was missing. At the moment, however, only general information for Switzerland and some cantons exists (Rütter 1991; Zegg et al. 1993; Rütter et al. 1995; Rütter et al. 2001; Rütter et al. 2004; Berwert and Mehr 2007; Rütter-Fischbacher and Höchli 2010;

[63] This indicator was not included in the analysis, data existing only for some regions. It was replaced by proxies: e.g. tourism intensity, length of the stay, and skier's visits.

Höchli and Rütter-Fischbacher 2011). Finally, some indicators were difficult to quantify (like the possibility of autonomous green energy development and landscape beauty). All of them, however, carry significant information in defining vulnerability.

Quantitative data was missing mostly where experts gave the most importance. Considering the weights given to each indicator, quantitative information was lacking for 66% of adaptive capacity and 30% of sensitivity. No data were missing for exposure. Quantitative data gaps in the sensitivity category mainly involved the environment (79%), the economy (41%), and the infrastructure (41%), whereas regarding adaptive capacity, only technological and institutional feasibility seem to be fairly well depicted. The online survey allowed us to gather data in relation in particular to adaptive capacity (e.g. past actions taken from the tourism sector in this direction, average financial health of municipalities, public participation actions in the region, and water availability). The survey and the subsequent gathering of qualitative data would have allowed us to reduce the data gap from the initial 45% to only 4% of the total. However, due to the exclusion of inconsistent data, 10% of the information was not covered.

4.5.6 Robustness analysis

In order to check the robustness of the results, we calculated new weights by randomly recombining (N=100) answers given by the different experts in the MCA. We then used these to generate new values of vulnerability for the 85 tourism regions. In Figure 4.12, a boxplot of the results is presented. The red bars represent the final results obtained with the vulnerability map.

The figure shows that lowland regions around lakes often appear to slightly benefit from the situation. On the other hand, quartiles for regions such as Sierre – Anniviers, the Sion Region - Les 4 vallées and Evolène, Lake Maggiore and Valleys, Brig – Belalp, Aletsch, Bellinzona and Northern Ticino always show high levels of vulnerability. For these regions our results (red horizontal lines) lie within the whiskers and they perhaps magnify the negative impacts brought by climate change. The variability of the results for the different regions was sometimes high (e.g. Adelboden, Central Graubünden - Arosa, Glarnerland, Haslital, and Nidwalden). The results very often encompassed both positive and negative values. This was due mainly to the high variability of experts' responses concerning the relative weights of the seven impacts (see Annex A.10). For instance, three out of five experts gave a high weight to snowpack reduction. The two remaining experts, on the other hand, defined glaciers melting/water scarcity and changes in scenic beauty and climate suitability as more relevant. Therefore, when snowpack reduction was taken as the most relevant impact, regions such as Nidwalden or The Pre-Alps - Gruyères - Moléson were particularly vulnerable whereas Central Graubünden - Arosa or Haslital (which lie in areas which will benefit from this impact) appeared well-off. On the other hand, when impacts like glaciers melting and changes in scenic beauty were given more importance, the latter two regions were particularly vulnerable, whereas the first ones showed almost no vulnerability. In the same way, lowlands like the Zürcher Oberland, the Zürcher Weinland, or the Züri-Unterland showed little variation because these regions generally show little exposure to all of the six negative impacts considered.

On the other hand, answers related to the relative importance of exposure, sensitivity, and adaptive capacity in addition to feasibility and acceptability in adaptive capacity were quite similar among the different experts, which increased the consistency and robustness of the results. In addition, our calculations were near the median and can therefore be considered as robust.

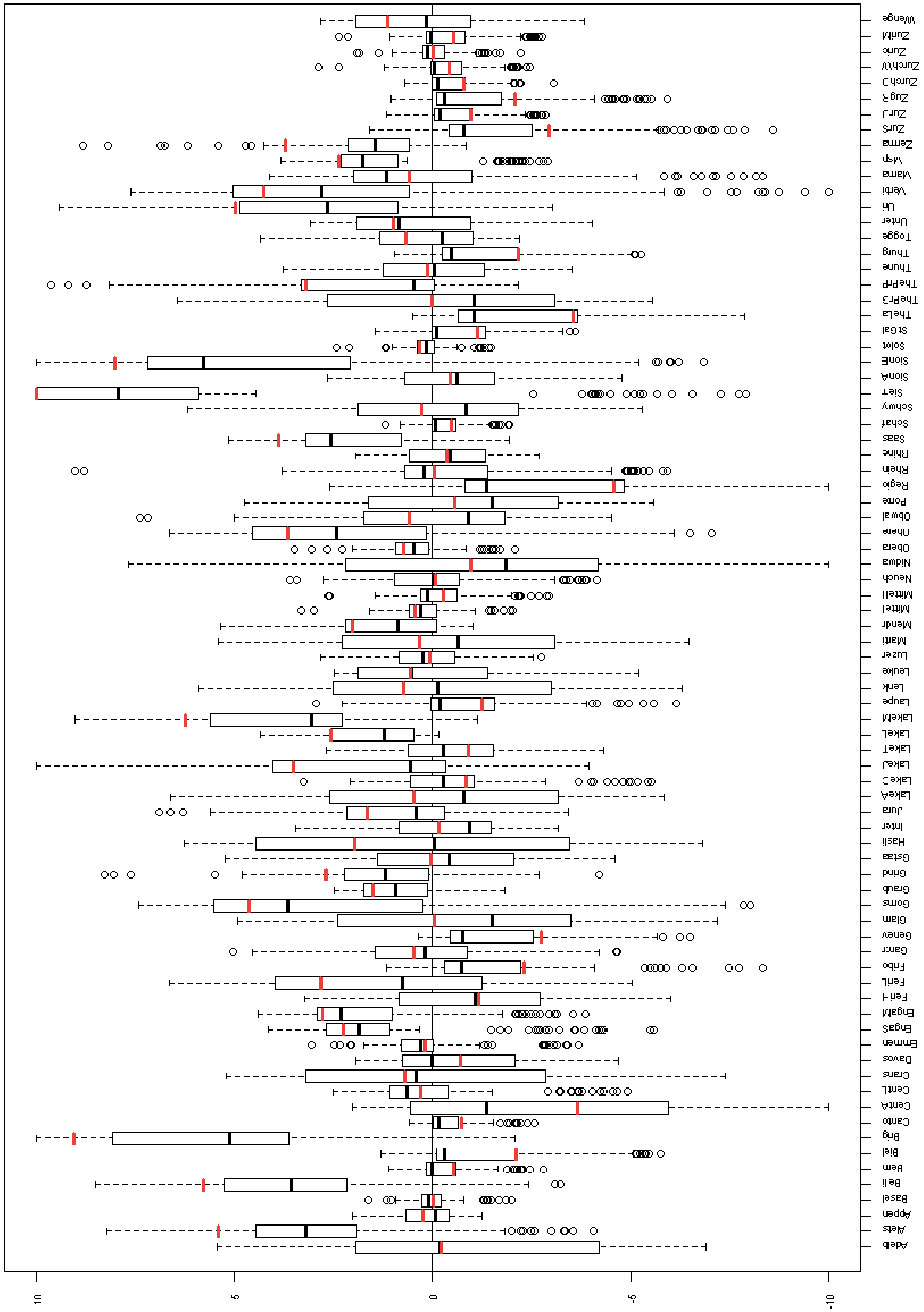


Figure 4.12: Boxplot representing the results of the total vulnerability after randomly recombining the matrices generated during the MCA (N=100). Boxes denote lower and upper quartiles and have notches at the medians. Maximum whisker length is 1.5 times the interquartile range. Outliers are shown with points. In red, the results obtained during the vulnerability mapping. In dark grey the 0 line. Adelb: Adelboden; Alets: Aletsch; Appen: Appenzellerland; Basel: Basel Region; Belli: Bellinzona and Northern Ticino; Bern: Bern; Biel: Biel/Bienne Seeland; Brig: Brig - Belalp; Canto: Canton of Jura; CentA: Central Graubünden - Arosa; CentL: Central Graubünden - Lenzerheide, Savognin, Bergün; Crans: Crans-Montana; Davos: Davos Kloster, Prättigau; Emmen: Emmental; EngaS: Engadin Scuol; EngaM: Engadin St. Moritz; FeriH: Ferienregion Heidiland; FeriL: Ferienregion Lötschberg; Fribo: Fribourg and the Centre; Gantr: Gantrisch Region; Genev: Geneva Region; Glarn: Glarnerland; Goms: Goms; Graub: Graubünden - Italian-speaking area; Grind: Grindelwald; Gstaa: Gstaad-Saanenland; Hasli: Haslital; Inter: Interlaken; Jura: Jura Bernois; LakeA: Lake Geneva Region - Alps; LakeC: Lake Geneva Region - Countryside; LakeJ: Lake Geneva Region - Jura; LakeT: Lake Geneva Region - Towns and Lakes; LakeL: Lake Lugano; LakeM: Lake Maggiore and Valleys; Laupe: Laupen Region; Lenk: Lenk - Simmental; Leuke: Leukerbad; Luzer: Luzern Region; Marti: Martigny Region; Mendr: Mendrisiotto; MitteI: Mittelland I; MitteII: Mittelland II; Neuch: Neuchâtel; Nidwa: Nidwalden; Obera: Oberaargau; Obere: Obere Surselva; Obwal: Obwalden; Porte: Portes du Soleil - Chablais; Regio: Region of Lake Murten; Rhein: Rheintal; Rhine: Rhine Valley, Bündner Herrschaft, Chur; Saas: Saas-Fee/Saastal; Schaf: SchaffauserLand; Schwy: Schwyz; Sierr: Sierre - Anniviers; SionA: Sion Region - Anzère; SionE: Sion Region - Les 4 vallées et Evolène; Solot: Solothurn and Region; StGal: St. Gallen - Bodensee; TheLa: The Lakes Region; ThePrG: The Pre-Alps - Gruyères - Moléson; ThePrP: The Pre-Alps - Les Paccots; Thune: Thunersee; Thurg: Thurgau - Bodensee; Togge: Toggenburg; Unter: Untere Surselva; Uri: Uri; Verbi: Verbier St-Bernard; Viama: Viamala; Visp: Visp Region; Zerma: Zermatt Matterhorn; ZurS: Zuerichsee; ZurU: Zueri-Unterland; ZugR: Zug Region; ZurchO: Zürcher Oberland; ZurchW: Zürcher Weinland; Zuric: Zurich; ZuriM: Zurich Mittelland; Wenge: Wengen-Mürren-Lauterbrunnental.

4.5.7 Stakeholders' perceptions of the potential impacts of climate change and the vulnerability of tourism in the region

In order to analyze differences between calculations and perceptions, we compare the results of the vulnerability map to the stakeholders' opinions on potential impacts and vulnerability in their region gathered with the online survey already presented in Section 3.1.3.3. 566 Swiss stakeholders replied to the enquiry. We compared the results of the MCA and the relative importance given by stakeholders to the three aspects determining vulnerability: exposure, sensitivity, and adaptive capacity. Hereafter (Sections 4.5.7.1 and 4.5.7.2), we first present the general results of the survey. We then present the results at the regional level and the differences with the calculated maps (Sections 4.5.7.3 and 4.5.7.4).

4.5.7.1 General perception of potential impacts, adaptive capacity, and vulnerability

In the first question, we asked stakeholders to define the severity of climate change at the global scale and for tourism in their region. We did this for both the present and for a 2030-2050 time horizon. Answers showed that climate change was seen by the majority of respondents as already causing global problems today: 48% of respondents agreed and 33% even strongly agreed with this assertion, *versus* respectively 4% and 3% who disagreed and strongly disagreed (Figure 4.13). The proportion was bigger concerning future impacts (2030-2050). Here 36% agreed and 48% strongly agreed with the assumption that climate change will lead to global problems in the future, *versus* 3% and 2% that disagreed or strongly disagreed.

Potential impacts are felt as important, but perhaps somewhat less pressing, at the local level and concerning tourism. To the question whether impacts of climate change are already causing problems in the tourism sector in their own region, 32% of the respondents agreed and 13% strongly agreed, whereas 23% disagreed and 5% strongly disagreed. Impacts are perceived as more important in the future: 34% of the respondents agreed and 28% strongly agreed with the assumption that the impacts of climate change will lead to problems in the tourism sector in their region against respectively 10% and 4% who disagreed or strongly disagreed.[64]

[64] In an phone survey (Univox 2011) conducted in the same period among Swiss citizens (Section 3.1.3.2) 53% of the respondents agreed that climate change will generally have impacts in the country and that measures should be taken now to address them, 37% agreed that some impacts will take place, but these will not be serious, and 5% that no impacts will be perceived even in the future.

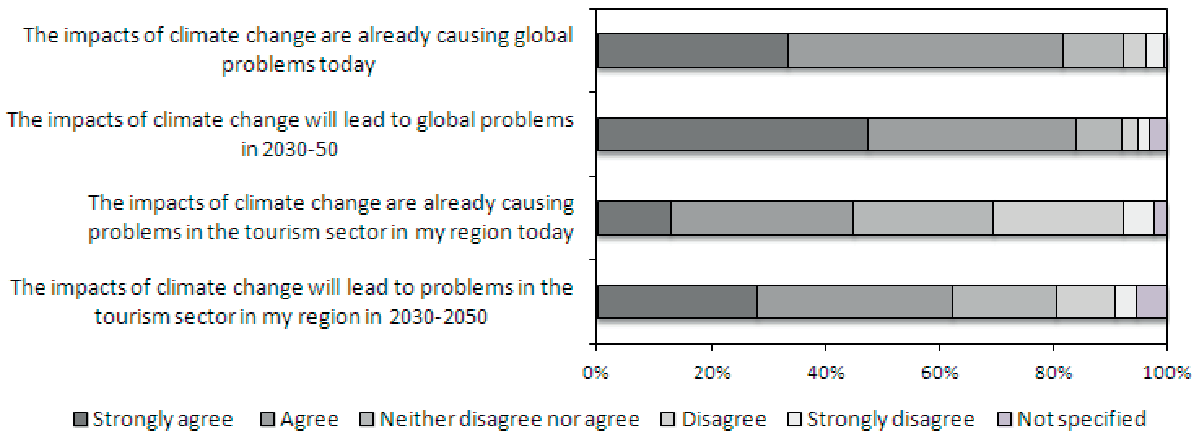


Figure 4.13: Stakeholders' perception of present and future (2030-2050) problems generated by climate change, both globally and regionally, for tourism (N=566).

Climate change is often seen as being as important as other factors that can affect the tourism sector, such as, for example, globalization or changes in preferences, population structure, mobility patterns, and the global economy. The majority of the respondents (42%) assigned a relative score of 4-6 out of 10 to the impacts of climate change in relation to the other factors. This is illustrated in Figure 4.14.

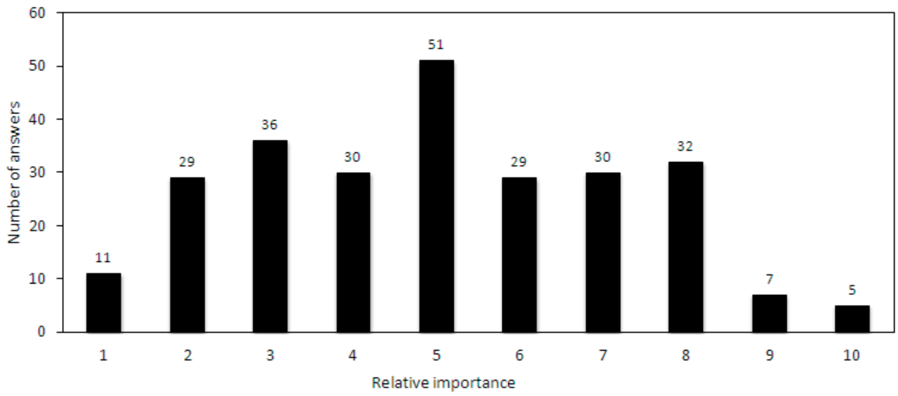


Figure 4.14: Distribution of the number of answers (N=260) to the question "How strong do you evaluate the impacts of climate change on tourism in your region in relation to other changes (e.g. globalization or changes in preferences, population structure, mobility patterns, and the global economy)?" (1 = far less important; 10 = much more important).

On a general level, stakeholders already perceive their region to be exposed to the impacts of climate change. In their opinion, this exposure will grow in the future. In an open question to the subject, only 4% of the respondents (23 out of 566) replied that no impact was observed in their region and less than 1% (10) said that there will be no consequence in the future (Figure 4.15, respectively black and white bars). When asked about the different impacts already perceived in their own region, the respondents mentioned shrinking glaciers most frequently (145 or 26% of the respondents) (Figure 4.15, black bars). This was followed by decreasing snow reliability (24%) (in particular in the lowlands: 12%), the increasing frequency and magnitude of extreme events (e.g. storms, mass movements such as debris flows, heavy rainfall events, floods, or heat waves) (22%), and decreasing in water availability (20%). 13 respondents also indicated increasing weather variability as an already perceived impact. The question related to the present impacts was open; respondents were invited to describe perceived impacts in their own words.

Concerning exposure at the 2030-2050 time horizon, the most cited impacts were the increase in mean annual temperature (84% of the respondents ticked it the a multiple-choices questionnaire), the general decrease in snow reliability (78%), and the increase in frequency and magnitude of extreme events (76%) (Figure 4.15, white bars). Shrinking glaciers followed with 70% of the respondents expecting them. Snow-reliability in higher altitudes appeared less frequently as a possible impact than in the lowlands, the latter having been ticked by 70% of the respondents against 41% for the former.

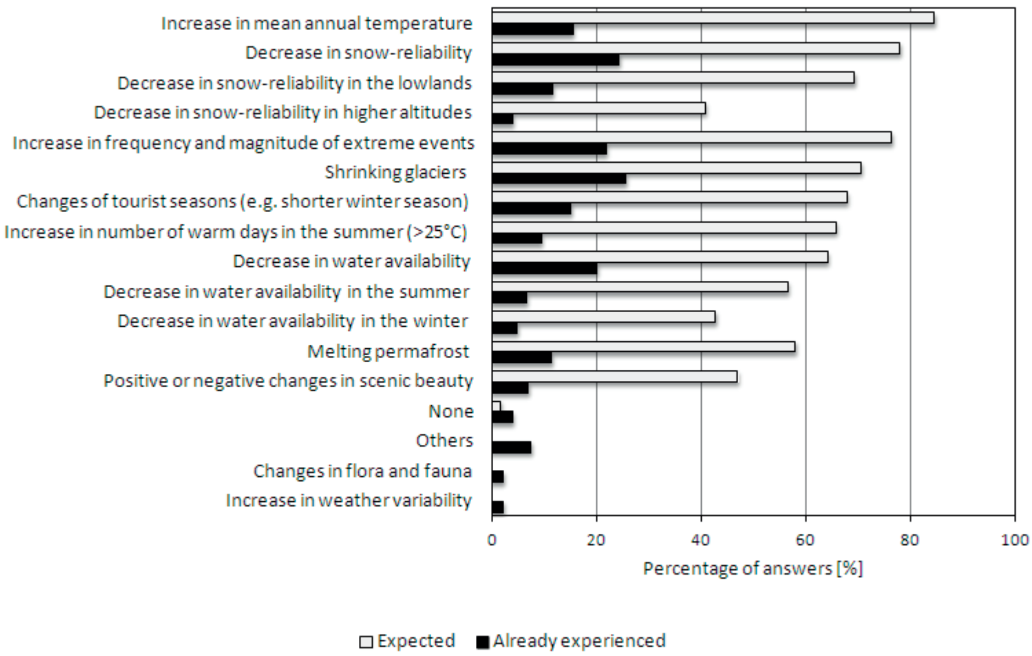


Figure 4.15: In white, percentage of answers (N=566) to the multiple choice question "What changes from climate change do you expect in your region by 2030-50?" In black, the percentage of answers to the open question "Have you already experienced some of these changes in your region? If yes, which ones?"

Regarding regional adaptive capacity, stakeholders considered it to be average (49% of the answers) (Figure 4.16). 6% defined it as very high and 18% as high. For 21% of the respondents the adaptive capacity in their region was low. Regarding vulnerability, 11% of the respondents considered the region they live in as very vulnerable, 29% as quite vulnerable, and 49% as partly vulnerable. 6% considered their region as not vulnerable at all (Figure 4.17).

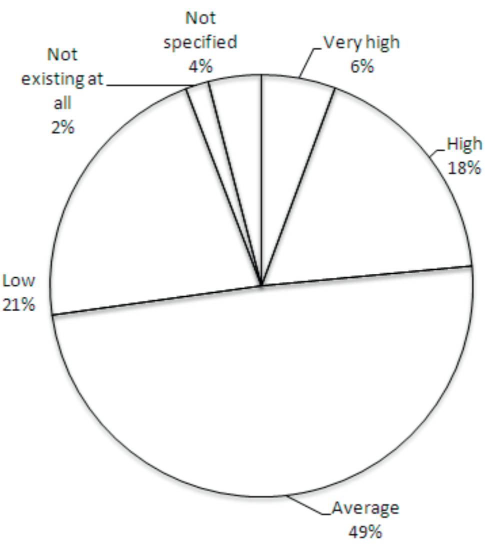


Figure 4.16: Answers to the question “How do you assess the ability of tourism to cope with climate change impacts in your region? E.g. its ability to moderate potential damages, take advantage of opportunities, or cope with the consequences of climate change?” (N=566).

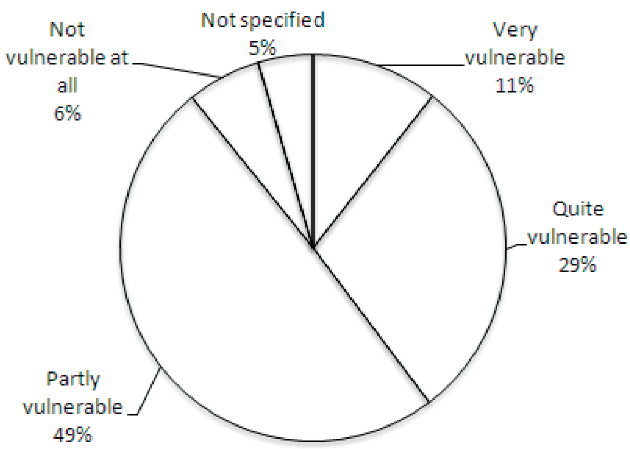


Figure 4.17: Answers to the question “In your opinion, how vulnerable is the tourism sector in your region to climate change? We consider a region as vulnerable if it is exposed to or unable to cope with the adverse effects of climate change, including climate variability and extremes” (N=566).

4.5.7.2 Relation among potential impacts, adaptive capacity, and vulnerability perceived by stakeholders

In the online survey, we asked respondents to evaluate the degree of present and future potential impacts (PI), adaptive capacity (AC), and vulnerability (V) in their region (Section 4.4). Analyzing the correlation among the four aspects (Figure 4.18), it appears that there is a significant and strongly positive correlation between the perception of present impacts and the perception of future impacts (>0.70***). A highly significant correlation also exists between both present and future potential impacts and vulnerability (both 0.35***). Stakeholders who see their region as highly impacted by climate change also see it as more vulnerable. The relation among adaptive capacity and vulnerability is, on the other hand, weaker (0.16***) and generally U-shaped. Low adaptive capacity is seen both in regions in which vulnerability is very low and very high, whereas higher adaptive capacity is perceived in regions with average vulnerability. A better visualization of this can be found in Figure A.10

in Annex A.14. As expected, no correlation exists between both present and future potential impacts and adaptive capacity.

In short, we find the expected correlation between potential impacts and vulnerability but not between potential impacts and adaptive capacity. Vulnerability and adaptive capacity seem to be almost independent. In fact, adaptive capacity is perceived to be very low for both regions with very high and very low levels of vulnerability.

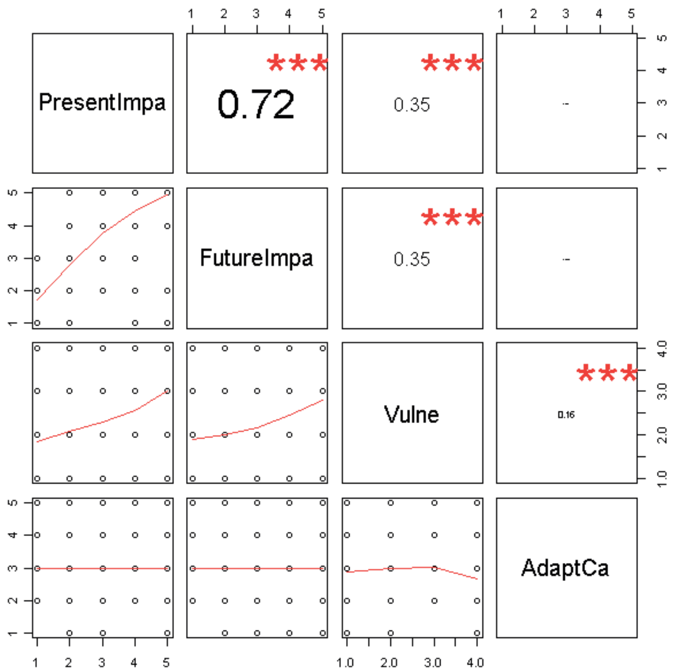


Figure 4.18: Representation of Pearson's correlation between perceived present (PresentImpa) and future impacts (FutureImpa), perceived adaptive capacity (AdaptCa), and perceived vulnerability (Vulne). The lower diagonal contains a scatter plot matrix. The upper diagonal contains the correlation coefficients, the font size reflecting the absolute value of the correlation (*significant at 5%; **significant at 1%; ***significant at 0.1%). Dots represent the possible combinations of answers given. To each of them, different numbers of respondents replied.[65]

4.5.7.3 Regional differences among stakeholders' perception of potential impacts, adaptive capacity, and vulnerability

Regional results concerning present and future problems caused by climate change (the potential impacts to the sector), stakeholders' willingness to adapt, adaptive capacity, vulnerability, and relative importance of climate changes in relation to other socio-economic changes are presented in Figure 4.19. The left hand side of the figure shows the mean and the right hand side the median among the different answers for the different regions. The number of answers for each region is shown in Figure 4.20.

[65] For present and future potential impacts: 1) I strongly disagree with the assertion that climate change causes problems in the tourism sector in my region, 2) I disagree, 3) I neither disagree nor agree, 4) I agree, 5) I strongly agree. For adaptive capacity: 1) not existing at all, 2) low, 3) average, 4) high, 5) very high. For vulnerability: 1) not vulnerable at all, 2) partly vulnerable, 3) quite vulnerable, 4) vulnerable.

Figure 4.19.a shows that stakeholders already perceive problems in the tourism sector caused by climate change all around the country, but mostly in the western Alps (e.g. Sierre - Anniviers, Leukerbad, Adelboden, Brig-Belalp), in Bern and the Canton of Jura. Stakeholders in Graubünden (Engadin Scuol, Central Graubünden - Lenzerheide, Savognin, Bergün, Untere Surselva) and in the Zurich area (Zurich, Züri-Unterland, Zürcher Oberland) also rather strongly agree with the statement that climate change is already causing problems in the tourism sector of their region. Regarding future impacts, scores increase quite uniformly all around the country, with a stronger increase for the Ferienregion Heidiland, the Jura Bernois, the Lake Geneva Region - Countryside, Mittelland I, and Obere Surselva (Figure 4.19.b).

The perception of vulnerability (Figure 4.19.c) follows approximately the same pattern, with respondents giving higher scores for vulnerability in Crans-Montana, Züri-Unterland, Grächen-St. Niklaus, and the Gantrisch Region. It should be noted, however, that only 1 and 3 people answered for the Gantrisch Region and for Züri-Unterland respectively (Figure 4.20.a), so the validity of that assessment could be questioned. Stakeholders consider the area in which the Rhine flows up to the Bodensee (Untere Surselva, Rhine Valley, Rheintal) and also the southern part of Ticino (Lake Lugano, Mendrisiotto) as quite vulnerable. On the other hand, they perceive the Graubünden region as not particularly vulnerable, even if some problems are felt. Respondents sensed low vulnerably mostly in the Jura Bernois.

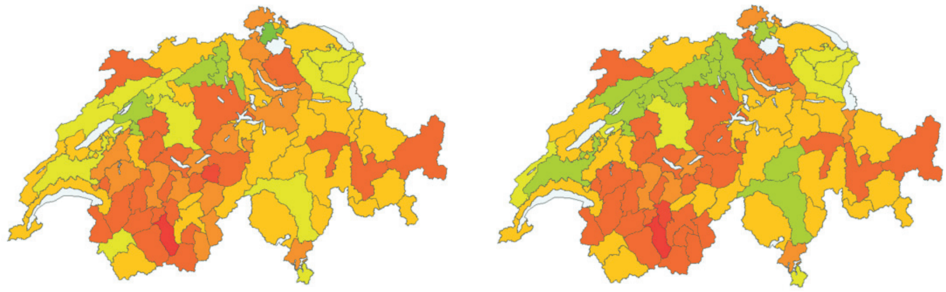
We also looked at the relation between the impact of climate change on tourism in the region and other factors (e.g. globalization and changes in preferences, population structure, mobility patterns, and the global economy) (Figure 4.19.d). The survey shows that climate change is perceived as relatively more important in Adelboden, Züri-Unterland, Obwalden, Untere Surselva, Engadin Scuol, Zurich, and Goms. Graubünden stands out particularly, interestingly, because Engadin Scuol stakeholders gave high scores to present and future problems for local tourism due to climate change, and assess a high importance of this phenomenon compared to other factors, but at the same time they perceive a relatively low vulnerability. It should be noted that only one person answered respectively for Adelboden, Züri-Unterland, and Goms (Figure 4.20.b).

Respondents perceive adaptive capacity as particularly high in Zermatt Matterhorn, Visp Region, Grächen-St. Niklaus, Gstaad-Saanenland, The Lakes Region, Zurich Mittelland, and The Pre-Alps - Les Paccots (Figure 4.19.f). They perceive it on the other hand as low in Ticino (Bellinzona and Northern Ticino, Lake Lugano, Mendrisiotto), the Rheintal, the Zürcher Weinland, the Glarnerland, Fribourg and the Centre, and Lauchernalp - Lötschental.

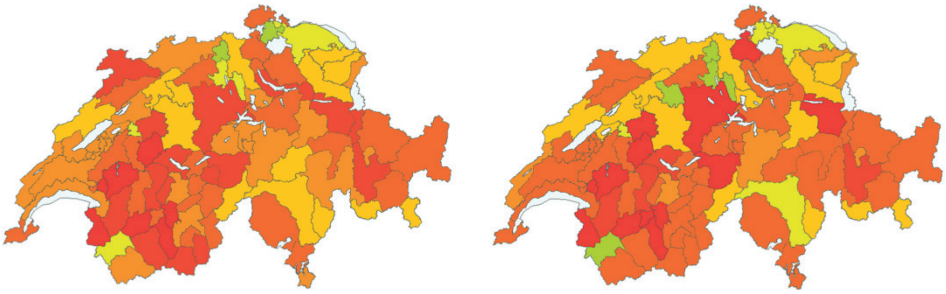
Finally, willingness to adapt seems to be quite high in the entire country, with the Eastern part being perhaps more willing to take action (Figure 4.19.e). Low willingness to act appears for the Ferienregion Lötschberg, the Laupen Region, Mittelland II, and Solothurn and Region. [66]

[66] A different score was given to the five possible answers to the question presented in Figure 4.19, showing different levels of willingness to act. From the lowest to the highest, these are: 1) I don't see the need to act. I would continue my business as usual; 2) I would begin start searching for information but would stop if this becomes too difficult; 3) I would not be the organizer of a meeting, but if someone else started organizing people in order to think about possible solutions, I would join for at least one meeting, 4) I would collect and review information, and I would then start planning possible solutions and eventually contact people, but I would stop if a possible solution doesn't clearly appear, 5) I would try to organize other concerned people in

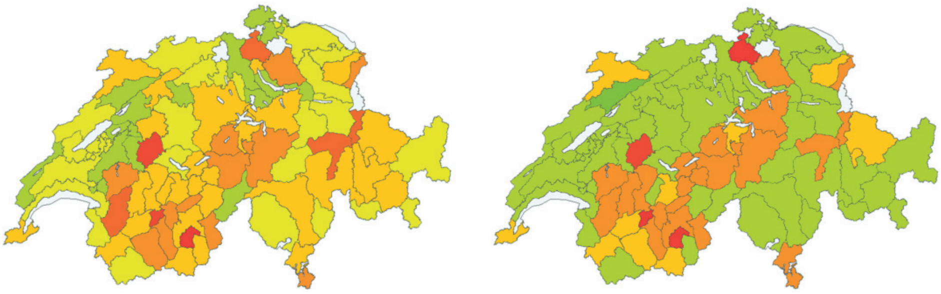
Mean	Median



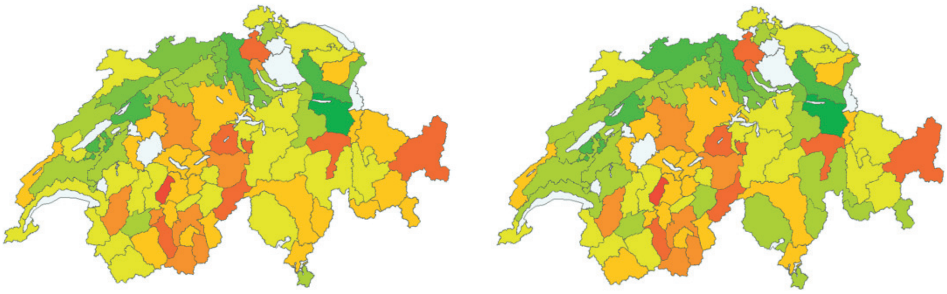
a) Climate change is already causing problems in the tourism sector in the region (dark green: strongly disagree; red: strongly agree).



b) Climate change will lead to problems in the tourism sector in the region in 2030-2050 (dark green: strongly disagree; red: strongly agree).



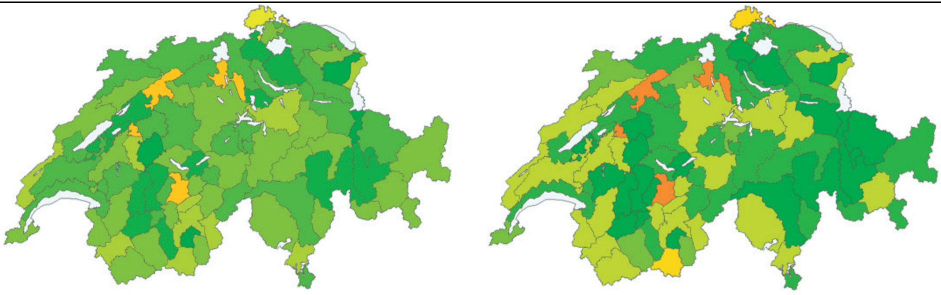
c) Vulnerability of the tourism sector in the region (dark green: not vulnerable at all; red: very vulnerable).



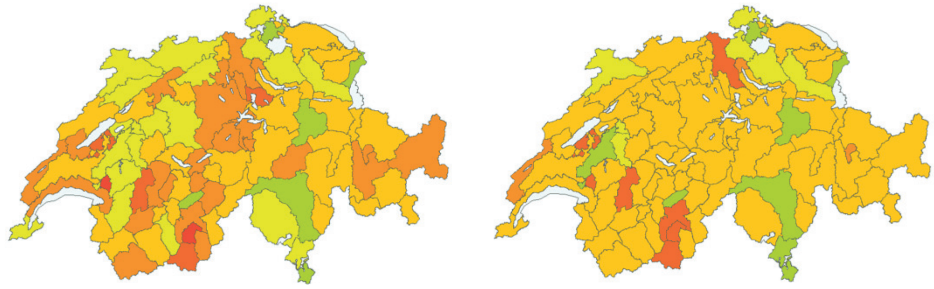
d) Relative impact of climate change on tourism in the region compared to other changes (e.g. globalization, changes in preferences, population structure, mobility patterns, and the global economy) (dark green: low importance; red: high importance).

my region to find possible solutions until something is found, even if it were to take much time and energy until a solution is found.

Mean	Median



e) Willingness to adapt if impacts of climate change become visible on the own business (dark green: I would act until a solution is found; red: I don't see the need to act).



f) Adaptive capacity (dark green: not existing at all; red: very high).

Figure 4.19: Mean (left) and median (right) score for the different tourism regions compared to present (a) and future problems (b) caused by climate change, vulnerability (c), relative importance compared to other changes (d), willingness to adapt (e), and adaptive capacity (f). For white regions data was not obtained.

Minimum number of answers for all questions except d)	Number of answers for question d)

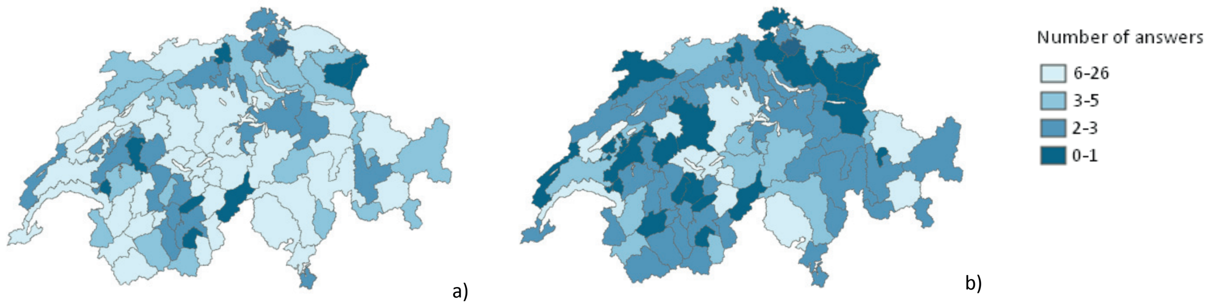


Figure 4.20: Number of answers for each region. On the left-hand side the minimum number among all questions except d) is shown, on the right-hand side the number of answers for question d). For more details, see the wiki (Annex A.18).

4.5.7.4 *Perceived vs. assessed vulnerability*

Stakeholders' perception and calculations generated by experts' opinions gave different results. By comparing the results of the MCA and the relative importance given by stakeholders to the three aspects determining vulnerability – exposure, sensitivity, and adaptive capacity – considerable differences appear. While the experts were rather unanimous in giving the highest score to adaptive capacity; on average: exposure 16/100, sensitivity 29/100, and adaptive capacity 55/100 (Section 4.5.1), stakeholders gave these three components almost equal weights: exposure 36/100, sensitivity 32/100, and adaptive capacity 33/100.

On a regional level, differences are quite striking. Figure 4.21 shows differences between the (a) calculated and the (b) perceived regional vulnerability, both on a relative 0-10 scale with determined intervals. Both stakeholders and calculations indicated that the Central-Western part of the Alps is among the most vulnerable regions, while the Plateau and the Eastern part of the Alps are less vulnerable. Nonetheless, some of the regions that appeared as particularly vulnerable in the vulnerability map (e.g. Verbier St-Bernard, the Northern part of Ticino, Sion Region – Les 4 vallées et Evolène, and Aletsch) were not perceived by stakeholders as particularly vulnerable. Similarly, the Prealps and the regions surrounding the Rhine to the Bodensee were seen by stakeholders as vulnerable, whereas the map did not show it. Note, however, that for some regions the number of respondents is quite low (see Figure 4.20.a), which might explain some surprising results (very high vulnerability of the Züri-Unterland, Grächen-St. Niklaus, or Mendrisiotto regions).

a. Calculated vulnerability b. Perceived vulnerability

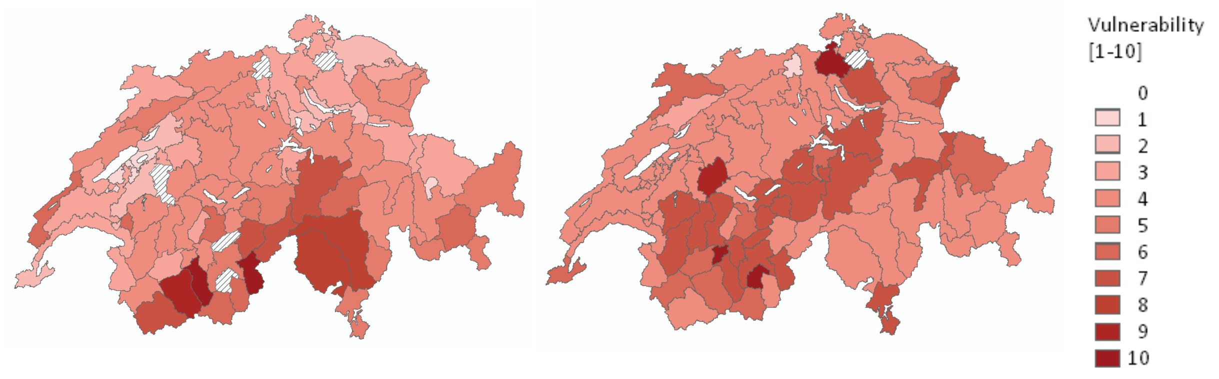


Figure 4.21: a) Calculated and b) perceived vulnerability depicted on a 0-10 scale with defined intervals (light red: low or negative vulnerability; dark red: high vulnerability). Hatched areas indicate regions with lack of data.

4.5.8 Comparison with earlier studies

Next we compare the distribution of the scores obtained for both the vulnerability map (Section 4.5.2) and the online survey (Section 3.1.3.3) at the level of geographical regions (Alps, Prealps, Plateau and Southern Switzerland, Lakes, Jura, and cities) with the results obtained by Müller and Weber (2007) presented in Figure 4.1.[67]

In Müller and Weber's analysis it appeared that, according to experts' opinion and for a 2030 time horizon, most regions are going to benefit slightly from climate change, with the exception of the Prealps. Average outcomes of the vulnerability map (Figure 4.22) illustrated similar results, with the lakes regions, the cities, the Plateau and Southern Ticino benefiting from climate change on average, and the Prealps, Jura, and the Alps appearing to be vulnerable. For the Alps, as in Müller and Weber's analysis, the direction of the vulnerability varies greatly, from the most positive to the most negative scores. The online survey (Figure 4.23) yielded similar results and generally highlighted that the lakes regions are the ones suffering the least and the Prealps among the ones suffering the most in stakeholders' opinion.

[67] See Table A.20 in Annex A.12 to see in which geographical region is situated each tourism region.

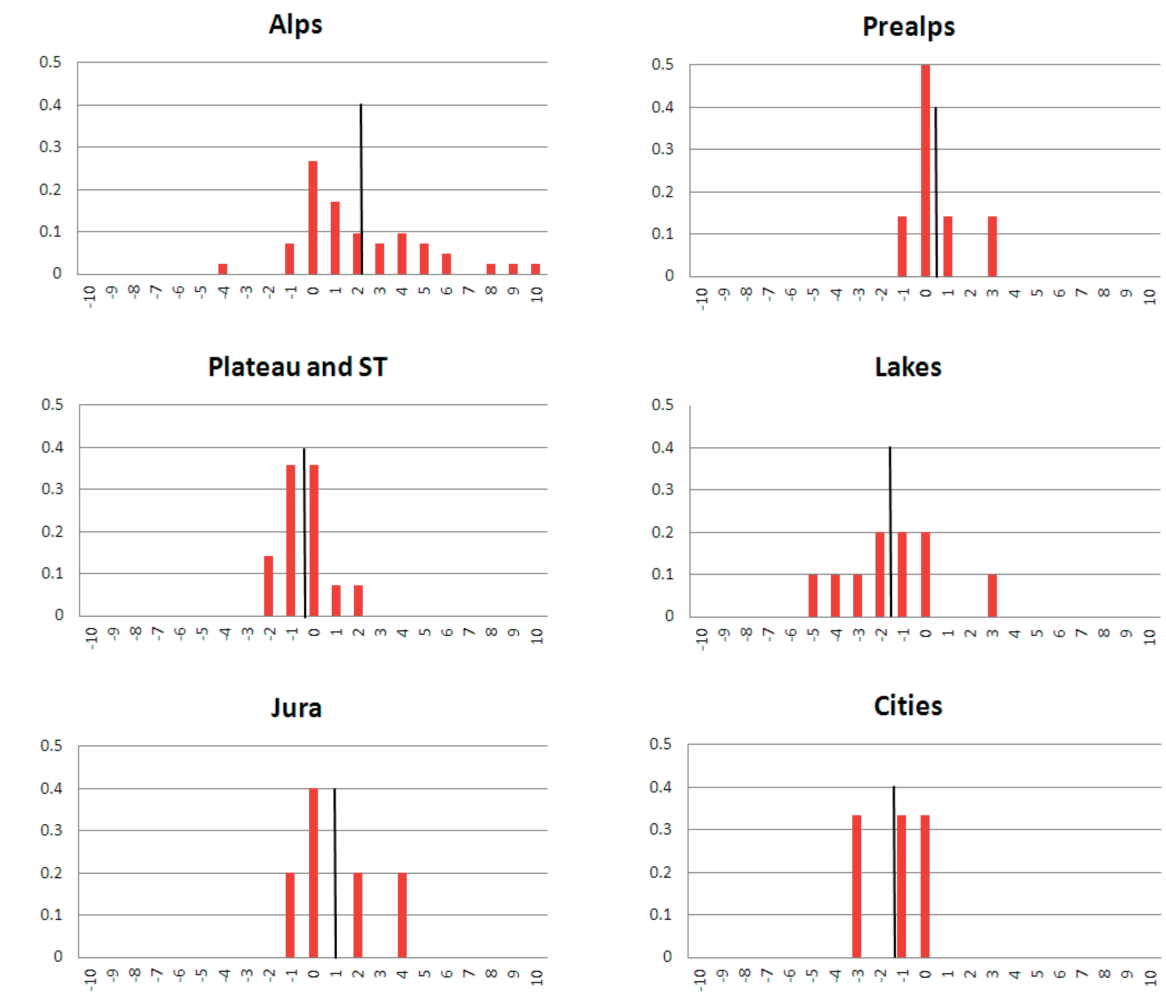


Figure 4.22: Direction of vulnerability in different geographic regions according to the vulnerability map. Red bars represent the frequency of the score of the tourism regions[68] differentiated by geographic regions (Alps: 41 regions, Prealps: 7, Plateau and Southern Ticino (ST): 14, Lakes: 10, Jura: 5, Cities: 3). We manually added the black line, which indicates the average. The lower the value on the x axis, the higher the benefits; the higher the value, the higher the vulnerability.

[68] Only 80 considered here due to the lack of information for Brugg Region, Grächen-St. Niklaus, Lauchernalp - Lötschental, the Pre-Alps - Schwarzsee, and Winterthur and its region.

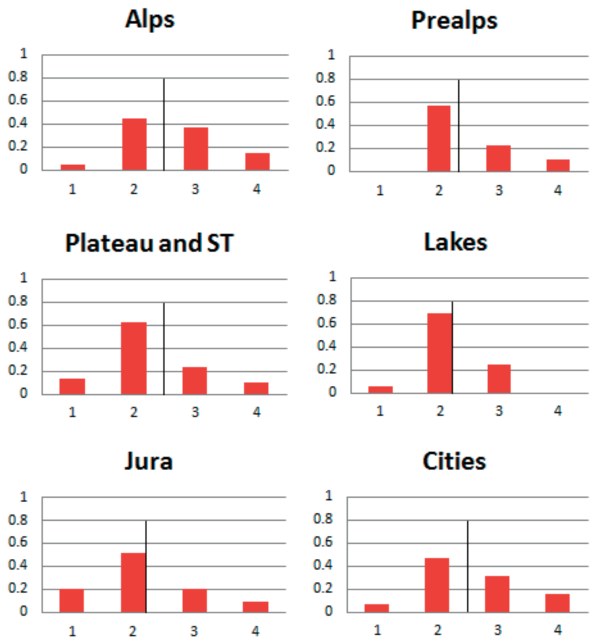


Figure 4.23: Degree of vulnerability in different geographic regions according to the 532 respondents of the online survey. Red bars represent the frequency of the score of the 85 tourism regions differentiated by geographic regions (Alps: 262 answers, Prealps: 49, Plateau and Southern Ticino (ST): 59, Lakes: 82, Jura: 35, Cities: 45). We manually added the black line, which indicates the average. The lower the value on the x axis, the lower the vulnerability and vice versa.

4.5.8.1 Stakeholders' perception of potential impacts and vulnerability of the tourism sector obtained from face-to-face interviews

As mentioned in Section 3.1.3.4, we carried out face-to-face and phone interviews with stakeholders between July 27, 2011, and October 13, 2011. These interviews provided, among other things, a broader insight of their perception of potential impacts on and vulnerability of tourism in their regions of activity and to compare these perceptions with our map (Figure 4.24). We highlight here some interesting responses. They were, when needed, translated into English and are marked with a * in the text. Longer exerpts from the interviews and the text in the original language can be found in Annex A.16. Unfortunately, none of the selected stakeholders where located in the three regions that turned out to be the main hotspots (Sierre - Anniviers, Brig – Belalp, and Sion Region - Les 4 vallées and Evolène).

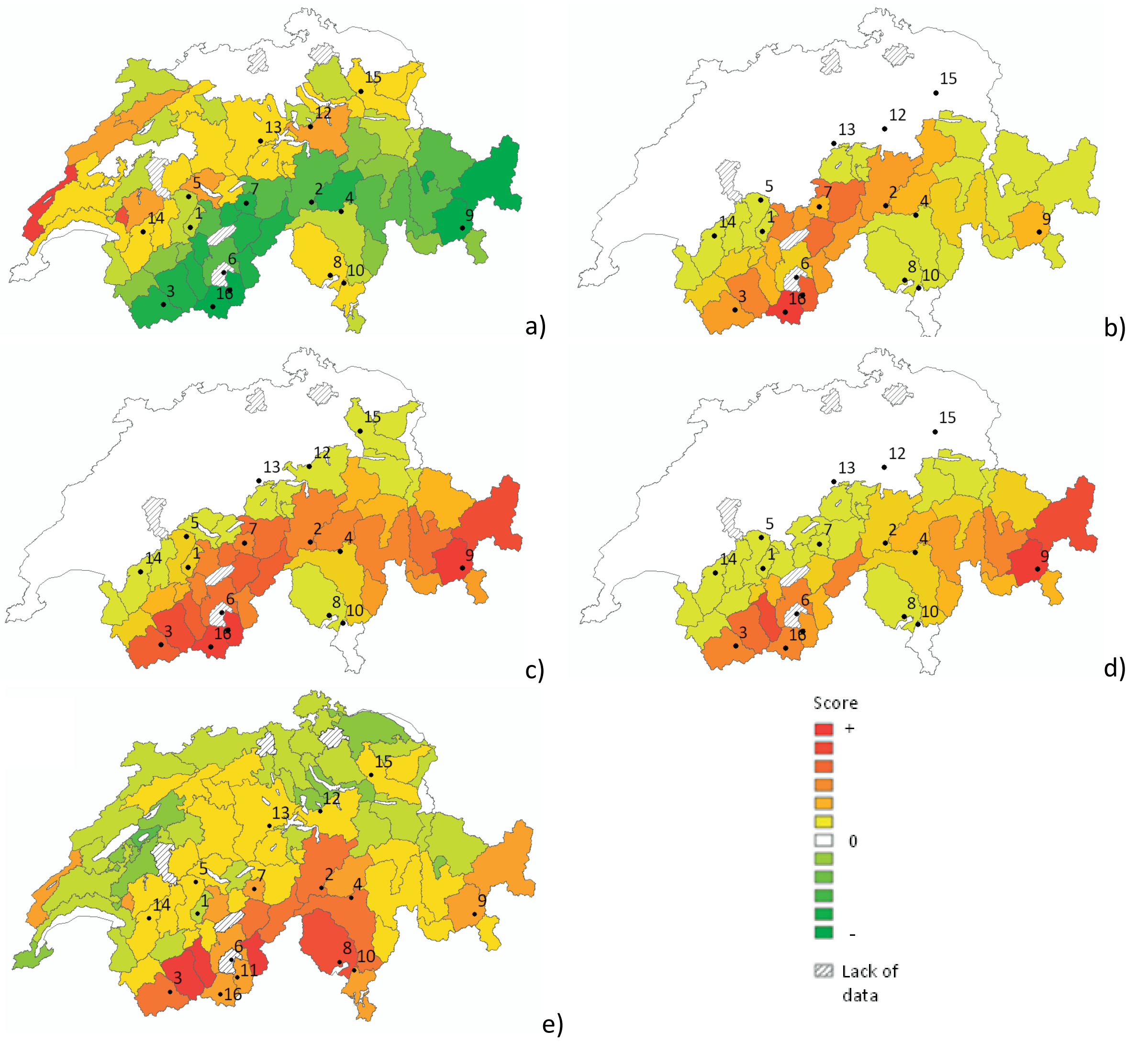


Figure 4.24**:** Regional exposure due to a) snowpack reduction, b) glaciers melting, c) permafrost melting - rockfall, d) positive and negative changes in scenic beauty, and e) final regional vulnerability depicted on a 0-10 scale with defined intervals. The redder the region, the more vulnerable; the greener the region, the more it will presumably benefit from the impact. In light gray, the limits of the 85 tourism regions presented in Section 3.1.2.1. Hatched areas indicate regions with lack of data, white areas, regions with null exposure or vulnerability. The 16 case study regions in which we carried out interviews are marked with black dots: 1. Adelboden; 2. Andermatt, 3. Bagnes (Verbier), 4. Campo (Blenio), 5. Erlenbach im Simmental (Stockhorn), 6. Grächen, 7. Grindelwald, 8. Locarno (Cardada), 9. Pontresina and St. Moritz, 10. Rivera (Monte Tamaro), 11. Saas-Fee, 12. Sattel, 13. Schwarzenberg, 14. Vaud Alps, 15. Wattwill (Obertoggenburg), and 16. Zermatt.

Regarding regional exposure and potential impacts affecting the region, we obtained different answers depending of the locations. All the seven impacts chosen in vulnerability mapping were mentioned by at least one of the interviewed persons, except for the increased risk of water scarcity. This impact doesn't seem to be perceived in the various regions up to now. Other major impacts not covered by the vulnerability map did not emerge during the interviews, whereas the impacts that we analyzed are already visible in many of the regions, as mentioned by respectively the stakeholders interviewed in Saas-Fee (number 11 in Figure 4.24) and in Grindelwald (no. 7):

"Every morning, when I come to work, I see that the Earth is changing. I cannot say if it's good or bad, I can only say that that we see the changes. Those in Zurich don't see, as I do here, the glacier. But we, here, we see the glacier, the forests ... ."

11. Saas-Fee (part of the Saas-Fee/Saastal region); 19.09.2011 - A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"If you live in a town, then you may have heard about climate change, but then every day you wake up in the morning, you take your car, you go to work and you feel nothing about climate change. But here, here you can see it, you can see how the glaciers retreat, you can hear the rocks fall, you hear the rivers transporting stones, there is the sound also ... ."

7. Grindelwald (part of the Grindelwald region), 20.09.2011 – A member of the municipality

As also shown in the vulnerability map, not all regions are equally affected by the different impacts. For example, interviewees from the Stockhornbahn in the Lenk-Simmental region (no. 5) and from Verbier (no. 3) agreed in saying that changes exist but they did not perceive these directly in their regions. In our map, Verbier St-Bernard is among the tourism regions that should benefit from changes in snow conditions in the future. The region is, however, also supposed to be affected by glacier and permafrost melting, and changes in scenic beauty (Figure 4.24.c and d). We discuss this aspect later in this section.

"At the moment, we still don't see [impacts of climate change on snowpack]. What we observe are more intense rainfalls during summer, but this remains a totally subjective perception. We don't have measures for that. But for winter, definitely, not. I am persuaded that there is a change which is taking place. […] But today, I cannot say that there is an impact in Verbier, honestly. Here, we have also an advantage, it is that we are very high in altitude […] So, we are less affected than, for example, a resort in the Fribourg Prealps."

3. Bagnes (Verbier) (part of the Verbier St-Bernard region), 18.08.2011 – A member of the cableway company*

In the majority of cases, stakeholders felt exposed to at least one impact and perceived the consequences on the tourism sector in their region. At the moment, visible impacts mainly relate to snowpack reduction and glaciers melting. Stakeholders in Campo Blenio (no. 4 in Figure 4.24), Monte Tamaro (no. 10), Sattel (no. 12), Schwarzenberg (no. 13) and Obertoggenburg (no. 15) mentioned the reduction of the snow cover in their region, which is in line with our map (Figure 4.24.a).

Regarding snowpack reduction in Grindelwald, the two stakeholders interviewed do not see the resort as particularly affected because the Eiger shadows the region and because the region lies above 2000 m AMSL. Moreover, the tourism sector does only partly depend on ski activities (the summer season is more important than the winter one as seen also in Section 3.1.2.3) and the region already developed alternative activities to ski for winter. Grindelwald did not appear exposed in our map either. Still, this point highlights the fact that regional characteristics other than altitude (here for example the Eiger) also influence the snow cover.

In addition, interviewees often felt the consequences of the lack of winter atmosphere in the lowland. Precipitations in lower altitudes are falling, on average, more as rain than as snow, as was confirmed in a paper of Serquet et al. (2011). As a consequence, the winter sport sector often needs to make much bigger efforts to really motivate people to come to the mountains for skiing because of the lack of winter atmosphere in the urban centers, as both people in Zermatt (no. 16) and in Adelboden (no. 1) mentioned:

> *„But what we also notice is that, if we can already walk around in T-shirts in Bern in January, then there is nobody who is interested in going skiing anymore […] There is really spring coming already in January. And then, we notice that we have to make much bigger efforts to really motivate people to come to the mountains for skiing because for them it's already spring."*
>
> 1. Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

In Grindelwald, stakeholders cited the formation of a glacier lake over the village as an indirect impact due to glaciers melting. We did not take this possible consequence into consideration when we developed the map. On the other hand, other studies are analyzing the topic.[69] In the calculated map, Zermatt appeared to be the most exposed region to the melting of glaciers in the 2030-2050 time horizon (Figure 4.24.b). The person interviewed in the region also brings up the subject:

> *"In the past, climate change was not really a topic […] because it was not as dramatic as it is nowadays. People were not so aware. Zermatt was one of the first places where people became aware of it, since we have a lot of glaciers and the glaciers are really involved in our tourism product."*
>
> 17. Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

In Saas-Fee too, the interviewed stakeholders (no. 11) saw glaciers melting as one of the three main impacts affecting the region, together with the upward shift of the treeline, and the higher weather variability. Regarding permafrost, two regions mentioned the problem:[70] Pontresina - St. Moritz (no. 9) and Zermatt. This, once again, is in line with our map:

> *"Zermatt is a climbing destination, and we note more accidents with rock falls [...] because often permafrost freezing is not there anymore [...]. You can see an increase of accidents in this way […]. And also, going back to the cablecar company, all these stations in the mountains with the posts holding the cables, they have to be examined more now because all the anchors are in the frozen rocks and they have to see if this is still OK."*
>
> 16. Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

Even though it is quite exposed, the stakeholders of St. Moritz did not feel vulnerable to this impact. They are affected but they know how to tackle permafrost melting:

> *"Yes of course we have a lot of permafrost in Engadin, […] but for us it is not a problem building on it, if we have a pylon or a chairlift or something on permafrost […]. As a mountain railway, I think we don't have a problem. We know permafrost, we can handle it."*
>
> 9. St. Moritz (part of the Engadin St. Moritz region), 25.08.2011 – A member of the cableway company

[69] http://www.nfp61.ch/E/projects/cluster-hydrology/lakes_melting_glaciers/Pages/default.aspx
[70] We couldn't contact Grächen for more information on the region.

Interestingly, quite frequently interviewees also spontaneously mentioned changes in tourism seasons, the upper shift of the treeline, and higher weather variability. We integrated these impacts in our map. Nonetheless, these are perhaps less discussed and less studied impacts. Two people mentioned the shift of the upper treeline during the interviews. The stakeholder in Saas-Fee referred to the phenomena and, when asked if the changes in forest cover could be caused by the fact that alpine meadows are not exploited anymore, the person interviewed said no, because they are located higher than the natural upper treeline. The president of the Cardada cableway company (no. 8) discussed the already visible consequences in his region:

> *"The problem with climate change is the upward shift of the forests. It is a huge problem for us. […] And then, another problem is that this shift of the forest is favored by the retreat of agriculture, by the, so to say, abandonment of alpine pasture. Here, frankly, for a place like Cardada I see the worst problem that we are facing."*
>
> 8. Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 - The president of the cableway company*

Concerning Cardada, impacts for the region did not appear as strong in the calculated map. It has to be remembered, however, that the underlying hypothesis concerning scenic beauty was that the forest would shift over the current upper line. Cardada lies below 2500 m AMSL and therefore under this line. Climate change must certainly be a trigger factor in changes in landscape beauty, accelerating forest growth and introducing new species as the bracken[71] mentioned during the interview. This phenomenon takes place, however, jointly with pasture abandonment.

Regarding greater weather variability, stakeholders in Adelboden, Toggenbourg, and Saas-Fee mentioned that the weather now changes much more frequently. It should be noted, however, that changes in weather conditions are sometimes difficult to assess objectively (Rebetez 1996).

> *"The third phenomenon, it's the weather that changes more rapidly. Before, here in our view, it was more stable. I am not saying better or worse, but today we have more extremes."*
>
> 11. Saas-Fee (part of the Saas-Fee/Saastal region); 19.09.2011 - A member of the regional tourism organization and of the municipality also active in the accommodation sector*

When stakeholders were asked to report on impacts on the tourism sector in their region, they generally mentioned the negative impacts on their business, e.g. in Cardada or Schwarzenberg. Some stakeholders, nevertheless, mentioned short-term benefits brought by climate change, mainly due to changes in climate suitability for tourism activities, the summer freshness that mountain regions could offer, and increases in snowpack at higher altitudes. In St. Moritz, the member of the tourism office interviewed by phone said that it was difficult to determine whether the number of skiers has decreased or increased in the last years. But she added that the region of St. Moritz will probably benefit from climate change at the beginning because of the impacts on other stations and also because the resort lies in a very good location. The resort already sees more tourists coming e.g. from Milan in summer in search of coolness. Regarding the impact on snow cover and summer coolness, this was confirmed by our map. Stakeholders interviewed in Saas-Fee and Zermatt also mentioned this topic. In particular, the stakeholder in Zermatt said:

[71] *Pteridium aquilinum* (L.) Kuhn, a species of fern.

“And a positive effect, when we talk about the product, maybe not this year but when you look back to a summer like 2003, when you have really a hot weather and people are seeking cooler places where you have 25 degrees. [...] It's not yet a big trend but you see that there is an increase and that people come more and more in the summer. [...] And it is also a quick decision, for people to come up not only for a day, but for a weekend or so.”

16. Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

And regarding changes in snowpack for higher altitudes:

„Here in Zermatt, we can offer skiing for another 10 or 20 years, and certainly more than almost anybody else because we are higher, we are in a good zone for a lot of snow, and we have invested a lot for snow security and snow machines; yet, even for us it's a big problem because the skiing usually doesn’t start in Zermatt.“

16. Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

Summing up, the tourism regions are exposed to differential impacts. Not all of these impacts, however, have consequences for the tourism sector. Glaciers and permafrost melting were cited quite frequently as already visible impacts. However, they do not always have direct consequences on the sector, as seen in the case of permafrost in the St. Moritz region. This could also explain why differences among answers generated by the online survey and results of the map were so big. It is possible that these impacts are strong and visible in some regions. However, we perhaps overestimated the sensitivity of the tourism region (and consequently its vulnerability) to them. Quoting for example the person interviewed in Sattel:

“We see from here the Uri Rotstock. There, there is a glacier and we can see that it’s retreating. This is obvious […], but for us in the Prealpine region it’s not important yet. It’s more an observation, not a repercussion.“

12. Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

Therefore, as the vulnerability map, face-to-face interviews supported the hypothesis that it is not necessarily the most exposed regions that are the most vulnerable. Stakeholders who perceived their region as being exposed did not necessarily see it also as sensitive or vulnerable. This is for example the case of Grindelwald, Saas-Fee, St. Moritz, or Zermatt, four important and well-known resorts lying at high altitude. For example in Zermatt or in Saas-Fee, citing a study carried out in the region:

“We are not more vulnerable than others but you can see the changes here, that’s the thing."

7. Grindelwald (part of the Grindelwald region), 20.09.2011 – A member of the municipality

“The study[72] showed that we are vulnerable. But the things that are vulnerable, are, for the type of tourism we are making here, rather beneficial. There are going to be consequences, but on the whole it is quite beneficial for us.”

11. Saas-Fee (part of the Saas-Fee/Saastal region); 19.09.2011 - A member of the regional tourism organization and of the municipality also active in the accommodation sector*

[72] Bättig et al. (2011).

"For me, personally, climate change is a chance more than a threat […] especially in the summer time in which in the last decades we had problems in attracting people on the mountain because it was not in fashion, because it meant an active holiday and passive holidays were much more attractive."

16. Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

If generally the outputs of the face-to-face interviews supported the findings we generated with the vulnerability map, sometimes results did not match so well. For example, the map showed some degrees of exposure and vulnerability for Verbier (Figure 4.24.e). However, stakeholders from both the face-to-face interview and the online survey perceived the region as neither affected nor vulnerable. The same appeared in a work of Serquet and Thalmann (2011, Serquet personal communication) in which no real threats for the region were perceived by the stakeholders interviewed except for the melting of the Tortin glacier, which already now has some consequences on the skiing activity. Further research should be carried out in order to assess whether the region is blind to the existing impacts and vulnerability or whether our map exaggerates them.

Another interesting region is Campo Blenio. Based on the calculated map, this resort lies in a not so exposed and only slightly vulnerable region. In the online survey, scores for vulnerability were even lower. It is possible that the joint results of the map and of the survey were realistic because Campo Blenio is a small ski resort in a quite vast area, and therefore its influence on the whole tourism sector in the region is relatively small.

4.6 Discussion

The different analyses presented in this chapter show that climate change affects tourism in a far broader way than is commonly discussed. Snowpack reduction is not the only concern. Glaciers melting, water scarcity and drought, changes in climate suitability and seasons, natural hazards, and scenic beauty are also relevant impacts of climate change and could become even more important in the future. Generally, as we saw from the online survey and from the face-to-face interviews, stakeholders are well aware of these impacts and of the potential problems that they can generate for the tourism sector in their region.

4.6.1 How different actors assess impacts and vulnerability

Interviewees from the online survey mainly cited glaciers melting, snowpack reduction, and the increase in the frequency of extreme events as already perceived and future impacts generated by the increase of mean temperature determined by climate changes. Participants in the face-to-face interviews interestingly also mentioned higher weather variability, the changes in tourism seasons and the upper shift of the treeline. Increased water scarcity and even droughts were not perceived in the various regions up to now.

In addition to these negative impacts, some changes are perceived to be (at least in the beginning) beneficial for tourism. This is the case for changes in climate suitability for tourism activities and changes in snowpack at higher altitudes. As a consequence, some regions appeared in the vulnerability map to benefit from climate change. These were in particular mountain and lakes regions. The latter in particular are modestly affected by the major impacts, but offer freshness to tourists in hotter summers. Both the interviewees in the online survey and in the face-to-face discussions mentioned beneficial impacts and their consequences, even if the situation in the lowlands could also have negative repercussions at higher altitudes (e.g. people from the urban centers do not learn anymore to ski). Benefits for the mountain regions were masked in the vulnerability map by the multitude of other impacts affecting these areas.

Looking at the negative impacts, after calculations, tourism in Alpine regions of Valais, Ticino, and Uri will suffer the most from the negative impacts generated by climate changes, such as glacier and permafrost melting, increases in intensity and frequency of natural hazards, and changes in scenic beauty. Nonetheless, the more exposed regions are not necessarily the most vulnerable. Generally speaking, adaptive capacity and sensitivity also play a role in defining vulnerability. This is particularly true for regions such as Zermatt Matterhorn, Saas-Fee/Saastal, and Engadin St. Moritz. In these regions, vulnerability is reduced mainly by the fact that stakeholders have already undertaken measures to adapt to climate change. Interestingly, face-to-face interviews confirmed our vulnerability map in places where we carried out discussions. The question remains, however, to what extent their answers were influenced by existing scientific work as opposed to own experiences and perceptions.

If face-to-face interviews and the calculated map gave similar results, outcomes generated by the online survey among stakeholders yield a slightly different picture. As in Müller and Weber (2008), stakeholders who took part in the online survey saw as most vulnerable mainly the Prealps and the Rhine Valley. Snowpack reduction and the increase in intensity and frequency of floods seem then to be perceived as the most important threats to the regional tourism sector. This could be due to the fact that stakeholders assessed vulnerability mainly by looking at already visible impacts, which affect the sector today.[73] We will further discuss this in Section 4.6.2.

Differences among the results obtained by the different methods could come from the limitations of the method. We shall show in Section 4.7 that they could be due to the lack of data. This clearly has the potential to mask some important aspects. Redundancy generated among indicators can also affect the results.

What additionally appeared from the online survey and from the face-to-face interviews is the complexity of the relation among potential impacts, adaptive capacity, and vulnerability. If the definition of vulnerability was fully understood by stakeholders in the online survey, the relation is for example not linear but U-shaped between perceived adaptive capacity and perceived vulnerability. This could be due to the fact that adaptive capacity is both very low in regions not concerned with tourism (because there is no need to adapt) and in regions where vulnerability is very high (due to the fact that there is no room for maneuver). Moreover, regions can be affected by more than just one impact, sometimes positively, sometimes negatively. As we saw, they can also be affected by impacts taking place in other regions.

We can also find fault with results generated by the vulnerability map, asserting e.g. that it appears astonishing that areas surrounding Zurich show low adaptive capacity even though this a wealthy and well-off area, possessing all the infrastructure and resources necessary to face climate change impacts. We would nonetheless mention the fact that what is depicted here is a relative score. Adap-

[73] Based on the survey, changes in snowpack reduction and the increase in frequency and intensity of natural hazards are among the already strongly perceived impacts, whereas others are foreseen for the future but are less felt now.

tive capacity in these regions is not necessarily low, but is *lower* than in other regions in the country. At the international level, the adaptive capacity of these regions is certainly among the highest. As we saw in Section 4.5.7.2, adaptive capacity can be low (compared to others) both in very vulnerable regions (being the cause of the present high vulnerability) and in regions that are not vulnerable at all (because there was no need to develop adaptive capacity). Low adaptive capacity can be evidenced, for example, by the absence of studies on climate impacts in the region and by little past action undertaken by the tourism sector in this direction.

4.6.2 Temporal development of vulnerability

As we saw all along this chapter, there is a temporal component of vulnerability that merits attention. Temporally speaking, future vulnerability is a function of future exposure (E_{t+1}), future sensitivity (S_{t+1}), and dynamic adaptive capacity ($AC_{[t;t+1[}$) (Equation (5), Figure 4.25).

$$V_{t+1}= f(E_{t+1}; S_{t+1}; AC_{[t;t+1[}) \quad (5)$$

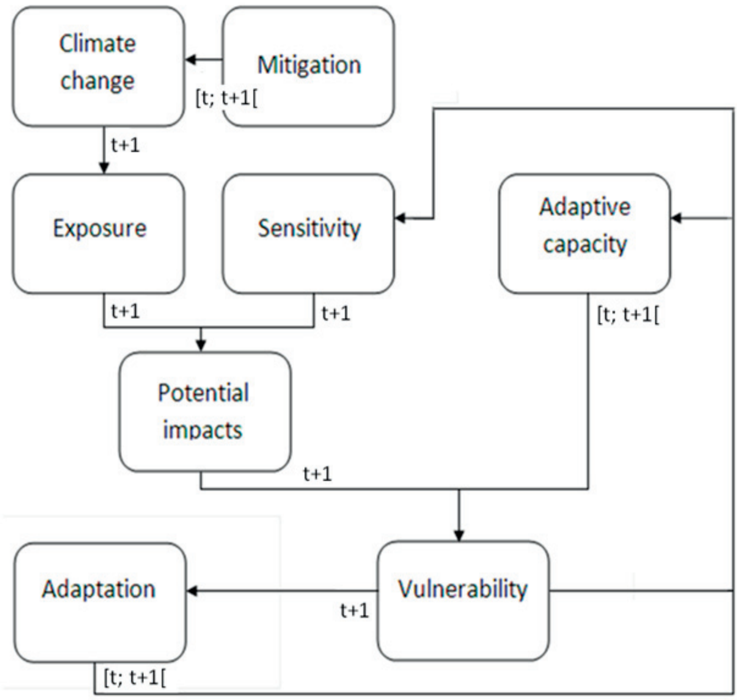


Figure 4.25: Components of vulnerability to climate change (exposure, sensitivity, and adaptive capacity) in a temporal perspective and their relation to adaptation and mitigation. The letter 't' stands for the current period of time.

Present vulnerability influences future sensitivity and adaptive capacity by modifying e.g. tourism, population, economic, infrastructure, institutional, and environmental structures. Channels could be the weakening of the local economy or infrastructure, or the reduction in the local population. Present vulnerability can lead moreover to adaptation. Adaptation can influence future vulnerability as well (Figure 4.25): the more efficient the adaptation measures taken, the more sensitivity is diminished and/or adaptive capacity increased. Imagine for example a winter sport domain suffering from the lack of snowcover. If the region shifts e.g. to summer tourism, exposure to the impact will remain the same, however the sensitivity is modified (the tourism in the region is no longer dependent on this resource). In the same way, successful present adaptation measures increase the willingness to act of stakeholders and the acceptability among the local population. This operates, however, only until vulnerability has been brought to low level (the willingness to act diminishes with the region losing vulnerability). Present adaptation has then the power to reduce future vulnerability. As formulated by Downing et al. (2005): 'vulnerability is seen as the residual impacts of climate change after adaptation measures have been implemented'.

In the frame of this study we considered that a high amount of past actions taken by the tourism sector to adapt to changes strengthens both the acceptability among inhabitants for the implementation of adaptation measures and the willingness to adapt of stakeholders (Annex A.3). We did not, however, consider the consequences of past actions on sensitivity, due to the impossibility to obtain sound data on future tourism demand and supply, and on the future local population, economy, infrastructure, institutions, and environment situation.

Regarding stakeholders' perception, we could summarize the results of the CARAVAN project (Carter et al. 2010): stakeholders' perception of future vulnerability is indeed a function of future exposure, sensitivity, and dynamic adaptive capacity. However, the perception of present potential impacts plays a very important role. As stated by Holsten and Kropp (2012), present impacts are easier for stakeholders to estimate on their own.

4.7 Limitations of vulnerability mapping

Even though it provides valuable results, vulnerability mapping is not immune to limitations and drawbacks (Patt et al. 2005; Preston et al. 2011). Differences in results between calculations generated by expert opinions and the perception of stakeholders gathered in the online survey were significant. Which of them is closer to reality? As seen in Section 4.6.2, a clear answer is difficult to give, seeing that vulnerability to long-term climate change is not a directly observable phenomenon and that uncertainties related to future developments are high. In order to answer our research questions, we combined different sources of data and methods. Even if we tried to minimize them, all methods employed here carry a certain amount of both natural and epistemic uncertainties and inaccuracies. We should remember this when looking at the generated results. We present hereafter the main sources of uncertainty and the measures that we took to decrease epistemic uncertainties (Table 4.5).

Table 4.5: Natural and epistemic uncertainties related to the three method developed (vulnerability mapping, online survey, and face-to-face interviews) and measures taken to decrease epistemic uncertainty.

Phases of the vulnerability assessment	Natural uncertainty[74]	Epistemic uncertainty[75]	Measures taken to decrease uncertainty
Definition of vulnerability	Nonobservability of the phenomenon	Lack of a clear definition	
Definition of the attribute of concern		Difficulty in defining case study regions with homogeneous internal vulnerability	Literature review and discussion with various stakeholders and experts in order to delimitate regions suitable for the scope of this study

[74] Variability of the underlying stochastic process. Uncertainty is not reducible.
[75] Incomplete knowledge about the process under study. Uncertainty can be reduced by more knowledge.

Phases of the vulnerability assessment	Natural uncertainty[74]	Epistemic uncertainty[75]	Measures taken to decrease uncertainty
Definition of the hazards	Uncertainty on future exposure and the importance of different potential hazards	Choice of relevant impacts having strong direct or indirect consequences on tourism supply and demand on the chosen time horizon	Literature review, discussion with stakeholders and experts
Method 1: vulnerability mapping			
Choice of indicators	Complexity of the system – inclusion of feedback loops, scale issues, and interactions among elements	Pertinence of the chosen indicators in depicting future exposure and sensitivity, and dynamic adaptive capacity	Literature review, discussion with stakeholders and experts Selection of indicators independently from data availability. Selection based upon theoretical linkages between different drivers of vulnerability and socioeconomic phenomenon (Preston et al. 2011)
Data collection		Data gaps due to knowledge gaps and lack of information Exactitude of the data collected	Missing quantitative data partly gathered with face-to-face interviews
Data calculation	Uncertainty on future development of the exposure compared to the seven chosen impacts. Difficulty in making robust projections	Exactitude of the calculations of the various indicators chosen	Literature review, discussion with stakeholders and experts
Weighting of indicators		MCA: Subjective appraisal of a small number of people Questions related to the knowledge of interviewed people on the complexity of the relation between impacts and the attribute of concern Complexity of the methodology leading to e.g. ambiguity, incomprehension, and confusion	Robustness analysis (Section 4.4.6)
Assembling of indicators		Choice of the assembling method (e.g. multiplication of exposure, sensitivity, and adaptive capacity)	Analysis of alternatives (e.g. summing of the three components)
Interpretation of the results		Visual representation of the results Subjective interpretation	Validation against observed data (face-to-face and online survey)
Method 2: online survey			
Definition of regional vulnerability		Subjective appraisal of a small number of respondents Representativeness of the sample Difficulty in obtaining a stratified sample of stakeholders Question relates to personal perceptions Partiality of the answers (due to personal interests) Difficulty for interviewed people to have a perception of future situations	Survey sent to virtually all reachable stakeholders related to food and beverage serving services, passengers and transport services, accommodation, travel agencies, cultural services, or to communal and cantonal administrations (for a total of 8 416 email addresses). Reminder sent in order to increase the low response rate. Consideration, in the discussion, of the small sample. Analysis of the stratification of respondents
Method 3: face-to-face interviews			
Definition of regional vulnerability		Subjective appraisal of a small number of people Representativeness of the sample (representativeness of the people interviewed for the entire region and to the entire system). Partiality of the answers (due to personal interests) Difficulty for interviewed people to have a perception of future situations	Efforts in trying to interviewing more stakeholders in the same region

A first source of uncertainty relates to the definition of vulnerability. As seen in Section 4.3, vulnerability is a complex concept that has no universally accepted definition. Consensus lacks on the exact meaning of the term and its relation to resilience (Luers et al. 2003; Turner II et al. 2003; Metzger et al. 2005; Janssen and Ostrom 2006; Füssel 2007; Ionescu et al. 2009; Malone 2009; Miller et al. 2010; Costa and Kropp 2012). For example, Füssel (2007) discusses an end-point and a starting point interpretation of the vulnerability concept. The two interpretations consider, e.g., different root problems (climate change vs. social vulnerability) and starting points of analysis (scenarios on future climate hazards vs. current vulnerability to climate stimuli). The definition used in the frame of this study lies between the two of them.

Additionally, there is clearly a scale problem, both temporal and spatial, linked to the definition of the attribute of concern. Reality cannot be depicted with exactitude, not only because it is difficult to define clearly vulnerability, but also because the vulnerability of the attribute of concern inside a region is rarely homogeneous and varies among stakeholders, companies, municipalities, and over time. For example, economic feasibility is a problem at the level of firms (e.g. ski area operators), possibly for some municipalities too. How can those problems be aggregated to determine regional economic feasibility? And the other way round, it is not necessarily because the economic feasibility of a region is high and there are high financial means in the region that all concerned stakeholders have the same access to them. In order to reduce uncertainty related to this aspect and for the 85 tourism regions considered, we reviewed the literature and drew on experts’ and stakeholders’ expertise.

As seen in Section 4.6.2, future vulnerability is a function of future exposure, future sensitivity, and dynamic adaptive capacity. Uncertainties exist regarding the frequency, intensity, and distribution of future exposure, and on future sensitivity and adaptive capacity. For example, since adaptation does not occur instantaneously, the relationship between future vulnerability and dynamic adaptive capacity depends strongly on the timescale and the impact considered (Lucas and Hilderink 2004; Füssel 2007). In the frame of our study, we supposed that it is the present adaptive capacity that determines future vulnerability. We also assumed (because of the impossibility of doing otherwise due to lack of information) that present sensitivity determines future vulnerability. This is a shortcoming, because, as seen in Section 4.6.2, it is future sensitivity that determines future vulnerability, rather than the present structure of the society, economy, and environment. However, uncertainties about future socio-economic development are too big to allow for reliable projections. We made nonetheless the assumption that the relative values among the different regions will not change significantly between the present and the time horizon chosen.

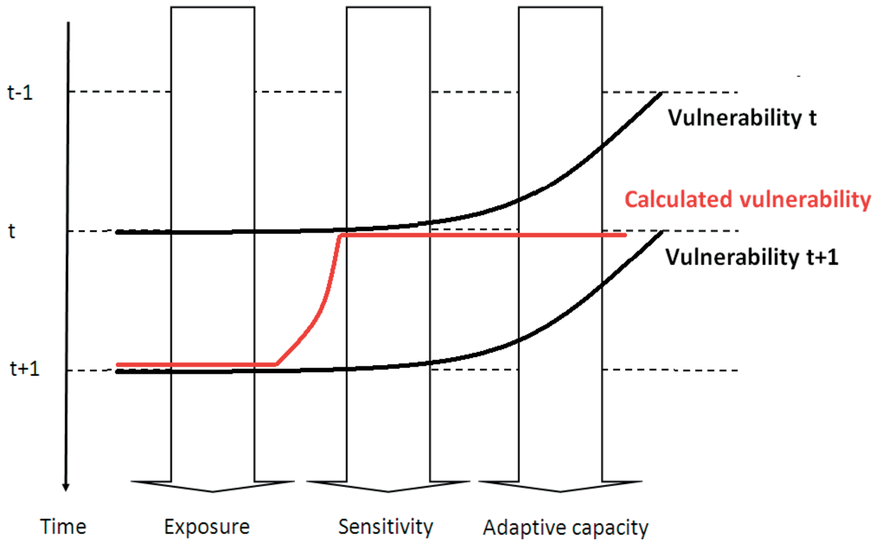


Figure 4.26: Temporal components defining vulnerability: present vulnerability is a function not only of present exposure and sensitivity but also of dynamic adaptive capacity. Future vulnerability, in the same way, is a function of future exposure and sensitivity and the dynamic adaptive capacity. In our calculations, represented by the red line, because of limits in data availability, we calculated vulnerability as a function of future exposure, but present sensitivity and adaptive capacity.

The choice of relevant impacts for both tourism supply and demand is also mired in uncertainty. We used here average scenarios for seven impacts considered to be relevant for the time-frame and the attribute of concern chosen. However other impacts could become important in the future. Moreover, we developed average projections and did not take into consideration extreme values.

Vulnerability mapping often looks at very complex systems. We did not consider interrelations, cross-scale interactions, side effects, and feedback loops between impacts, and only partly considered what lies outside the system. We did so for example for snowpack reduction and changes in climate suitability for tourism activities and the combined effects of biophysical (e.g. climate change) and socioeconomic stressors (e.g. globalization, market fluctuations).

Additionally, we assessed the impacts of climate change on a relative basis, i.e. the vulnerability of each region compared to the other ones and not the absolute risks for each of them. We can also mention the subjective choice of indicators as a source of uncertainty. Even if we made broad use of the literature on the subject and of experts' opinion in order to select the 70 indicators retained, the choice remains subjective.

The analysis of data gaps showed another limit of the method. The lack of data, and therefore information, could lead to biased results. Quantitative data were sometimes lacking, and more research and effort should be carried out to fill these knowledge gaps. When qualitative data were collected instead of quantitative data, a degree of precision was lost (because data relied on subjective perceptions and because of the limited number of responses). For some data, we found neither quantitative nor qualitative information of sufficient quality. Such entirely missing indicators represent, however, only 10% of the total weights given in the MCA analysis.

Another source of uncertainty is linked to the relative weighting of the different indicators. It relied on the appraisal, through the MCA, by a small number of experts, and not on objective and measurable data. As seen, the responses of these experts were not always homogenous and sometimes even went in opposite directions. In Section 4.4.3, we defined the 5 factors that helped us in selecting experts. We contacted people working at the Swiss level and with a very good knowledge on tourism in the country and/or climate change related topics and/or the social and economic situation in the Alps (Annex A.9). Nonetheless, knowledge generated came from personal observations and is therefore limited. Moreover, their judgments could have been influenced by subjective factors and interests. We tried to limit this bias by including experts from different domains with different interests. Moreover, the robustness analysis allowed to consider the spectrum of possible answers obtained. The MCA, even if praised as a tool for its accuracy, was often perceived by the experts as being too complicated and not very intuitive. A simple ranking might have given better results.[76]

Finally, the choice of the assembling method (Section 4.4.4) also carries uncertainty. Different methods of aggregation would have given different results. We analyzed different alternatives and selected what we considered to be the most suitable. What perhaps is missing in this study is a larger analysis of vulnerability, by e.g. using multiple alternatives related to the choice of attributes of concern, hazards, indicators, and assembling methods. We could not carry out this analysis mainly because of time constraints.

Regarding the online survey, we can mention again uncertainty stemming from the collection of qualitative data. It might be difficult for stakeholders to speak for their region as opposed to just their company or local authority, and to have a broad image of vulnerability. They may relate perhaps also more to the present situation. It is therefore possible that the map generated by the online survey is closer to present vulnerability, whereas the one developed from the indicators represents better vulnerability at the time horizon 2030-2050. Moreover, the sample of respondents could be biased. It could be that only stakeholders most concerned by the subject participated in the survey.

The small number of participants in the online survey and the resulting small number of answers for many regions makes it difficult to infer average results for these areas. Sample representativeness of the online survey is a critical component of the analysis. The survey was sent to virtually all stakeholders we could identify (a total of 8 416 email addresses) and a reminder was sent to increase the response ratio. Nevertheless, only 6.72% answered the survey.

The same is true for the face-to-face interviews with stakeholders. We selected people in regions that were already concerned by the topic. What are the perceptions in regions that are not? Moreover, we generally selected one, sometimes three, stakeholders for each region. It could be questioned, as before, whether they speak for their entire region. This is perhaps less important, because with this survey we wanted nothing more than some source of validation for our calculated map. Finally, there are limits related to the visualization and appraisal of the results. Different forms of representation could have lead to different evaluations and judgments.

We are aware of the different limitations caused by uncertainties linked to the methods employed, in particular the low number of respondents per region both in the face-to-face interviews and in the online survey. Clearly, our results should be taken with care. Nevertheless, we are convinced that there is important informative data generated by the various methods presented.

[76] It appears for example questionable that in the sensitivity analysis the local environment and institutions play a bigger role than the local tourism structure.

4.8 Conclusion

The vulnerability map created in the context of this study should not be taken as a precise assessment of the impacts of climate change on tourism in Switzerland, nor as a tool to establish where money should be allocated. As seen, the method has many limitations, and the accuracy of the results is limited. The map generated should be then seen more as an instrument allowing stakeholders to compare results with their own subjective perceptions, to define where more research should be carried out, and to discuss and share information. The final goal of the map is to raise stakeholders' awareness and to be an enticement for the starting of local adaptation processes. In addition, what we think is still missing in this research is a better definition of adaptive capacity and barriers hindering the process. The next step, presented in the following chapters, aims therefore at better defining these concepts and at collecting feedback from stakeholders.

5 The tourism sector's response: adaptation to climate change

These are the main findings of this chapter:

- Not only are Swiss tourism stakeholders generally quite aware of the impacts of climate change (Chapter 4), they are also taking measures to adapt to it;
- There are various adaptation measures being planned or already implemented, with the goal of developing the offer, reducing the risk, or increasing communication;
- Swiss tourism underwent a first wave of adaptation mostly aimed at ensuring snow sports activities. Now, a second wave aimed at diversifying and promoting year-round tourism is taking place. Communication on the impacts of climate change is also increasing;
- It is difficult to define a measure taken as solely adaptation to climate change. Often action taken is more an answer to a multitude of interrelated socio-economic factors, and climate change is only one of them.

Our case study will show that adaptation processes are very often hindered by many barriers.

5.1 Abstract

Many regions in Switzerland are particularly vulnerable to the impacts of climate change on tourism. We estimated a map of vulnerability in Chapter 4 under the premise that adaptation measures should be carried out where the greatest environmental, social, and economic damages are likely to occur. In this chapter, we analyze more in detail possible adaptation measures and processes. In the first and second part of the chapter, we make use of results of an online survey and of face-to-face interviews carried out among different Swiss stakeholders in order to define which adaptation measures exist or are planned, and which are seen as most effective. Making use of the second source of information, we also analyze how adaptation processes evolve over time. In a third part, we present a participative adaptation process carried out in the context of the ClimAlpTour project. This allows a more concrete understanding of how Swiss tourism is already adapting to the impacts of climate change and how it could further do so.

5.2 Introduction

As seen in Chapter 4, tourism regions in Switzerland are affected by various impacts of climate change and many of them are already reacting. Various studies analyzed possible and already implemented adaptation options for the sector in the country (Bürki 1995; Elsasser et al. 1995; Abegg 1996; Meier 1998; Bürki 2000; Elsasser and Messerli 2001; Hahn 2004; Perruchoud-Massy and Délétroz 2004; Abegg et al. 2007; Bürki et al. 2007; Müller and Weber 2007; Teich et al. 2007; Gonseth 2008; Müller and Weber 2008; Hoffmann et al. 2009; Lang 2009; Hill et al. 2010; Loubier et al. 2010; Abegg 2011; Lehmann Friedli and Müller 2011; Pütz et al. 2011; Rixen et al. 2011). These authors presented various possible adaptation measures, both technical and behavioural. Because the most observable impact affecting Swiss tourism until now was snowpack reduction, solutions have been proposed in the past mainly to address this impact. As it appears in the various publications mentioned above, one of the best known adaptation options in order to secure the *status quo* of winter tourism is artificial snowmaking. However, at the present time many people recognize the high costs, water and energy consumption, and the environmental impacts of this measure (Hahn

2004; Teich et al. 2007; Badré et al. 2009; Abegg 2011). As a result, it has been suggested that both more behavioral adaptation and mitigation are needed.

The aim of this chapter is to analyze more in detail the existing and possible adaptation options for the tourism sector and to evaluate their effectiveness. We address the topics from different points of view. First, we tackle it on a broader level by means of an online survey which should draw the big picture of the existing and planned adaptation measures in the Swiss tourism sector. Then, on a deeper level, we draw on face-to-face discussions designed to provide a closer insight of adaptations processes. Finally, we deal with the topic on an inside level with a participative adaptation process in a case study that allows us to analyze a recently initiated adaptation process. In sum, this chapter will:

i) provide information on the state and the type of adaptation measures in the tourism sector in Switzerland;
ii) define the process that brought about adaptation and the adaptation solutions taken in a selected number of adaptation measures.

This chapter is structured as follows: Section 5.3 provides background information on adaptation. Section 5.4 shows the outcomes of the online survey carried out among stakeholders. Section 5.5 briefly reports on the insights from the face-to-face discussions with stakeholders. Section 5.6 presents the participative process carried out in the Aletsch region. Section 5.7 discusses the general outcomes of this chapter. Section 5.8 follows with a discussion of the limitations of the various methods used. The final section concludes.

5.3 Background on adaptation

Generally speaking, adaptation to climate change is the '*adjustment in natural or human systems in response to current or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities*' (IPCC 2007b). It can therefore include measures meant to reduce sensitivity or increase adaptive capacity (Figure 4.25). Adaptation occurs through public policy-making and/or through actions taken by private stakeholders. As stated in Conde and Lonsdale (2004), it is fundamental to characterize current and possible future vulnerability in order to analyze the capacity of stakeholders to deal with and to adapt to direct and indirect impacts of climate change.

5.3.1 Different types of adaptation measures

The process of adaptation is complex and multifaceted. There are different possible criteria for categorizing adaptation measures, depending on nine axes: i) the driving force; ii) the actors; iii) the timing of action; iv) the spatial scope; v) the temporal scope; vi) the function/the effect; vii) the form; viii) the method; and ix) the valuation of the performance (Smit and Pilifosova 2001; Agrawala and Fankhauser 2008; Bosello et al. 2009). Often implemented measures are a mix of the proposed types of adaptation and can be located between the two extremes of an axis:

i. Driving force: autonomous → planned adaptation
   Autonomous adaptation is the reaction of, for example, a mountain tourism region to changing patterns of snow availability, in that it changes the type of offer (e.g. from winter to summer activities or from skiing to wellness). Planned adaptation measures are conscious policy options or response strategies, often multisectorial, whose purpose is to modify the adaptive capacity of

tourism or to facilitate specific adaptation measures. For example, financial aid for investment projects, taking the form of e.g. subsides, interest-free loans, and tax relief.

ii. Actors: private → public adaptation
Private adaptation is an action taken by a private entity (individual or firm), whereas public adaptation is an action taken by a group or government that acts to protect the group's interest (Mendelsohn and Neumann 1999).

iii. Timing of action: proactive, anticipatory → reactive, responsive
In proactive adaptation, action is taken in anticipation of future climate change, whereas in reactive and responsive adaptation, action is taken in response to observed climate impacts.

iv. Spatial scope: localized → widespread (regional, cantonal, national, international adaptation)
Local and regional adaptation considers localized problems, generated for example by snowpack reduction, glacier melting, or slope instability in a tourism resort or a region. Cantonal adaptation often consists of policy measures and financial incentives, designed to solve problems faced in different areas of the territory. Adaptation on a national or international level follows similar spatial trends.

v. Temporal scope: short term → long term
Short-term adaptation measures are meant to be a palliative solution for short-term problems; long-term adaptation often includes a reflection on the future evolution of tourism in the region.

vi. Function/the effect: retreat – accommodate – protect – prevent
The adaptation measure could be either meant to retreat (e.g. stopping ski activities in a tourism resort or ending tourism in a region with a shift to alternative sectors), to accommodate (e.g. modify the existing structure to the new situation), to protect lives and infrastructure (e.g. by means of dams and more resistant infrastructure), and finally to prevent (e.g. by means of a warning system). The IPCC (Smit and Pilifosova 2001) enumerates a list of measures that could be taken in relation to this: bear the losses, share the losses, modify the events, prevent the effects, change use, change location, research, and encourage behavioral change through education, information, and regulation.

vii. Form: structural – legal – institutional
Adaptation measures can take a variety of forms: structural reorganization (e.g. changes in strategy), the creation of a legal framework (e.g. legislation concerning natural hazards), or institutional changes (e.g. merging of neighboring ski resorts).

viii. Method: technological → behavioral adaptation
Technological adaptation focuses on measures given by technology. Examples of technological adaptation in relation to ski areas are landscaping, slope development, a move to higher altitudes and North facing slopes, glacier skiing, and artificial snowmaking. Behavioral adaptation focuses on operational practices, financial tools and new business models. Examples are year-round tourism, withdrawal, and a move towards the diversification of activities.

ix. Valuation of the performance: effectiveness – efficiency – equity – feasibility
Non-effective adaptation measures could consist of under-, over-, or maladaptation. Underadaptation takes place when climate change factors are given insufficient weight in decision making; overadaptation when, on the other hand, climate change is given too much weight. Finally, maladaptation takes place when decisions are taken that make an activity or region actu-

ally more vulnerable to climate change (Allen Consulting Group 2005). It is difficult to assess the effectiveness of adaptation measures, because their effect could be visible only after several years, decades or perhaps even centuries. Efficiency is also particularly hard to measure, since it usually implies resources spent per unit of effect, and there is no single unit in the adaptation effect (Levina and Tirpak 2006). Equitable adaptation measures are measures that also promote the welfare of the poorest members of society (Smit and Pilifosova 2001). Finally, an adaptation measure can be either politically, technically, socially, or economically feasible (or not) if there are respectively the political, technical, social, or economic conditions to allow its implementation (or not).

5.3.2 Temporal development of an adaptation process

All adaptation processes go through phases and subprocesses, starting from the perception of the impact and leading to the outcome of the action taken. Few examples of these complete processes exist, in Klein et al. (1999), Risbey et al. (1999), and Moser and Ekstrom (2010).

Klein et al. (1999) describe planned coastal adaptation to climate change as a multi-stage and iterative process composed of four basic steps: (i) information collection and awareness raising; (ii) planning and design; (iii) implementation; and (iv) monitoring and evaluation. In a similar way, Risbey et al. (1999) describe as follows the different phases of an adaptation process: (i) definition of what is signal and noise, and signal detection; (ii) evaluation; (iii) decision and response; and (iv) feedback. Finally, Moser and Ekstrom (2010) split the adaptation process in 3 phases: (i) understanding the problem; (ii) planning adaptation actions; and (iii) managing the implementation of the selected option(s). Each of these phases includes a series of stages (for a total of nine):

1. Understanding
   - i) problem detection and awareness raising;
   - ii) information gathering and use to deepen problem understanding; and
   - iii) problem (re)definition.
2. Planning
   - iv) development of adaptation options;
   - v) assessment of options; and
   - vi) selection of option(s).
3. Management
   - vii) implementation of the selected option(s);
   - viii) monitoring the environment and outcome of the realized option(s); and
   - ix) evaluation.

5.3.3 The strategy of the Swiss Confederation and the Swiss adaptation strategy

The Swiss Confederation tackles both climate change causes (mitigation) and consequences (adaptation) (FOEN 2010). Previous legislation dealing with the subject of climate change (the October 8, 1999, CO_2 Act)[77] only partially addressed the latter, and basically only in terms of financing adaptation measures in developing countries and risks prevention. On December 23, 2011, the revised law

[77] RS 641.71 'Bundesgesetz über die Reduktion der CO_2-Emissionen (CO_2-Gesetz)'.

was accepted by the Federal Parliament, and the legal bases for the Swiss climate policy for 2013-2020 were then adopted. In this new version, adaptation obtains a more important status. In particular, Article 8[78] specifically addresses the subject by asking the Confederation to coordinate a coherent national adaptation strategy.

Already in 2009, the Confederation asked the Federal Department of the Environment, Transport, Energy, and Communications (DETEC), in collaboration with the Federal Department of Home Affairs (FDHA), the Federal Department of Finances (FDF), the Federal Department of Economic Affairs (FDEA) and the Federal Department of Defense, Civil Protection, and Sport (DDPS) to analyze risks linked to climate change and to elaborate a general adaptation strategy. The final goal of the strategy was to take advantage of the opportunities created by climate change (such as greater attractiveness of higher regions in hot summers), to minimize risks, to protect people and livelihood, and to increase the adaptive capacity of the system. The high impacts of climate change on tourism were recognized, tourism being one of the nine sectors addressed, together with agriculture, health, water management, natural hazards, forestry, energy production, biodiversity management, and soil use (DETEC/FOEN 2010). The strategy was submitted to the Federal Council for approval in 2011. On March 02, 2012, the Federal Council finally adopted its first part, in which goals are formulated, challenges assessed, and measures defined (FOEN 2012). The second part, in which an action plan will be defined, will be presented by the end of 2013. This adaptation strategy should help the different departments concerned to elaborate coordinated adaptation to climate change.

Until now, the punctual and uncoordinated approach to climate change risked creating overlaps, not taking advantage of potential synergies, badly defining priorities, and therefore using the available resources in an inefficient way (DETEC 2008). Generally, the elaboration of strategies and of legislation on adaptation was sector- and problem-specific and often implicitly included in already existing legislation, particularly on forest and river protection.[79] Instruments implemented in the past consisted mostly of both technical regulation and economic mechanisms. The existing legislation mainly relates to the increase in frequency and intensity of extreme events (e.g. heat waves and storms) and natural hazards (e.g. floods and slope instability) and to the progressive changes of other factors such as average temperature and rainfall. Jurisdiction concerning adaptation to natural hazards and application of measures is generally under the purview of the different cantons and municipalities. Particularly considered are floods protection and protective forests. Adaptation to other extreme events (forest fires, avalanches, hailstorms, winter- and wind-storms) is more difficult to quantify since the existing measures are already effective. Concerning natural hazards, in the recent years, the tendency has been to pass from remediation to the reduction of their effects. Therefore more and more importance is given to the evaluation of the risks, risk mapping, monitoring, the development of technical measures, early warning systems, and the limitation of residual risks. The new adaptation strategy mentioned above includes both the adjustment and reinforcement of these mechanisms to

[78] Art. 8 'Koordination der Anpassungsmassnahmen 1) Der Bund koordiniert die Massnahmen zur Vermeidung und Bewältigung von Schäden an Personen und Sachen von erheblichem Wert, die sich als Folge der erhöhten Treibhausgaskonzentration in der Atmosphäre ergeben können. 2) Er sorgt für die Erarbeitung und Beschaffung von Grundlagen, die für die Ergreifung dieser Massnahmen notwendig sind.' (RS 641.71 'Bundesgesetz über die Reduktion der CO_2-Emissionen (CO_2-Gesetz)').

[79] RS 921.0 'Loi fédérale du 4 octobre 1991 sur les forêts (Loi sur les forêts, LFo), état juin 2006' and RS 721.100 'Loi fédérale du 21 juin 1991 sur l'aménagement des cours d'eau, état juin 2006'.

the new frequency and intensity of already existing events (floods, avalanches) and their extension to 'new' events (heat waves, drought, permafrost melting). Concerning adaptation to other factors, such as the increase in average temperature or changes in rainfall, instruments rely generally on sector-specific approaches.

Existing legislation related to adaptation for tourism principally deals with economic promotion and regional development. Its application mainly consists of supporting policies carried out at federal, cantonal, and communal level. These policies mostly refer to financial aid for investment projects taking the form of, for example, subsidies, interest-free loans, loan guarantees, tax relief, or debt forgiveness (Gonseth 2008). Different entities manage the Swiss tourism policy (Figure 5.1). The Federal Department of Economic Affairs (FDEA), and more specifically its State Secretariat for Economic Affairs - Tourism (SECO/Tourism), is in charge of the execution of tourism federal policy elaborated by the Federal Council and the Federal Parliament (Swiss Federal Council 2010). The Federal Council also approved the strategy on adaptation to climate change, which will be implemented by a multitude of actors at the national and cantonal level and which was elaborated from the Climate Policy Section of the FOEN. The Confederation delegates important tasks of tourism policy to two organizations: Switzerland Tourism and the Swiss Society for Hotel Credit (SGH), respectively a corporation and a cooperative of public rights. The first is in charge of the promotion of Swiss tourism (destination marketing), the second of helping the accommodation sector (financing accommodation investments). The Swiss Tourism Federation is the umbrella organization that groups and defends the interests of the different tourism suppliers and sectorial associations such as Hotelleriesuisse – the Swiss Hotels Association and cablecars of Switzerland (RMS). It also works closely with the SECO. A parliamentary group[80] operates for tourism and transports interests. Finally, cantonal and municipal policies are coordinated with decisions taken by the Federal Council.

[80] The Parliamentary Group for Tourism and Transport is composed of 80 members, which makes it the largest interest group in the Federal Assembly. http://www.swisstourfed.ch. Last accessed 27.09.2012.

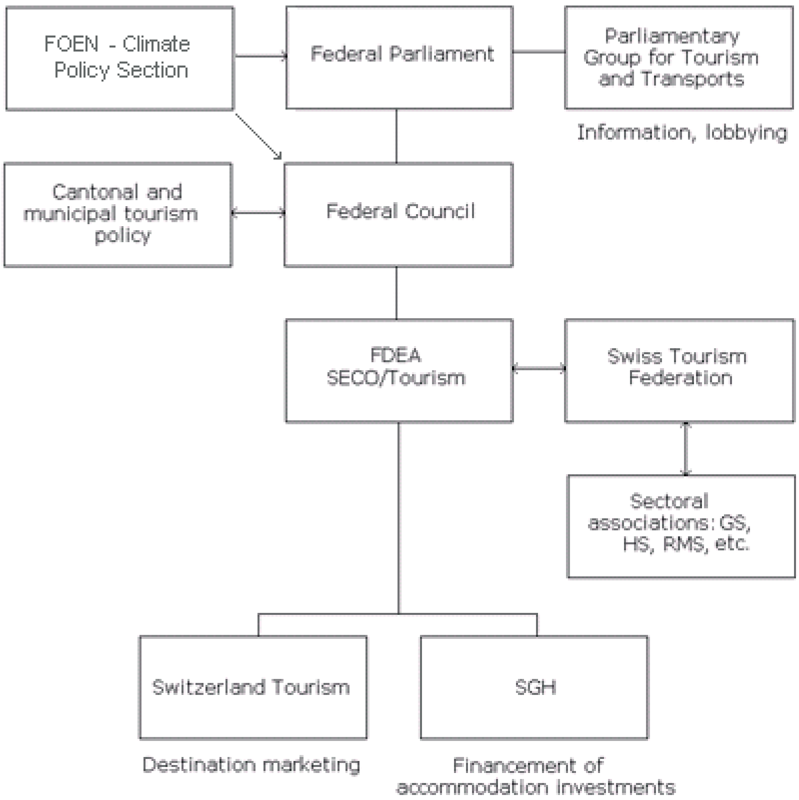


Figure 5.1: Units in charge of the Swiss tourism and climate change policy. Adapted from Swiss Federal Council (2010). FDEA: Federal Department of Economic Affairs, GS: GastroSuisse, HS: Hotelleriesuisse - Swiss Hotels Association, FOEN: Federal Office of the Environment, RMS: Cablecars Switzerland, SECO/Tourism: State Secretariat for Economic Affairs - Tourism division, SGH: Swiss Society for Hotel Credit.

On June 18, 2010, the Federal Council included climate change as one of the 5 major challenges for Swiss Tourism in the growth strategy of the sector (Swiss Federal Council 2010),[81] seing it both as a contributor and a victim. It called, therefore, for both mitigation and adaptation. This legislation was taken into consideration during the elaboration of the new Swiss adaptation strategy. As a consequence, the SECO commissioned the Research Institute for Leisure and Tourism (FIF) of the University of Bern to write a report presenting the consequences of climate change on the Swiss tourism sector and the possible options (Lehmann Friedli and Müller 2011). The report was also to identify priorities in the context of the 2012-2015 implementation program of the Swiss tourism growth strategy. Moreover, in 2007, the SECO organized, together with UNWTO, UNEP, the World Economic Forum (WEF), and the WMO the second international conference on climate change and tourism, in which the 'Davos Declaration' (UNWTO et al. 2007) was adopted (Lehmann Friedli and Müller 2011). This calls for urgent actions by governments and other actors in sustainable tourism to address the challenges brought by climate change.

In general, the Confederation, the cantons, and the municipalities try to avoid the implementation of what is called 'maladaptation': adaptation measures which contribute to enhancing climate change

[81] Together with increasing globalization, evolution of demand patterns, technologic progress, and structural deficit.

(DETEC 2007). These are for example snowmaking[82] and energy-intensive climate control of buildings. It also privileges 'no-regret' adaptation measures, '*adaptation options (or measures) that would be justified under all plausible future scenarios, including the absence of man-made climate change'* (Eales et al. 2006).

5.3.4 Possible adaptation options for Swiss tourism

Adaptation options are many and various. Müller and Weber (2008) propose in their report '2030: Der Schweizer Tourismus im Klimawandel' (2030: Swiss tourism in climate change) commissioned by MySwitzerland a list of 43 possible adaptation measures. These were divided in 3 main groups and 6 central measures:

1. Development of the offer
   i) Promoting research, innovation and diversification of tourism offers;
   ii) Further developing and securing snow sport activities;
2. Risks reduction
   iii) Improving natural hazard management;
   iv) Risk reduction through organizational measures;
3. Communication
   v) Clear positioning and targeted marketing;
   vi) Awareness rising among the population.

The accompaniment group to the report, composed of 11 persons related to the sector, scored the relative importance of the different measures. They defined as particularly important (with a score of 5 or 6 out of 6) the following measures:

Measure i):
- Diversification of the offer, with the development of new tourism activities;
- Development of wellness activities;
- Revalorization and popularization of the summer season;

Measure ii):
- Elaboration of a general concept for artificial snowmaking in order to optimize planning;
- Upward spatial development of ski resorts;
- Creation of accumulation lakes and targeted artificial snowing of slopes;
- Investment in water security;
- Extension of retention lakes for water storage;

Measure iii):
- Systematic and subsequent monitoring of areas at risk;

Measure v):
- Common development of a strategy among regions;
- Specialization on specific segments;

[82] This is a contradiction, seeing that in reality snowmaking is broadly diffused and supported by cantons (Gonseth 2008).

- Communication on climate-friendly tourism;
- Communication on snow security when this exists;
- Marketing of regional strength, making use of the 'summer freshness potential';

and finally, for Measure vi)
- Joint elaboration of mitigation and adaptation strategies.

5.3.5 Economic assessment of adaptation measures for the tourism sector

From an economic point of view, adaptation could be evaluated in terms of whether, and by how much, the benefits of such actions exceed the costs incurred (Agrawala and Fankhauser 2008). Benefits are often difficult to estimate because outputs might only be visible after several years. On the other hand, there exists a relatively large amount of literature on adaptation costs at a sectorial level (see Agrawala and Fankhauser (2008) for an overview).[83] Parry et al. (2009) published a complete analysis of the costs of adaptation. This study qualitatively discussed the estimates and illustrated the uncertainties of several recent studies reporting worldwide adaptation costs for climate change, without developing new estimates. It pointed out how under-estimation can be generated by three main factors: (i) some sectors are not included in the assessment of cost (in particular tourism, ecosystems, and energy); (ii) some sectors are included but only partially covered; and (iii) the additional costs of adaptation are calculated as 'climate mark-ups' against low levels of assumed investment. They furthermore stressed how residual damages also need to be evaluated and reported due to the fact that not all damages can be avoided (technical and economic constraints). Moreover, they stressed that a major problem is the absence of case studies on a regional or national level to test the top-down form of these worldwide analyses.

Only a small number of studies provide estimates of adaptation costs and benefits for tourism. They often only address the further development and securing of snow sports activities (Agrawala and Fankhauser 2008; Parry et al. 2009). Researchers often omit the promotion of year-round tourism, innovation and diversification of tourism offer, and the benefits that could be generated. Mathis et al. (2003), Hahn (2004), Perruchoud-Massy and Délétroz (2004), Zurschmitten and Gehrig (2004), Teich et al. (2007), Agrawala and Fankhauser (2008), and Lang (2009) assessed the costs and benefits of adaptation measures in the winter tourism industry and some of the costs provided for technological adaptation. Behavioral adaptation is also addressed, but is more difficult to assess in monetary terms. Examples of technological adaptation costs are given hereafter:

- protection of glaciers with white sheets: 3 Euros/m^2 (Agrawala and Fankhauser 2008);
- extension of ski areas to higher elevations in Switzerland: 25-30 million Euros (Mathis et al. 2003);
- investment costs for snowmaking material in Switzerland up to 2003: 500 Mio. CHF (Mathis et al. 2003); in 2006-2007 only: 409 Mio CHF (Lang 2009); for each km of slopes: 750 000-1 000 000 CHF (Lang 2009);
- estimations of investment costs for snowmaking in Valais (if 12% of the slopes would be additionally artificially snowed)[84] 210 Mio CHF or 840 000 CHF/km (Zurschmitten and Gehrig 2004);
- production of artificial snow: 1-5 Euros/m^3 (according to the Association of Austrian Cableways in Agrawala and Fankhauser 2008), or 3-5 Euros/m^3 or 136 000 Euros/ha (Hahn 2004);

[83] General studies on world-wide costs of adaptation: Stern (2006); Oxfam (2007); and World Bank (2009).
[84] Nowadays 420 km (or 21%) of Valais slopes could be artificially snowed (Zurschmitten and Gehrig 2004).

- operational costs for producing artificial snow in Switzerland: 19-32 000 Euros/(km year) (Mathis et al. 2003); 20-30 000 CHF/(km year) (Lang 2009); in sum, for Switzerland, 7-10 Mio CHF are spent yearly to cover the energy costs of artificial snow (Lang 2009);
- operational costs for producing artificial snow in Valais: 50 000 CHF/(km year) (or 49 000 and 52 000 CHF/(km year) with respectively good or bad winter conditions); this corresponds to approximately 8.5% of the income generated dedicated to this effect (Zurschmitten and Gehrig 2004);
- construction costs for reservoir lakes: 1.5-2.5 Mio CHF for lakes with a capacity of 30- 50 000 m^3 and 3.0-3.5 Mio CHF for lakes with a capacity of 80 000 m^3 (Lang 2009).

Gonseth (2008) analyzed the level of investments towards snowmaking facilities and the future commitment of cantonal authorities in the adaptation process. He found that the overall financial support (the overall equivalent subsidies) reached 12.5 Mio CHF_{2006} in 2006.

The adaptation measures presented above are not necessarily sustainable in the long term (e.g. due to high energy and water consumption, ecosystem degradation) and could generate negative externalities. These externalities have not been taken into account until now. Their inclusion could increase costs significantly (Agrawala and Fankhauser 2008). Finally, what is really missing in these values is a more global view. As seen, tourism is not a closed but an open system, part of a bigger structure, intimately linked to other sectors and to other regions. Therefore, costs could be gains for other segments of the society and adaptation measures could have spillover effects in the region. General equilibrium models take this aspect into account. A study carried out by Faust et al. (2011) looked at this aspect, considering the costs of climate change on Swiss tourism and on other Swiss sectors particularly affected by climate change. They found that autonomous adaptation (mainly artificial snowmaking) could decrease costs of climate change for the sector and that generally Swiss tourism will benefit from the relatively worse impacts in the neighboring countries in relation to snowpack reduction. Nonetheless, they outlined the important ecological impacts that this measure implies.

5.4 Stakeholders' perceptions on adaptation in the Swiss tourism sector: results from the online survey

In this chapter three different sources of information are employed: the online survey presented in this Section, the face-to-face interviews presented in Section 5.5, and the participative adaptation process presented in Section 5.6.

5.4.1 Data and methods

We collected data on the past, current and future adaptation measures and processes through an online survey carried out between the November 2, 2011, and January 4, 2012, in which 566 tourism stakeholders took part (Section 3.1.3.3). The survey attempted to obtain information on these questions in relation to adaptation in the tourism sector in the region of activity of each respondent:

- the different sets of adaptation activities which have been implemented in the past, which are currently being implemented, or which will be implemented in the future and their effectiveness;
- possible other adaptation measures that could be implemented;
- the reasons for not having undertaken adaptation;

- the existence of short- and long term development measures and the possible consideration of adaptation and mitigation aspects in it;
- the use of available information by stakeholders.

The survey and its complete results are respectively presented in Annex A.13 and in the wiki (Annex A.18).

We used here a classification of possible adaptation options similar to the ones presented in Section 5.3.4. This was first developed in a very similar way by Kruse et al. (personal communication). This classification is composed of 3 groups and 7 classes of measures:

1. Development of the offer
   - i) Promotion of year-round tourism and innovation and diversification of tourism offer;
   - ii) Further development and securing of snow sports activities;
2. Risk reduction
   - iii) Improvement of natural hazards management;
   - iv) Monitoring of the impacts of climate change on the tourism sector;
   - v) Use of insurance instruments;
3. Communication
   - vi) Promotion of research and development projects in order to actively participate in climate change adaptation of tourism;
   - vii) Information of tourists about climate change impacts.

These 7 classes of measures are further composed of 12 subclasses. In Table 5.1 these are classified following the characterization given at the beginning of this chapter (Section 5.3.1).

Table 5.1: Classification of the 7 classes of measures. We present the nine following characteristics: answer to which impact [1: changes in climate suitability, 2: snowpack reduction, 3: glaciers melting, 4: permafrost melting - rockfall, 5: natural hazards, 6: water scarcity - drought, 7: changes in scenic beauty], driving force [A: autonomous, P: planned], actors [Pr: private, Pu: public], timing of action [Pro: proactive, R: reactive], spatial scope [L: localized, W: widespread], temporal scope [Sh: short-, M: middle-, Lo: long-term], function/the effect [Re: retreat, Ac: accommodate, Pro: protect, Pre: prevent], form [St: structural, Le: legal, I: institutional], and method [Te: technological, Be: behavioral].

	Answer to which impact	Driving force	Actors	Timing of action	Spatial scope	Temporal scope	Function/the effect	Form	Method
i) Promotion of year-round tourism and innovation and diversification of tourism offer									
Increase of the attractiveness of the region by emphasizing regional specialties	1, 2, 3, 7	A/P	Pr/Pu	Pr/R	L	Lo	Ac	St	Be
Development of year-round tourism offers that are climate and weather independent	1, 2, 3, 7	A/P	Pr/Pu	Pr/R	L/W	Lo	Ac	St	Be
Creation of new summer attractions	1, 2, 3, 7	A/P	Pr/Pu	Pr/R	L/W	Lo	Ac	St	Be
Improvement of learning opportunities and cultural offers	1, 2, 3, 7	A/P	Pr/Pu	Pr/R	L/W	Lo	Ac	St	Be
Development of spa programs and promotion of health specific aspects	1, 2, 3, 7	A/P	Pr/Pu	Pr/R	L	Lo	Ac	St	Be
Withdrawal from ski tourism at lower elevations	2	A/P	Pr/Pu	Pr/R	L/W	Lo	Re	St/I	Be
ii) Further development and securing of snow sports activities									
Securing snow-reliability by using additional snowmaking equipment	2	A/P	Pr/Pu	R	L/W	S/M	Ac	St	Te
Construction of reservoirs for water supply of artificial snowmaking	2, 6	A/P	Pr/Pu	Pr/R	L	S/M	Ac	St	Te
Cooperation or merger of cableway companies	2	A/P	Pr/Pu	Pr/R	W	M/L	Ac	I	Be
Extension of existing ski areas to higher elevations	2	A/P	Pr/Pu	Pr/R	L/W	M/L	Ac	St	Te
Building new high-altitude ski areas	2	A/P	Pr/Pu	Pr/R	L/W	M/L	Ac	St	Te
Promotion of glacier skiing	2	A/P	Pr/Pu	Pr/R	L/W	M/L	Ac	St	Te
iii) Improvement of natural hazards management	4, 5	P	Pu	Pr/R	L/W	L	Pr/Pre	St/Le/I	Te/Be
iv) Monitoring of the impacts of climate change on the tourism sector	All	A/P	Pr/Pu	R	L/W	L	Pr/Pre	St/Le/I	Te/Be
v) Use of insurance instruments	2,4,5	A/P	Pr/Pu	Pr	W	L	Pro	St/Le/I	Be
vi) Promotion of R&D projects in order to actively participate in climate change adaptation of tourism	All	A/P	Pr/Pu	Pr/R	L/W	L	Pr	St/I	Be
vii) Information of tourists about climate change impacts	All	A/P	Pr/Pu	Pr/R	L/W	L	Pre/Pro	St/I	Be

5.4.2 Outcome of the survey

As seen in Section 4.5.7.1, almost all stakeholders who participated in the online survey agreed in saying that impacts of climate change are already visible in their region and will continue to be si in the future. Only 4% affirmed that no impacts of climate change are visible now in their region, while only 1% responded that they would not be effective in the future. Shrinking glaciers, decrease in snow reliability, and the increase in frequency and/or magnitude of extreme events were the most cited impacts for the present. For the future, the principal expected changes are the increase in mean annual temperature, the general decrease in snow reliability, and the increase in frequency and magnitude of extreme events, followed by the shrinking of glaciers.

All these impacts will have consequences for the tourism sector. Mentioning again Section 4.5.7.1, 45% of stakeholders affirmed that climate change creates problems for the tourism sector in their region already today. 62% of the respondents, on the other hand, asserted that problems would exist in the future. It is therefore natural that the sector is already taking measures to face these changes. The survey showed that a variety of activities have already been implemented, are currently being implemented or will be implemented in the future to adjust the tourism sector to the impact of climate change. We present respondents’ answers in Figure 5.2, Figure 5.3, and Figure 5.4 below.

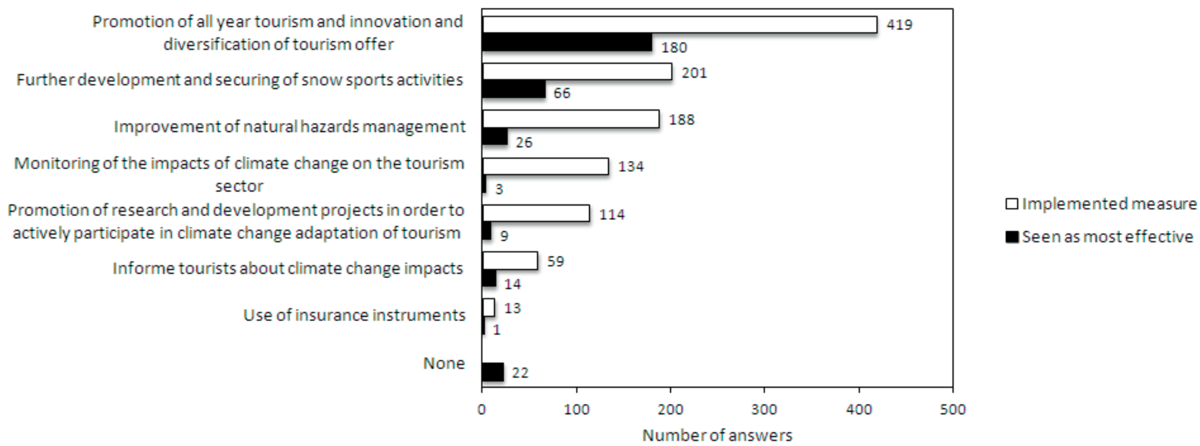


Figure 5.2: In white: number of answers to the multiple-choice question (N=553) “A set of activities to adjust the tourism sector to the impact of climate change is being discussed. Please select from the following list those adaptation activities that have been implemented in the past, are currently being implemented, or will be implemented in the future in your region”. In black, the number of responses to the open question “Which of the measures that have been implemented in your region do you consider as most effective?”. Note that some of these measures have not been developed specifically in relation to climate change. 293 of the 553 people who answered the first question also cited most effective measures.

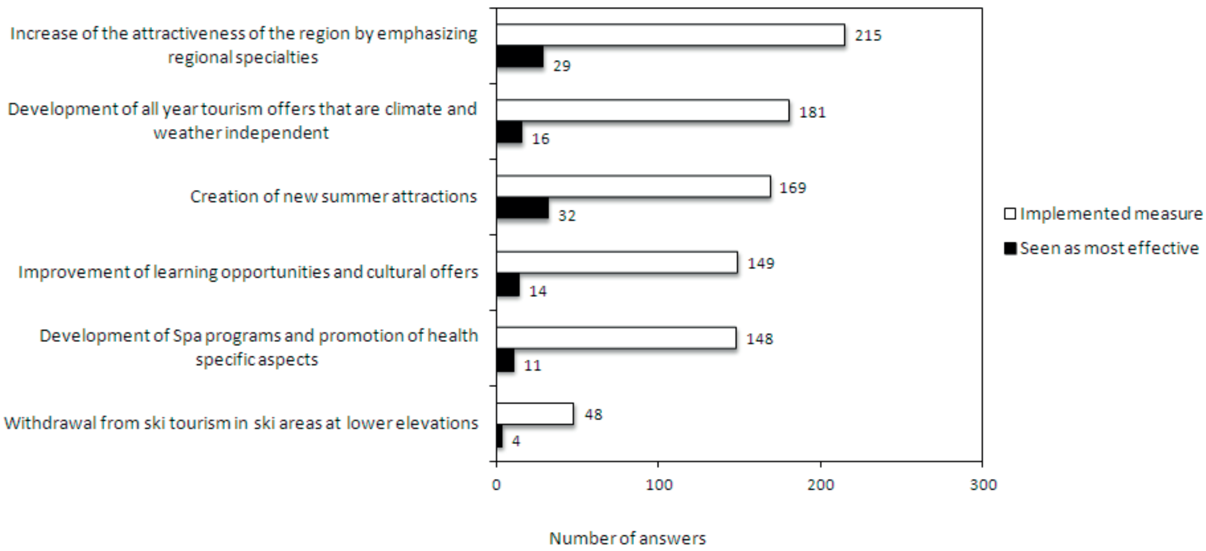


Figure 5.3: Details for the 'Promotion of year-round tourism and innovation and diversification of tourism offer' category. As in Figure 5.2, in white the number of responses for the adaptation activities that have been implemented in the past, are currently being implemented or will be implemented in the future in the region and in black for the measures that have been implemented in the region and are seen as most effective (N=419).

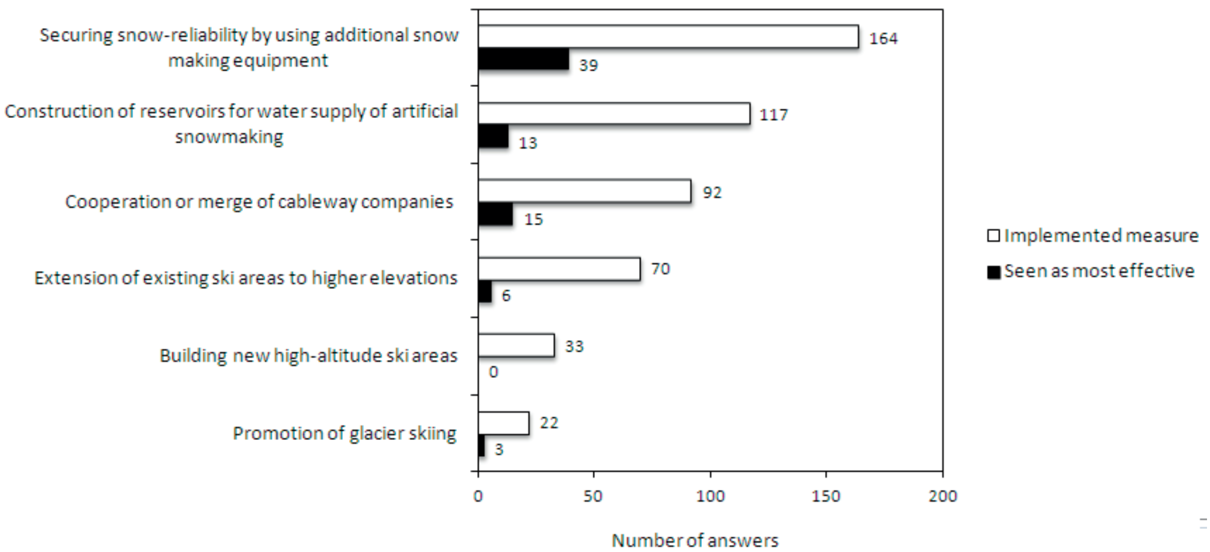


Figure 5.4: Details for the 'Further development and securing of snow sports activities' category. As for Figure 5.2 and Figure 5.3, in white the number of responses for the adaptation activities that have been implemented in the past, are currently being implemented or will be implemented in the future in the region and in black for the measures that have been implemented in the region and are seen as most effective (N=201).

The promotion of year-round tourism and innovation and diversification of tourism offer was cited by 419 respondents (from a total of 553 who answered the question) as being one of the measures that have been implemented in the past, is currently being implemented, or will be implemented in the future by the tourism sector in the region. It was the most cited measure, before the further developing and securing of snow sport activities (201), and the improvement of natural hazards management (188) (Figure 5.2).

Looking more in detail at the first category, the increase of the attractiveness of the region by emphasizing regional specialties (215), the development of year-round tourism offers that are climate and weather independent (181), and the creation of new summer attractions (169) were the three most mentioned adaptation measures (Figure 5.3). In relation to the further development and securing of snow sports activities, most cited are the securing of snow-reliability by using additional snowmaking equipment (164), the construction of reservoirs for water supply of artificial snowmaking (117), and the cooperation or merge of cableway companies (92) (Figure 5.4). Looking then at the three groups of measures presented in Section 5.4.1, the development of the offer seems to prevail on risk reduction[85] and communication.

We also asked stakeholders in an open question which of the measures implemented in their region they consider as most effective (in black in the figures). In their opinion, the most effective solutions are clearly the promotion of year-round tourism and innovation and diversification of tourism offer (43% of the respondents who selected this class of adaptation measures defined it as most effective), followed by the further development and securing of snow sports activities (33%).

Within the first category, it is the creation of new summer attractions (19%) and the focus on regional specialties (13%) that obtained the greatest share. Within the second, respondents most cited the use of additional snowmaking equipment (24%) and the cooperation or merger of cableway companies (16%). On the other hand, in relation to artificial snowmaking, 18% of the stakeholders who indicated it as an effective solution said that probably this will be so only in the short term, but that for the long term other options have to be found. In answering the question, they wrote for example:

> *"Snowmaking, but in the short term. In the long term I see it as a bad solution for some ski resorts";*
>
> *"Low-lying ski resorts that focused on years in which snow was abundant have to rethink their strategy. It was a short term vision. Snow cannons are only cures";*
>
> *"In the short term: securing of winter sports. Medium-long term: emphasize regional specialties";*
>
> *"In the short term: all the ones that have already been implemented.[86] In the long term: innovation and diversification of the tourism offer";*
>
> *"Promotion of year-round tourism, independent from snow. In the short- and medium-term the construction of artificial snowmaking at our elevation (1650-3000 m AMSL) does also make sense";*
>
> *"The development of artificial snowmaking (middle term measure until enough water is still available)";*
>
> *"In the short- and middle-term the further development of artificial snowmaking and water reservoirs (in the long term a strategy is still missing)".*[87]

[85] Perhaps also because this is taken care of by other actors.

[86] Author's note: e.g. securing snow-reliability by using additional snowmaking equipment and construction of reservoirs for water supply of artificial snowmaking.

[87] *«L'enneigement artificiel mais à court terme, à long terme je vois ça comme une mauvaise solution pour certaines stations»; «Les stations de basse altitude qui ont misé sur des années où la neige était abondante doivent repenser leur stratégie. Ce fut une vision à court terme. Les canons à neige ne sont qu'un palliatif»; «Kurzfristig: Sicherung des Wintersports. Mittel- Langfristig: Betonung regionaler Besonderheiten»; «Kurzfristig jene, die bereits ergriffen worden sind (nda: Securing snow-reliability by using additional snowmaking equipment; construction of reservoirs for water supply of artificial snowmaking, etc.), längerfristig die Innovation und Diversifikation des touristischen Angebots»; «Förderung des Ganzjahrestourismus, unabhängig von Schnee. Kurz- und mittelfristig macht der Ausbau der mechanischen Beschneiung in unserer Höhe (1650 - 3000 m.ü.M) ebenfalls Sinn.»; «Développement de l'enneigement artificiel (mesure à moyen terme tant qu'il y aura assez d'eau)»; «Kurz- und mittelfristig: Ausbau der künstlichen Beschneiung, Speicherseen (langfristig fehlt noch eine Strategie)».*

For 22 respondents, none of the implemented actions are effective. Finally, 23 respondents indicated measures designed to offer a more sustainable and soft tourism[88] (as for example the promotion of soft mobility and renewable energies) as the most effective adaptation measure undertaken.

When asked in an open question which other adaptation activities or measures they think are feasible in the tourism sector of their region by 2020, respondents mostly cited measures meant to promote year-round tourism and innovation and diversification of tourism offer (48% of the 206 responses) (Figure 5.5). In this category, stakeholders mainly mentioned the creation of new summer attractions (15%), followed by the increase of the attractiveness of the region by emphasizing regional specialties and the development of year-round tourism offers that are climate and weather independent (both 5%). Another activity cited (which we did not directly suggest in our questions) is the development of low-impact, long-term, and sustainable solutions (31%). Here in particular 10% of the 206 respondents cited the promotion of public transports and/or improvement of the existing transport system; 8% mentioned energy saving measures and/or the use of renewable energy. A third activity seen as feasible is stronger regional and cantonal/private and public cooperation. This is perceived by 10% of the respondents as a feasible measure in their region. Communication (seen mostly as awareness rising among the population, tourists, and stakeholders) was mentioned, on the other hand, by 7% of the respondents and attained the same importance as the further developing and securing of snow sports activities. 3% of the respondents mentioned in particular the securing of snow-reliability by using additional snowmaking equipment.

As it also appears in Figure 5.5, the development of soft tourism and of long-term, sustainable solutions was seen both as effective and feasible. Cooperation and communication, as well, stood out as activities that could be fostered more in the future.

[88] We use the term 'soft tourism' to indicate a form of tourism that has low impact on the environment and on the society.

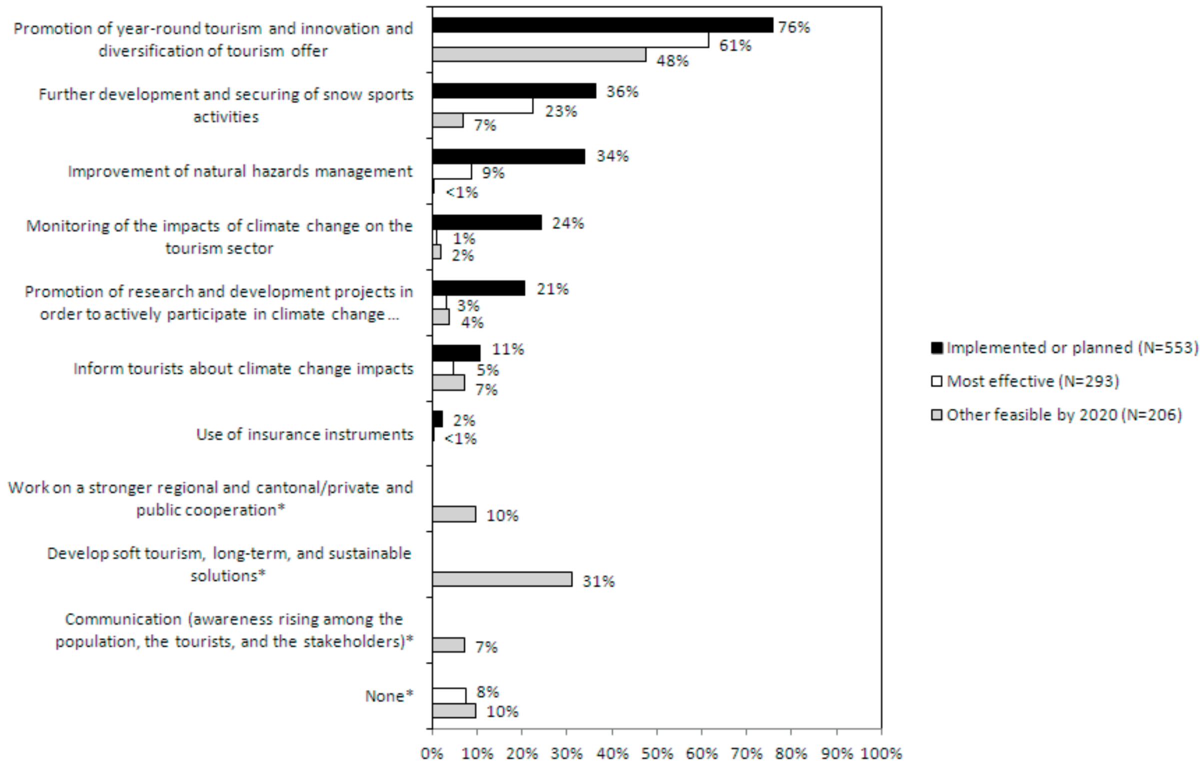


Figure 5.5: Comparison of the results for the three questions concerning implemented or planned, most effective, and other solutions feasible by 2020. For each question, we present here the percentage of responses for the different answers. Stars * indicate answers which we did not initially give as a choice. The question related to the most effective measures and the one on possible other measures that could be feasible for 2020 were open ones. Stakeholders had then the possibility to freely express themselves. Not all 556 people interviewed answered all questions (respectively N=553, N=293, and N=206).

In the past, when no adaptation measure to climate change was taken, this was mainly due to the fact that there was too much uncertainty concerning the impacts (55% of the respondents) (Table 5.2). Other reasons are the fact that stakeholders did not think about this possibility (20%), they did not know how to do it (13%), that they were not affected (8%), and that they did not believe in climate change (6%). Additional answers given are presented in the wiki (Annex A.18).

Table 5.2: Answer to the question "If no adaptation measures to climate change have been taken in your region, why?" In this question, we gave the possibility to select multiple answers and to indicate other reasons (N=227).

	Count	% respondents
There is too much uncertainty concerning the impacts of climate change	125	55%
We have not thought about it	45	20%
We don't know how do to it	29	13%
We are not affected	19	8%
We don't believe in climate change	14	6%
Lack of economic means	8	4%
I don't know	7	3%
Lack of coordination	6	3%
Lack of motivation	2	1%

Adaptation measures could be part of a strategy or not. From the survey, it appears that often general short/long term strategies for tourism exist in the region (43% of the respondents answered positively, against 21% who stated that no adaptation strategy exists) (Figure 5.6). Among the positive responses, 11% of the respondents affirmed that both adaptation and mitigation strategies are included, for respectively 43% adaptation and 14% mitigation strategies are included, whereas for 32% strategies integrate neither adaptation nor mitigation.

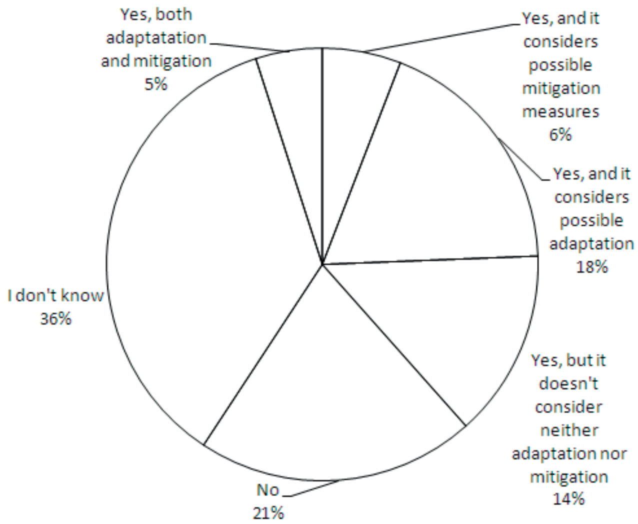


Figure 5.6: Answers to the question "Generally speaking, does the tourism sector in your region have a short/long term strategy? And if so, does it consider adaptation to the impacts of climate change (e.g. moderate potential damages, take advantage of opportunities, or cope with the consequences) or possible actions to reduce greenhouse gas emissions (mitigation)? Several answers are possible" (N=562).

The last section of the survey addressed what stakeholders know about climate change. They generally perceive the available information about the impacts of climate change on their region as being sufficient (37%) or partly sufficient (35%) to plan and implement activities to adapt to climate change (Figure 5.8). For 20% of the respondents, however, information is still lacking. What they ask for are mainly regional climate change scenarios (55% of the respondents), regional climate impact studies (39%), and vulnerability assessments (38%). For 5%, no further information is needed, often because the existing information is felt as sufficient (Figure 5.9). Stakeholders get mostly their information from newspaper (87% of the respondents), television (70%), and radio (56%). Nonetheless, 40% of the respondents affirmed making use of academic literature, 36% of internal sources of information, 12% of invited scientists, and 10% of external consultants in order to gather information about climate change (Figure 5.7).

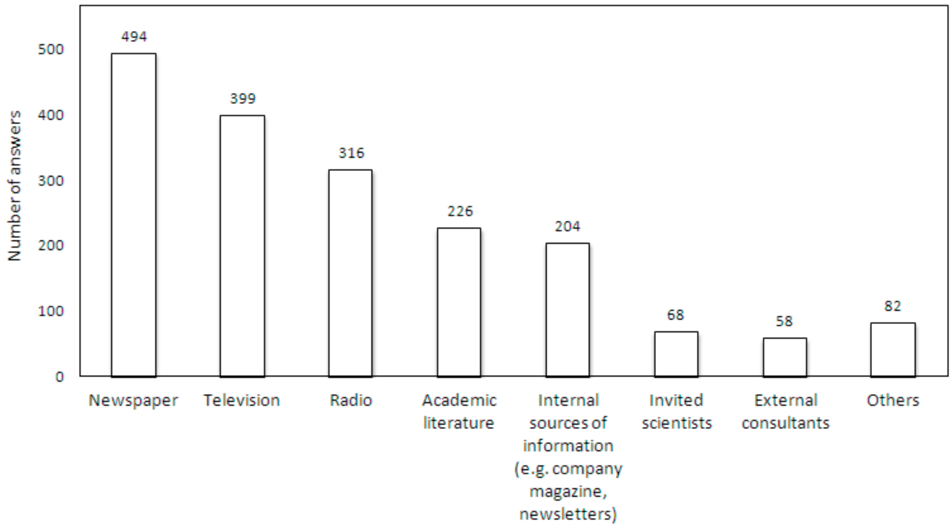


Figure 5.7: Answers to the question "How do you gather information about climate change and possible coping strategies and activities? Multiple responses are possible" (N=566). Respondent did not give further specifications in relation to the open question 'Other answers'.

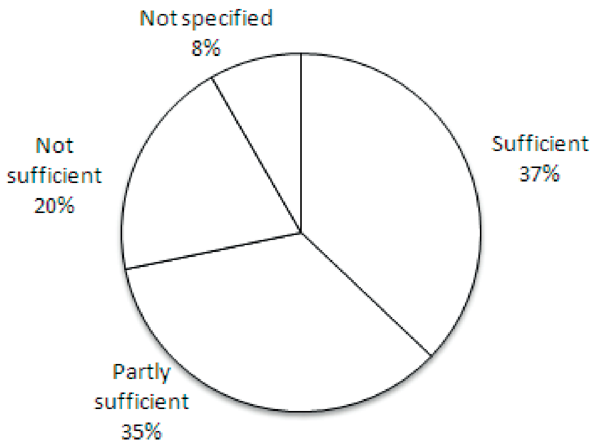


Figure 5.8: Answers to the question "Is the available information about the impacts of climate change on your region sufficient to plan and implement activities to adapt to climate change?" (N=566).

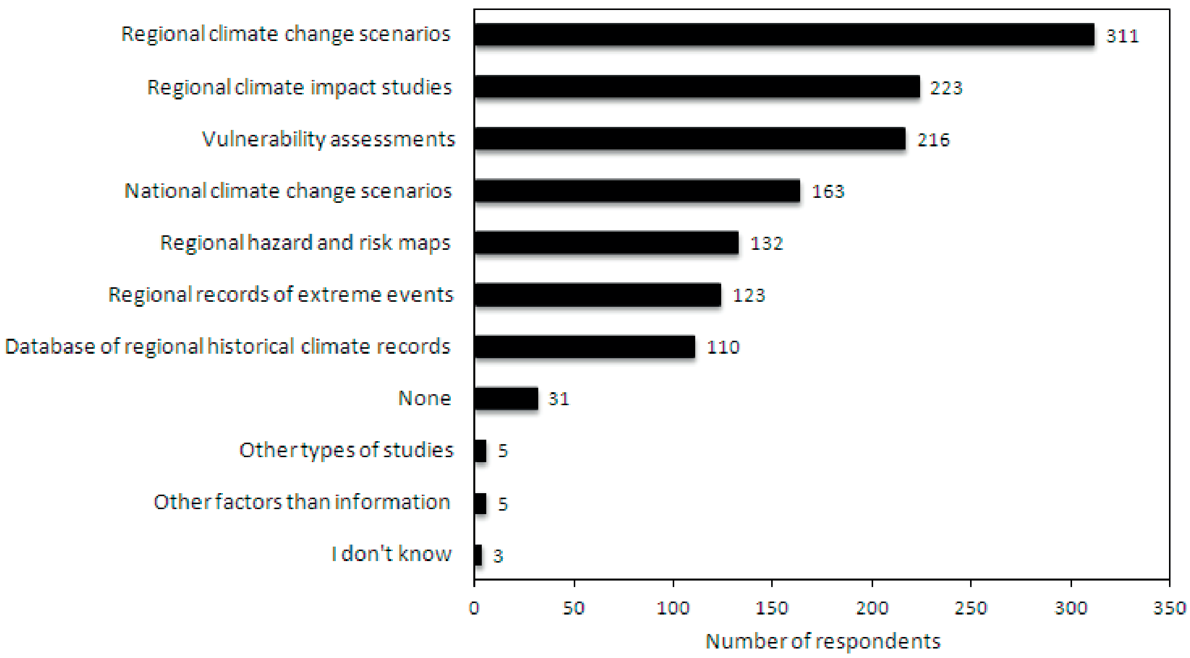


Figure 5.9: Answers to the question "Which other information would you need to plan and implement activities to cope with climate change? Multiple responses are possible" (N=566).

5.4.3 Discussion on the results of the online survey

We carried out the online survey among the various Swiss tourism stakeholders to obtain a better picture of adaptation processes going on in the tourism sector in the country. Outcomes illustrated how the sector is already strongly aware of the changes taking place as a result of climate change, and how it generally keeps itself informed. They do this, however, mainly by making use of common information channels and second-hand information. Results also showed that adaptation is already taking place all over the country, also because pushed by other factors as international competition, changes in habits, and environmental concerns.

The promotion of year-round tourism is one of the most important measures that is already being taken up or planned. It was also defined as one of the most effective. This perhaps suggests not so much a shift back to a predominance of summer tourism (Figure 5.10) but instead an equal promotion of the four seasons, focusing on diversification and innovation. A question mark remains nonetheless on the financial viability in regions where the goose that lays the golden eggs represented by the skiing sector comes to disappear, given also the competition from abroad and from other forms of tourism.

The further developing and securing of snow sports activities was and still is an important adaptation measure being undertaken. It is perhaps the most visible and discussed one. Nonetheless, when stakeholders are asked to evaluate its effectiveness, they seem to indicate that this is really effective only in the short- and middle-term, bridging the shift to other forms of tourism.

Concerning the availability of information, the survey shows that stakeholders have access to general information on climate change. What they would like to see, perhaps, is more specific, honest and pertinent information on the regional effects of the phenomenon and on the real consequences that it will have on their work. The principal channels to gather information presently used by stakeholders are perhaps not the most adequate ones. Newspapers, television, and radio provide second-hand general information. *Ad-hoc* conferences and publications, in addition to invited scientists or external consultants could perhaps better answer stakeholders' needs.

The relative importance given to the different measures by the focus group to the Müller and Weber (2008) report corresponded rather well with our results. Differences were to be found however in relation to the upward spatial development of ski resorts (less effective than what might initially be suspected because of the need for greater depth of snow to ski on rocky terrain).

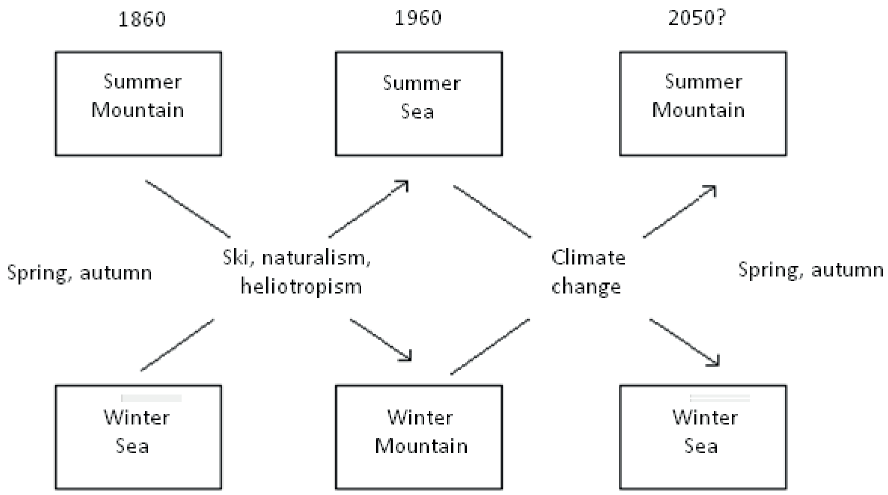


Figure 5.10: Towards a new seasonal reversal of tourism polarities? Adapted from Bourdeau (2009).

5.5 Ongoing adaptation: results from the face-to-face interviews

As seen in Sections 3.1.2.2 and 3.1.3.4, we interviewed stakeholders coming from 13 tourism resorts between July 27, 2011, and October 12, 2011. Adaptation measures undertaken in these areas are very wide-ranging, going from artificial snowmaking to a shift to summer tourism passing by the construction of protection dams. An attempt to classify them along the definitions given in Section 5.3.2 is presented in Table 5.3. In the two following sections we let stakeholders describe the adaptation process they undertook. We look in particular at the understanding-planning-implementing-managing phases presented in Figure 5.11. We translated, when needed, responses into English and marked them with a * in the text. The text in the original language can be found in Annex A.16.

Table 5.3: Characterization of the 13 case study regions addressed in the face-to-face interviews according to the descriptions given in Section 5.3.2 and in Table 5.1.

Case-study region	Description of the adaptation measure	Category of adaptation	Phase
Adelboden	Wellness	Development of spa programs and promotion of health specific aspects	Planning, conception, and managing
Andermatt	No particular one yet		
Bagnes (Verbier)	Snowmaking optimization	Further development and securing of snow sports activities	Managing
Campo (Blenio)	Artificial snowmaking	Securing snow reliability by using additional snowmaking equipment	Managing

Case-study region	Description of the adaptation measure	Category of adaptation	Phase
Erlenbach im Simmental (Stockhorn)	Abandonment of ski offer focusing on other forms of winter tourism and on summer tourism	Withdrawal from ski tourism in ski areas at lower elevations - Creation of new summer attractions	Planning and managing
Grindelwald	Construction of a tunnel to catalyze water accumulated in a glacier lake	Improvement of natural hazards management	Managing
Locarno (Cardada)	Abandonment of ski offer, focusing more on summer tourism[89]	Creation of new summer attractions - Increase of the attractiveness of the region by emphasizing regional specialties	Mainly planning
Pontresina and St. Moritz	Construction of protection dams, artificial snowmaking	Improvement of natural hazards management - Cooperation or merger of cableway companies - Further development and securing of snow sports activities	Managing
Saas Fee	No particular one yet	Promotion of research and development projects in order to actively participate in climate change adaptation of tourism - Monitoring of the impacts of climate change on the tourism sector	Understanding, planning
Sattel	Higher focus on summer tourism	Creation of new summer attractions - Further development and securing of snow sports activities	Managing
Schwarzenberg	Abandonment of the alpine ski offer	Withdrawal from ski tourism in ski areas at lower elevations	Managing
Wattwill (Obertoggenburg)	Not a particular one yet	Promotion of research and development projects in order to actively participate in climate change adaptation of tourism	Understanding, planning
Zermatt	Adjustment of the offer	Monitoring of the impacts of climate change on the tourism sector - Cooperation or merge of cableway companies	Planning, managing

5.5.1 Data and methods

We saw in Section 5.3.2 that the adaptation process is a chain of different phases. We slightly modify here the proposition of Moser and Ekstrom (2010) and look particularly at localized adaptation measures. We split the adaptation process in four phases (Figure 5.11): i) Understanding, ii) Planning, iii) Implementing, and iv) Managing. In the understanding phase, climate change impacts are detected/perceived, information on climate change and the possible adaptation measures gathered and the problem defined. In the planning phase, options are developed, then assessed and selected. In the implementing phase, options are put into practice. Finally, in the managing phase, these options are monitored together with the state of the environment, and lastly evaluated. This is a simplified structure, and it is important to remember that in every adaptation process some phases can be skipped or shortened, that often in a region phases overlap (i.e. some actions are in the understanding phase whereas others are already in the managing phase), and that this is a recursive process, often subject to revisions.

[89] In Cardada, the resort planned 12 measures of soft tourism, in particular the collaboration with the agriculture sector to avoid the increase of the forest and the closing up of the alpine meadows and to create an agritourism with both benefits for the tourism and the agriculture sector.

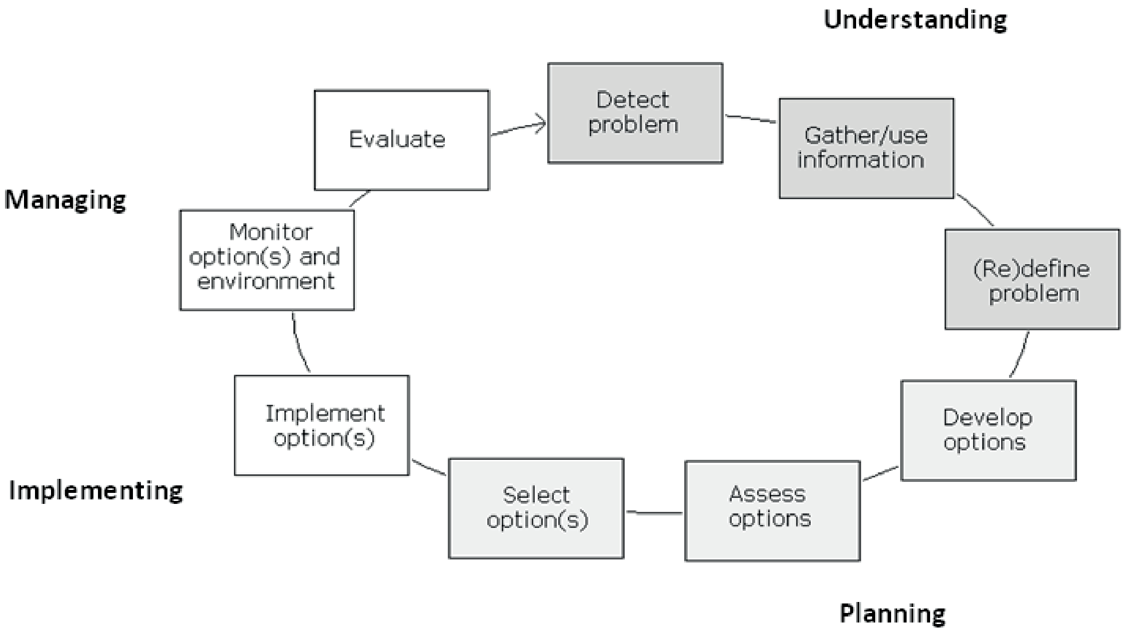


Figure 5.11: Phases and subprocesses of the adaptation process. Adapted from Moser and Ekstrom (2010).

The adaptation process can also be seen as a chain of decisions leading to the reduction of climate impacts. If no barriers hindering the process exist (and they generally exist, as seen in Chapter 6), this can be seen as follows (Figure 5.12): climate change has real impacts on tourism in a given region. Stakeholders of that region can either perceive the changes or not. If they perceive the changes, they can recognize impacts for the tourism sector either as existing or as taking place in the future. In the second case, this could simply delay the adaptation process until the impacts become strong enough to be recognized. In both cases, stakeholders can decide or not to act to address the situation. If they take the decision, they could develop adaptation measures both on the short and on the long term, leading to actions and finally to reduced impacts for the sector in the region. Adaptation could also take place unconsciously, if stakeholders do not perceive the changes and do not recognize the impacts but that nonetheless they take action to adapt to the new situation. This is for example the case of a low-lying and small ski domain that stops its winter activity because it believes that it is no longer competitive. Climate change and snowpack reduction are only one of the many reasons that it saw a decrease in competitiveness, together with, for example, increased operational costs or the changes in customers behaviors. Climate change and its impacts are therefore not necessarily recognized as causes, and adaptation to them is not fully explicit. We used here both illustrations in order to analyze the temporal development of an adaptation process.

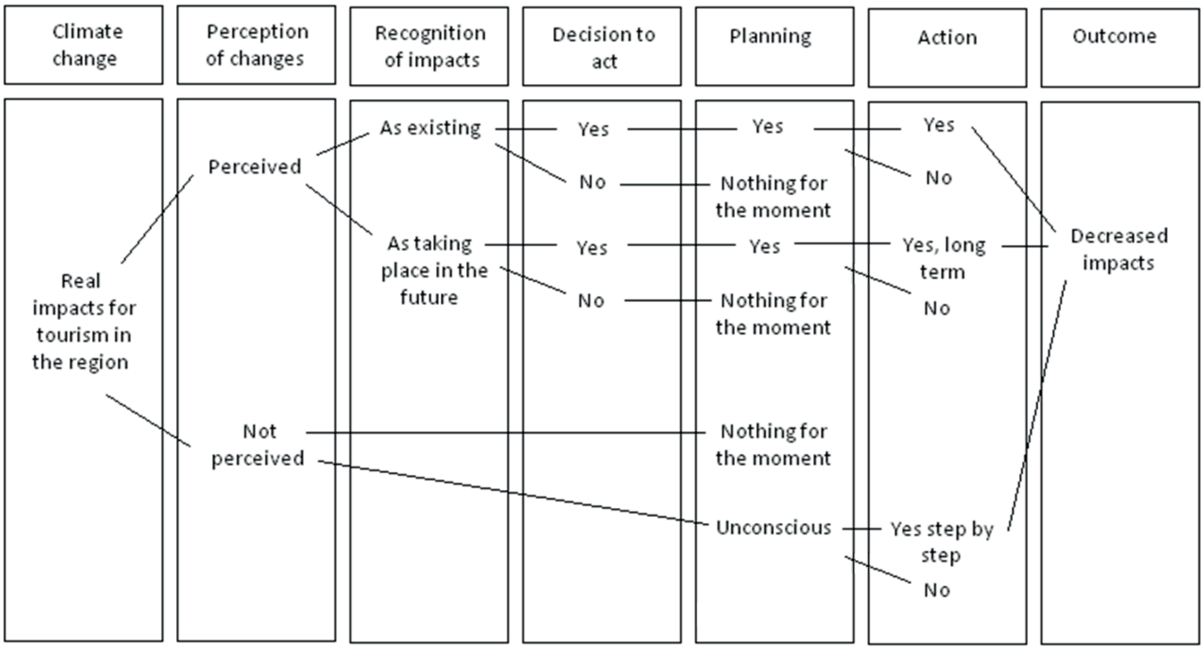


Figure 5.12: Possible process leading to adaptation and reduced impacts. 6 phases follow the appearance of climate change: the perception of changes, the recognition of impacts for the sector, the decision to act, the planning, the action, and finally the outcomes.

5.5.2 Outcomes of the face-to-face interviews

As seen in Table 5.1, many varied actions were undertaken. They are often (but not only) responses to the different impacts detected in the regions (Section 4.5.2), like snowpack reduction, glaciers melting, permafrost melting, changes in weather conditions, and the upward shift of the treeline. Stakeholder sometimes saw these impacts as important, sometimes as existing but not affecting the sector or the region, or sometimes even as beneficial to them. Nevertheless, different reasons brought them to action and different triggering factors initiated the process. Several respondents emphasized that these triggering factors were often not linked directly to climate change. For example, the member of the cableway company interviewed in Cardada admitted that climate change is a hot topic among cableway companies. He underlined, however, that the choice to change strategy and generally to give more weight to summer tourism and to diversify is often also dictated by other factors. He highlighted, for example, how the necessity to stop depending on a single season brought and brings many resorts to reconsider their strategy:

> *"It's true that Cablecars Switzerland is also very aware of the topic and that we discuss it frequently. There are ski resorts that clearly have to totally change their strategy. On the other hand, it must also be said that it is becoming increasingly necessary to have at least two seasons because the costs of the infrastructure are getting higher and higher, and so the general conditions force us to make more investments, incur more expenses, and therefore we look more and more for a double season. Therefore, we must differentiate between strategies that changed really because of the impossibility to continue a project as before and the ones in which there was also the willingness to improve the situation and to find solutions in order to reinforce the weakest season. This is a bit of a grey area."*

And to continue:

> *"We also have regions in which the situation is very unambiguous, but there are not so many of them. For example Tamaro, which was created as a winter sport resort because there was enough snow. But then it got to a point in which it was not possible anymore to continue that way for various reasons, but*

mainly because of the lack of snow […] Anyway, Tamaro is a place that really changed its strategy. In Cardada, to be honest, we didn't change our strategy that much. It's true that Cardada was born as a place for Locarnese people to go skiing. But it's also true that summer has always been the strong season. Therefore, fundamentally we didn't change our winter strategy. The only thing that we did, because the winter was always a cost that lied on the summer season, is that we decided (also for economic survival) to transfer to the ski club everything which was related to ski. This doesn't preclude that today we continue to collaborate with them."

"Facing these new meteorological conditions, you have to decide what is worth doing, whether to go in the direction of winter or in the direction of summer. I see that generally in the last years the purely winter-related cablecar companies made huge investments in order to secure the winter season. So artificial snowmaking surely generated the highest expenses for the big societies of the Alpine arch in which ski predominated. But today, these same resorts are thinking of ways to further improve their situation. And seeing that with the investments that they did they cannot further improve the situation of their winter season, they are now thinking of ways to improve their second season. This, depending on the location, could be more or less cost-effective. The luckiest are the ones that possess a strong season which represents 55% and a weak that represents 45% […] But the ones that earn 90% in a season and 10% in the other one, today for sure they won't invest anymore in the 90%, but will try to improve the 10%. Because the 90% during winter today mean that they reached the top and that they cannot go further. There, they have only to be careful to make small renovations, but mainly technical ones, in order not to let the infrastructure become too old […] These, however, are very small investments in relation to what was invested at the beginning or then for artificial snowmaking."

Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 - The president of the cableway company*

In Adelboden, the person interviewed mentioned the same. Changes and shifts to diversification and summer tourism were indeed triggered by snowpack reduction, but the need to foster summer tourism and wellness was also due to current economic conditions, to the situation in neighboring regions, and to changes in demand:

"Normally, if the season is at 100%, we have more than the half in winter and less than the half in summer. And therefore, we told ourselves that more efforts were needed for summer because, for sure, the number of beds doesn't change. And so, capacity increases. And also, the other effect is that we become a bit less dependent on winter and winter sports. I know that there are some studies that say that in 100 years there will be only two regions in Europe in which people could go skiing, or something like that. Maybe it's a bit of a black picture. But in fact yes, the development is not for us because we are at a height of 1450 m, that's it. And then, surely, mountains go to 2400 something meters. But still, we don't have mountains up to 4000 m here. And also in relation to wellness; we clearly needed a subject for the summer. So we voted for a healthy environment, for hiking, and for water. Water is very important here […] it's very present […] and because of that, we didn't have to search too far away to decide to develop wellness here."

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

And the second stakeholder continued:

"We have two main strategies. These are mainly skiing in the winter and wellness in the summer. Wellness, which doesn't mean only wellness for hotels. We also introduced the aspect of nature, the possibility for clients and local people to meet and finally, the third aspect which is the products of the farmers in the Alps […] The idea was born because we saw that we had too many products in the basket to say 'So, there we are strong and then we have these other products that others have as well'. In order to differentiate a bit from the others, we had to focus on the two of them."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

In Stockhorn, one of the two stakeholders interviewed did not define the action undertaken as brought about by climate change. The reason was more an economic calculation determined also by the bleak situation for skiing in comparison to neighboring resorts. Despite this stated reason, he still mentionned exposure to climate change towards the end:

> *"We are not shifting to summer tourism. We have our origins in the summer. But we also had ski lifts in the winter. But we stopped that in 2004 because here we are a little bit different from other areas […] one part of our slopes is very steep and it's not so easy for skiing and also the reason is that it is not always sure that we will have enough snow in this area at all times […] then we have to have the snow machines but that is a too expensive investment […] The reason to stop the skiing activity was not climate change. The reason was the economic scale for our company […] we are not involved exactly in this climate change. We did it before, the change from winter to summer. From the beginning [author's note: 1968] with the Stockhornbahn, we said that summer tourism is our business. Winter tourism was always the smallest part."*
>
> Erlenbach im Simmental (Stockhorn) (part of the Lenk - Simmental region), 25.07.2011 – Two members of the cableway company

The interviewee in Sattel explained the reasons that made the cableway company decide to keep winter sport and to continue with snowmaking, while at the same time further developping the summer potential.

> *"And it was also something to think about, talking about the cablecar company, that we think whether yes or no we will continue with winter sports at a height of 800-1600 m AMSL. I am also a member of the advisory board of the cablecar company and communal recorder. We discussed that in the company and we decided that we will continue with winter sport as before. We continue, and the consequence of this decision is that we have to snow artificially […] In 1991 the company was near bankruptcy. Then, in 1992, we issued an increase in capital stock, we constructed a summer toboggan run. This means that we noticed that the potential in the summer was really to be increased. We didn't have it before. So, we decided in 1990 that we wanted to reinforce the summer offerings in order to earn money also in this season and not only in the winter anymore […] It wasn't because of climate change, it was an economic decision. We used to have a year-round business. It winter we used to make money, when the snow conditions were good. In summer, on the other hand, we never earned much, more like nothing I'll say. […] So, when the danger of bankruptcy appeared, we thought about possible potentials that we still had. […] It was never a decision determined by climate change, one instead determined by the economic situation of the company. Though, naturally, it appears now that the decision to focus on the summer was also a good one in relation to climate change."*
>
> Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

Concerning the information used, it appears that some well-known and well-accepted scientific reports on the impacts of climate change written specifically either on or for the tourism sector (e.g. Müller and Weber 2007; Abegg et al. 2007; Müller and Weber 2008) had an influence on the process and helpped stakeholders in directing their decisions. Sometimes, as for example in St. Moritz, stakeholders are so interrelated with the research that they inevitably get informed:

> *"As I said as an own practice, own experience. And then as I said, by the mountain railway we are very open to Switzerland and also Austria. We discuss everything together, we have no secrets. We help each other so you can get practical information very easily. That, for sure, it's a thing. And then of course you can build nothing without permission. So we are always in contact with the government, with WWF, with Pro Natura and that's daily business. And then of course a lot of other studies like these here for example. And then of course for these kinds of jobs you are always involved. And I think maybe not so on the scien-*

tific level, but on a practical level yes. I mean … when Uni Bern or ETH Zurich come and make a study, where do they go? They come to us so we are always together and we have to make so many expertises for the government to get permissions. These are maybe ten thousand Swiss francs. If you read studies, then you become automatically an expert. Not because you want to, but because you have to."

St. Moritz (part of the Engadin St. Moritz region), 25.08.2011 – A member of the cableway company

Sometimes, stakeholders acted proactively and asked specifically for case studies on their region. This is for example the case of Cardada, in which stakeholders asked for the help of external researchers in order to assess the situation. In Saas-Fee, stakeholders took the opportunity to join a research project of Econcept (Bättig et al. 2011) that was already launched in order to assess the vulnerability of the region in relation to tourism and other sectors. At the moment, however, real action in response to the outcomes of the report covers the areas mainly of agriculture and water because these are seen as priorities. In Adelboden, the tourism office produced a report on the subject (Tschannen and Dänzer 2007):

"There were some studies that were made by the Canton of Bern [author's note: Müller and Weber 2007] on the consequences over the next 30 years. That's what we also did. Because we said that it wouldn't tell us anything to know how the world is going to change in 50 years and that we have to act now and then see what is going to happen in the next 25 years. And so, here in Adelboden, we did that. We said that we have to react, that we have to do something. It's not only the people who we are going to keep here, but we have also to tell people how we are going to act in relation to climate […] We asked ourselves what is going to happen in Adelboden, which steps we already took, what is going to happen without climate change, which the analyses that we made on tourism, and also politically with the municipality, what we can do with the skiing school, perhaps with the cablecar company, what hotels can do, and so on."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

From different interviews, the responsibility that researchers and information channels have in the adaptation process emerged, as did the importance of including uncertainties in the studies. Wrong previsions generate wrong adaptation and perhaps improper investments. Stakeholders sometimes mistrust information coming from the media, finding it not always objective.

"All the sources are very important for us. I also participated in some studies in which they asked experts, well technical experts, or ones from the political side. And we get the results from there. We work very closely with universities and other companies that work on problems due to climate change. The University of Bern has a long tradition of working here in Grindelwald, to make studies. […] There was a study called "Man and Biosphere" already in the 1990s'. […] I know that we have a very close relationship to all these technical schools and universities."

Grindelwald (part of the Grindelwald region), 20.09.2011 – A member of the municipality

"They say that the available time to produce snow will be shorter and then we have to strengthen our possibility to make snow on time. So, this means that we need enough water, that we have to store water. It means building lakes, not to produce more snow that we do now, but in a shorter time. Now, we snow over six weeks to two months. We have to be able to produce it in three weeks if all the experts are right. If they were wrong, we spent our money for nothing."

St. Moritz (part of the Engadin St. Moritz region), 25.08.2011 – A member of the cableway company

> *"But sometimes I have the impression that both the media and the documentaries that they show, sometimes, they show things under a worse light than what really is."*
>
> Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

As seen previously, once problems are detected and the planning defined, options are selected and finally carried out. Sometimes decisions are taken autonomously by the private sector, and sometimes they are determined by the public sector. Sometimes, the two sectors collaborate in a participative process, with or without a leader conducting the process. An example is the protection tunnel constructed over Grindelwald in order to prevent the newly formed glacial lake from flowing into the valley:

> *"There are two aspects. As you said, most of the people are in some ways involved with tourism in Grindelwald so the people who we involved directly had interest in this direction, but we also realized that the threat of danger in Grindelwald would be critical for tourist organizations. Therefore we took them all together before we made the decision.*
>
> *So, about a month after, we had this scenario here, we showed them the problem and that we had to act, in a way we didn't know at the time. But we said that we have this and that schedule, until this time we want to have some measures that would be possible and then make the decision which is the best. And that we will realize this until this and that time. And so they were involved and they knew the potential of the glacier lake, but they knew also that we were acting and that the solution would come. And then we informed them from time to time, so this was a good way to work with them. […] This was done so that we had also the support from tourist organizations in case someone would suddenly come and say 'You're not acting the right way' or who says 'It's not necessary what you do' and also it a was part of the concept of communications that we would heavily involve the tourist organizations because they are almost the most important thing in Grindelwald. You can't do anything without them."*
>
> Thun (for Grindelwald) (part of the Grindelwald region), 25.07.2011 – A member of the cantonal office (office director of the construction, transport and energy department)

Sometimes stakeholders decided to keep the *status quo* and to accommodate, while at other times they decided to shift to other options and to retreat. Sometimes, finally, as in Grindelwald or in Pontresina, stakeholders decided to protect and prevent. In Campo Blenio, as in Sattel, the decision was made to maintain the ski offer and to make use of artificial snowmaking. The interviews showed that such choices were not merely dictated by economic reasons, the measure not being cost-effective for the company, but were made to maintain the economic and social structure of the region. Stakeholders are nonetheless aware that another solution for the long term has to be found:

> *"Last year, you can write it down, at the end of January we would have closed. But thanks to artificial snowmaking we could continue until the 20th of March. But we are really much dependent on weather conditions, in the sense that without snow you don't do anything. But, as I told you before, when we work at top speed, there are more or less 30 working places plus all the things that rotate around. It is worth it to invest and to produce artificial snow. I know that the costs are high; […] then [author's note: in 1996] everything started. There, we had to decide either to stop or to do something. It's a bit like a big industry that needs millions in order to survive. For us it was something very similar. Then perhaps … we are at the end of a valley, the economy is what it is. Somehow or other we manage to keep some working places. […] You know, everything is somehow linked, people come to holiday houses, restaurants have work. It's a circle that works also thanks to a small resort like ours."*

And answering the question of whether they follow a long-term strategy or evolve step by step:

"It's a mix of both. We must go on step by step. But also the fact that we want to focus on summer, I think, is part of a strategy. It was also suggested to us. […] It's a bit what I was telling you before. Because somehow or another it's thanks to an economy like ours that a small part of the economy turns. It's true that if we do not receive help, we can hardly stand up. Actually, last year the municipality gave us a big contribution for what we did. […] We did something to adapt. We also spent a big amount of money. But we will fight until the end to keep going."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

Stakeholders did not explicitly mention monitoring and an evaluation of the measures taken during the interviews. However, during discussions with the different stakeholders, the topic of mitigation also often emerged. Many regions act more or less intensively in order to reduce their GHGs emissions and their impacts. We can cite for example Adelboden, in which stakeholders built the climate neutral hotel Engstligenalp and developed a master plan of public transportation.[90] We can also mention Grindelwald, which is part of the Jungfrau Klima-co2operation,[91] and in which people raise awareness through the Jungfrau climate guide,[92] produce clean energy for heating,[93] and proposed an improvement of the public transport system. The areas of St. Moritz (Energy City,[94] the Plusenergie-Hotel[95]) and Saas-Fee (HotelFerienArt,[96] attempts to be a fine dust free city), or Sattel (e.g. improvement of the public transport system, a wind turbine for snowmaking's energy production). All these regions also act in this direction. It is often the question of determining whether people carried out these actions as a marketing strategy, for their cost-effectiveness, or because of environmental awareness. Not surprisingly, quite often interviewees answer that it is a mix of the three components. For example, in Adelboden the stakeholder answering the question of whether the mitigation action undertaken was determined by a higher awareness to the topic or for their economic benefits, said that both are true. And in response to the question of whether tourists ask for more green tourism:

"Not for the moment, but I think that it will come soon. So, if we don't do anything today, in five years they will ask us what we did."

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

And Sattel, Saas-Fee, and St. Moritz to the question of why they did that:

"In connection with climate change. We can either not do anything, or say that we adapt because the climate will change. But on the other hand, we should also do something, or at least try to do so. Perhaps it helps, who knows. But if nobody acts, it certainly doesn't help."

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

[90] http://www.adelboden.ch/de/page.cfm/Region/EnvironmentAB/WastutAdelbodenTourismus. Last accessed 03.04.2012.

[91] http://www.jungfrauklima.ch/de/portrait/uebersichtportrait/. Last accessed 03.04.2012.

[92] http://www.jungfrau-klimaguide.ch/en/#/en/home. Last accessed 03.04.2012.

[93] http://partner.1to1energy.ch/grindelwald/de/home/ueber_uns.html. Last accessed 03.04.2012.

[94] http://www.stmoritz.ch/en/winter/village/town/energy-city.html. Last accessed 03.04.2012.

[95] http://www.muottasmuragl.ch/. Last accessed 03.04.2012.

[96] http://www.ferienart.ch/. Last accessed 03.04.2012.

"It started in 1991. I was following a seminar and it affected me. A second reason, as I already told you, it's that I have kids. A third one, that I am Christian. […] In my heart I think that we have to care, as much as we can. We cannot change everything. And then I see everyday how it's changing."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 - A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"Of course people here are maybe a little bit more sensitive about climate change since we see the effects every day. And of course, as Zermatt, you can't change the world climate but I think that people here are much more aware about it and you can also see the reactions. When, for example, people build houses in Zermatt, they start using, the majority of them, not fossil oil anymore. We usually use ground heat or solar power. I'll say that 80% of the new buildings you see are like this. Also Minergie… private people but also companies."

Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

In St. Moritz as well much is being done to decrease the emissions and to increase the awareness of the effects of climate change, with, for example, the Energy City and the Plusenergie-Hotel cited above. One of the members of the tourism office interviewed by phone explained this by saying that climate change affects all of us. Reasons are not to be found in marketing for tourism; tourists visiting St. Moritz would never call themselves green tourists. The reason has to be found more in the fact that people in the region are so linked to tourism and to the landscape of the region that they would suffer if there were more effects of climate change in the area. The same person said that 80% of the people in the region work in the tourism industry and that the process of making tourism more sustainable started in 2003, with the World Cup event, which was powered by green energy.

5.5.3 Discussion on the outcomes of the face-to-face interviews

We carried out face-to-face interviews in 13 locations related to adaptation to climate change. The goal of these encounters was to observe the diversity of measures that can be undertaken, to analyze more in detail how these started and how they evolved, to identify the triggering factors and the different phases that the processes went through. Results show that answers to the impacts are truly numerous and varied, each one tailored to the specific issue and not necessarily better or worse than another.

The interviews also showed that adaptation to climate change is seldom an action in itself. As the interviewed person in Cardada stated, often the definition of adaptation measures lies in a grey area: it is difficult to determine whether some action taken was really done specifically in response to climate change or if other factors also played a (perhaps more important) role in initiating the process. Outcomes in relation to adaptation to climate change are then sometimes simply beneficial side effects. So, if the change in strategy in Tamaro, the dams in Pontresina, and the channel in Grindelwald can quite easily be defined as adaptation actions, actions undertaken in Sattel, Stockhorn, Cardada, or Verbier are more difficult to qualify.

A second aspect is the importance and the influence played by the media and by the scientific world in driving and directing these actions and the way information flows into stakeholders' hands. Some well-known reports surely provided information and inspiration for many stakeholders. Moreover, there is often a tight collaboration between the tourism sector and researchers, which can only be applauded. Nevertheless, information not received directly but through media channels was sometimes seen as untrustworthy.

During various interviews, the interlinkage and the mutual support existing among different stakeholders and among different regions also appeared. Information and experiences are shared, and sometimes financial or technical help is given to smaller resorts. Various stakeholders are brought from the beginning into the process and information is shared transparently. In regions in which this is the case, the management seemed more effective and efficient than in other regions. Finally, what perhaps did not emerge so much from the discussion was a monitoring of the measures undertaken, perhaps because it was not asked directly, but perhaps also because it was not yet common practice.

5.6 The participative process carried out in the context of the ClimAlpTour project in the Aletsch region

5.6.1 Introduction to the participative process

Between 2009 and 2011, the ClimAlpTour project[97] worked with stakeholders from the six Alpine countries France, Italy, Germany, Switzerland, Slovenia, and Austria, in order to find concrete adaptation measures to address climate change in the tourism sector. My personal contribution to this project consisted of preparing the scientific background on the impacts for the region, participating in the organization of the workshops and analyzing the results.

In Switzerland four research centers coordinated the work. These are the University Institute Kurt Bösch (IUKB), the Valais branch of the University of Applied Sciences of Western Switzerland (HES-SO Valais), the Institute for Landscape and Open Space at the University of Applied Sciences Rapperswil (HSR), and the Institute for Tourism and Leisure Research at the University of Applied Sciences Chur (HTW). We selected three Swiss case study regions in the context of the project: the Aletsch, the Surselva, and the Pizol regions.

Even if some differences existed among the processes used in the three of them, they all rotated around rounds of workshops with stakeholders and, more generally, around participative processes. The main purpose of these participatory processes was to identify and implement adaptation measures that are feasible and practical at the local or regional level. We particularly focus here on the one carried out from December 2009 to June 2010 in the Aletsch region. We already presented the case study region in Section 3.1.2.3.

In the Aletsch region, we carried out three workshops, using them to perform a SWOT analysis. Hereafter, we give the bases to explain both methods.

[97] Climate Change and its impact on tourism in the Alpine Space.

5.6.2 The participative process

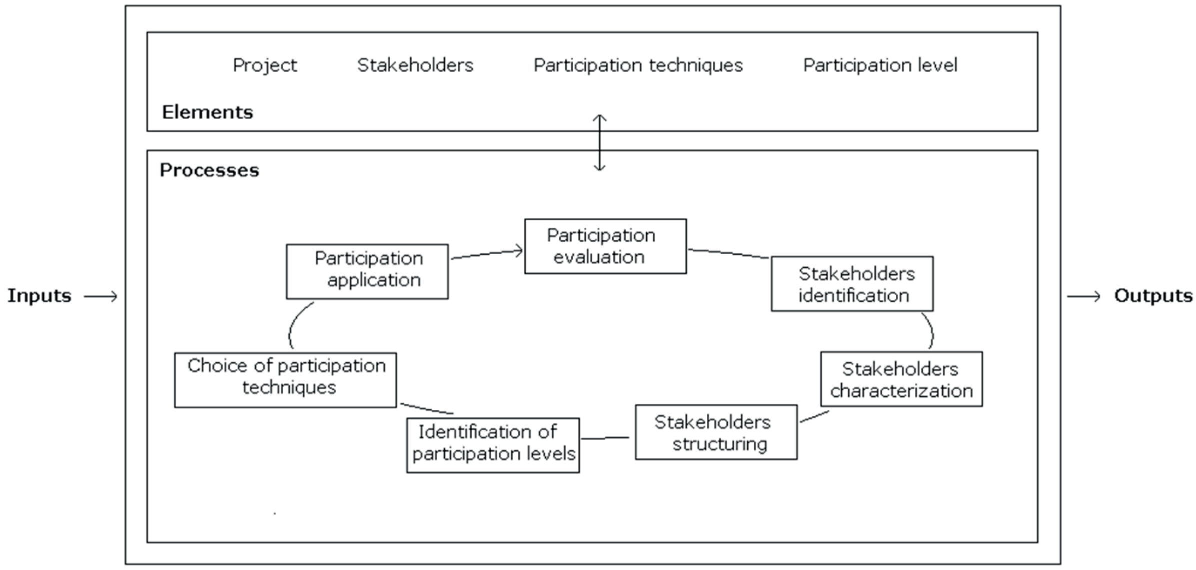


Figure 5.13: Conceptual model of the system of participation proposed by Luyet (adapted from Luyet 2005). The system is composed of various elements and processes in interaction.

A participative process has many definitions. We cite here the one given by the joint Food and Agriculture Organization of the United Nations (FAO)/Economic Commission for Europe (ECE)/International Labor Organization (ILO)/Committee on Forest Technology, Management Training (2000), which defines participation as a "*voluntary process whereby people, individually or through organized groups, can exchange information, express opinions and articulate interests, and have the potential to influence decisions or the outcome of the matter at hand*".

Luyet (2005) proposed a methodological framework to carry out participative processes in which a system of participation is composed of elements (the project, stakeholders, participation techniques, and levels of participation) and processes in interaction (identification, characterization and structuring of the stakeholders, identification of the participation levels, choice of the participation techniques, application and evaluation of the participation) (Figure 5.13). This method is interesting when the participative process is led by an entity that has to set up the process. This is the case of the ClimAlpTour project. We used this framework to present the work carried out in the region, even if this was not directly employed during the process.

A way to identify, characterize, and structure stakeholders has been given by Mason and Mitroff (1981, in Luyet 2005). This consists in asking questions about procedures, which allow identifying active stakeholders. Typical questions are: Who is in the position of giving his approval or disapproval? Who has interests because of the position that he or she occupies? Who because of his or her own reputation? Who operates in relation to the topic and in order to solve it? Who is an opinion leader? Who plays an important role in the organizational unit? And finally, who will be affected by the project?

During the process carried out in Aletsch, we identified 27 stakeholders: 5 coming from the passengers and transport services, 2 from accommodation, 5 from tourism offices, 2 mountain guides, 6 from the public administration, 4 from public interest associations, and finally 3 from other domains (Table 5.4).

Table 5.4: Identified stakeholders for the participative process in the Aletsch region.

Domain	Stakeholder
Passengers and transport services (cableway companies)	Bettmeralp Bahnen AG
	Aletsch Riederalp Bahnen AG
	Luftseilbahnen Fiesch – Eggishorn AG
	Belalpbahnen AG
	Sportbahnen Bellwald Goms AG
Accommodation	Hotel association section Aletsch
	Hotel association section Goms
Tourism offices	Brig-Belalp Tourism
	Riederalp Mörel Tourism
	Bettmeralp Tourism
	BellwaldTourism
	Eggishorn Tourism
Mountain guides	Aletsch Mountaineering Centre
	Belalp Alpin Center
Public administration (municipalities)	Municipality of Betten
	Municipality of Riederalp
	Municipality of Naters
	Municipality of Fiesch
	Municipality of Fieschertal
	Municipality of Bellwald
Public interest associations:	
- Nature and environmental organizations	Pro Natura Valais
	WWF Upper Valais
- Swiss Alpine Club sections	Swiss Alpine Club (SAC) subsection Birg-Ried
	SAC section Brig
Others	Flying Center Upper Valais
	Association for water management Aletsch
	ClimAlpTour Project team Switzerland

Following Luyet and Conde and Lonsdale (2004), stakeholders can take part with different levels of engagement, every level being more appropriate for different stages of the project, given the experience of the research team in addition to the goals of the process. It is important that stakeholders understand how they are involved, how the information they provide will be used and whether they have any power to influence decisions.

These different levels of involvement can be illustrated by a "ladder of participation" presented by Conde and Lonsdale and adapted from Pretty et al.'s (1995) *A trainer's guide for participatory learning and action.* These include i) self-mobilization (stakeholders take the initiative); ii) interactive participation (joint analysis and joint action planning; the stakeholders themselves take control), iii) functional participation (stakeholders tend to be dependent on external resources and organization); iv) participation by consultation (asking stakeholders for views on proposals and amending them to take these views into account); and v) participation in giving information (people are involved in interviews or questionnaire-based 'extractive' research). In the context of this study, we used the same participation level, functional participation, for all the stakeholders. Stakeholders, therefore, tended to be dependent on the external organization.

In addition to levels of engagement, different participation techniques exist, some more suited for a level of participation than others (Luyet 2005). For the chosen participation level many techniques seem suitable, like the focus group, workshops, citizen juries, consensus conferences, open space conferences, scenario workshops, steering committees, and future workshops.[98] In the context of the ClimAlpTour project, we chose workshops as the main technique, the same for all stakeholders.

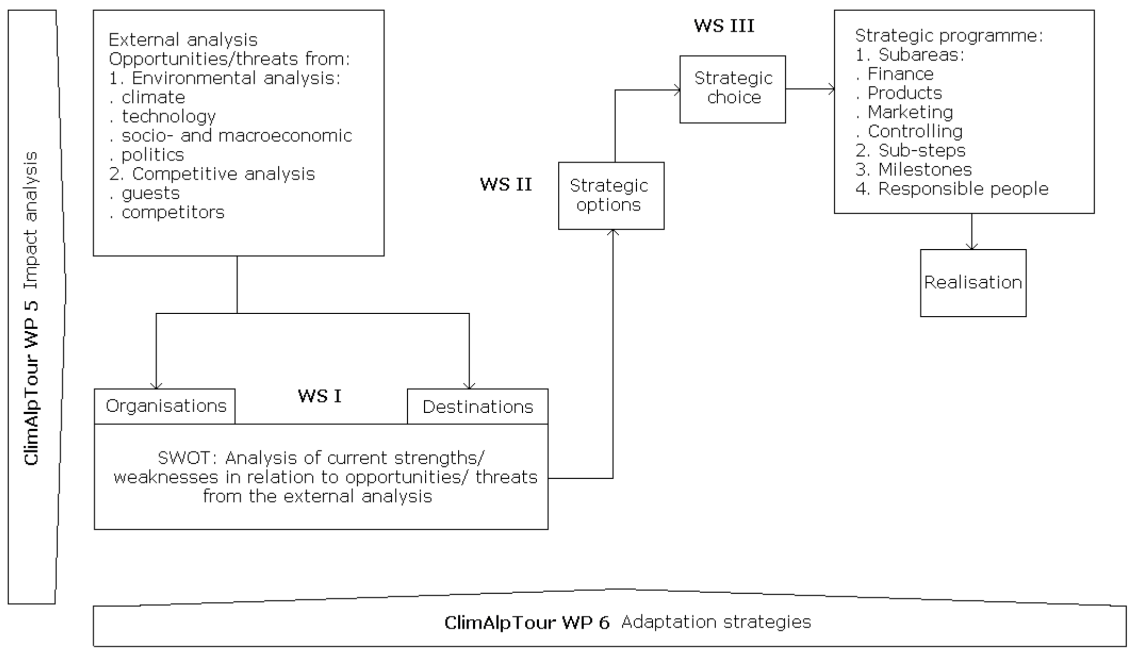


Figure 5.14: Theoretical strategic process in a model region of the ClimAlpTour project, as part of the different workshops (WSs) and linked to the various projects' working packages (WPs). Adapted from ClimAlpTour, internal documentation.

As illustrated in Figure 5.14, in which the theoretical framework is presented, the process revolved around three workshops. In the first (WS I), we assembled key stakeholders in order to evaluate strengths, weaknesses, opportunities, and threats of tourism in the region in relation to climate change. In the second (WS II), we discussed strategic options. Finally in the third (WS III), we set forth strategic choices and a strategic program focusing on the realization of adaptation measures. We provide a more detailed description of the organization in Table 5.5. A person able to guide the discussion in the chosen languages (High German and the Upper Valais dialect) was picked to conduct the workshops. ClimAlpTour and UNESCO organized the workshops.

[98] An explanation of the different methods can be found in Luyet (2005).

Table 5.5: Description of the organization of the three workshops carried out in the Aletsch region.

	Goal	Date and location	Attendance
Workshop I	- Present the state of the art of knowledge of climate change and its consequences on tourism in the Aletsch region - Define the strength, weaknesses, opportunities and threats of tourism in the region in relation to climate change by carrying out a SWOT analysis (the method is presented in Section 5.6.3)	7. December 2009, 13.30 - 17.45 Naters	12
Workshop II	- Present the results of the SWOT analysis - Define the state of the art of existing strategies - Analyze and choose strategic opinions specifically regarding tourism and climate change	5. February 2010, 13.30 - 17.45 Naters	6
Workshop III	- Present the results concerning the strategic options - Settle concrete measures (strategic choices) and planning (strategic program) in order to develop the adaptation strategies	18. June 2010 13:30 - 17:00 Naters	8
Following	- Provide continual support of the ClimAlpTour partners		

The first workshop took place in December, the second in February, at the end of the winter season, when stakeholders had more time, and the third in June. The priority was to find out if strategies concerning tourism already existed in the region, in order to build on them. As can be seen in Table 5.5, not all the 27 invited stakeholders attended the three workshops or part of them; the interest decreased as the project went on. This aspect will be discussed later. It should be noted that participation is often a long and expensive process, in which stakeholders may sometimes feel discouraged. Nonetheless, it gives them the possibility to express themselves, to learn additional information about their region, to diminish conflicts, and, very often, to eliminate opposition or rejection of the project.

5.6.3 The SWOT analysis

The SWOT analysis is a method often used in strategic planning (Böhm 2008), which has now found application in a far broader set of fields of application (Hill and Westbrook 1997; Wheelen and Hunger 1999). The idea is to consider internal and external elements that are either favorable or unfavorable to achieve an objective. It is often based on decision makers or stakeholders and gathers their opinion. We used here the SWOT analysis in order to develop an adaptation strategy. The SWOT considers the regional strengths as well as the avoidance of the regional weaknesses. It enables the tourism sector of the region to benefit from future opportunities with consideration for future risks, both linked to the impacts of climate change (Nieschlag et al. 2002; Scheuch 2007). The main advantages of the SWOT concept lie in its simplicity and the fact that it provides a solid basis for further, more detailed strategy formulation.

We used the SWOT approach to analyse the seven impacts presented in Section 2.3,[99] in addition to the *status quo* situation. We present hereafter first the results of the SWOT analysis carried out in the first workshop and then results concerning the strategic options selected and their settlement in the following two workshops.

[99] These are changes in climate suitability for tourism activities, snowpack reduction, glacier melting, permafrost melting and rockfall, increase in the frequency and intensity of natural hazards, and finally the changes in scenic beauty.

5.6.4 The results of the SWOT analysis

The SWOT analysis in Table 5.6 highlights the relatively advantaged situation of the Aletsch region in relation to snowpack due to its high-elevation and the existence of infrastructure to remedy the lack of snow when needed. It also highlights the strengths provided by the possibility of employing the glacier as a story-teller of climate change, the relatively secure infrastructure, the large water availability, and the UNESCO World Heritage label, in addition to the presence of the Pro Natura center (Clivaz et al., in press). It also highlights some weaknesses, as the scarcely existing hotel offer, the parochial thinking, the above-average dependency on ski-based offers, the high costs of artificial snowmaking, and the need to diverge hiking trails affected by soil instability due to permafrost melting. As opportunities are cited intra-regional cooperation, the development of a better winter/summer ratio, and the promotion of a more qualitative offer. Finally, threats mainly relate to the risk of copying what has already been done elsewhere, and the question mark due to the uncertainties related to future development (e.g. customers' behavior or climate impacts).

Table 5.6: Results of the SWOT analysis.

Consequences on the environment	Socio-economic consequences	Strengths	Weaknesses	Opportunities	Threats
General	General		Parochial thinking Balance in the accommodation sector (relatively weak hotel offer in comparison to 'parahotellerie')	Increase in professionalism	Fixing on the "Me too strategy" (copy what done elsewhere) Fear, bad media reports
Temperature and rainfall changes	Shorter winter seasons, less operating days	Good alternative offer Available scientific research High elevation Lengthening of the season over 2000 m (increase in temperature) Change of offer already taking place	Not enough alternative offers Cost-effectiveness (high fix-costs)	Changes in needs New business models New clients Intra-regional cooperation and products/client offers Better winter/summer ratio	Communication Better competitively Cost-effectiveness Uncertain development of the summer/winter tourism Better cooperation of the concurrence
Changes in snow conditions	Viability of ski resorts Water supply	Existing artificial snow production infrastructure Good product/image Relatively good snow-security due to high elevation Sun terrace	Lacking in artificial snow production infrastructure Not enough communication on snow security Audacity of dismantling ski resorts High fixed costs of snow machines A sole type of offer	Focusing on core competences Reorientation Marketing of snow and sun security Marketing for one-day tourists Summer coolness	Decrease in frequentation because of the closure of ski resorts Late understanding Missing tourism differentiation Migration Distance to and from agglomerations Quality vs. mass tourism
Glacier melting	Changes in tourism and hydro-power production	Ice as exclusiveness Direct thematic accessibility, the climate history is visible Development potential Better awareness raising about climate change Accumulation for energy production	Lack of practical projects Needs of investments from the municipalities Routes no more accessible	The glacier is not going to disappear Communication potential trough perceivable climate history Attitude change towards renewable energies To trust forecasts New hiking trails	Changes in costumers behaviors Natural hazards (glacial lakes outbreak) No more accessible routes Cost-intensive protection measures
Permafrost melting	Damages to infrastructure	High elevation Relatively secure infrastructure (e.g. in comparison to Maldives) Thematic access, illustration	Diversion of the hiking trail needed Infrastructure affected	Excursions, education Alternative tourism (e.g. farm holidays)	Relocation of the hiking trails needed Theme negatively affected Territory changes High investment costs Security questioned, negative image

Consequences on the environment	Socio-economic consequences	Strengths	Weaknesses	Opportunities	Threats
Hydrology	Conflicts in water supply – use	Large-scale water resources	Water resources badly reachable, in particular for agriculture Small scale water scarcity (southeast flank)	Alternative energy On-site taxation (water taxes) Reversion of water rights	Higher risks of natural hazards Desertification in lower areas Competition for water resources (artificial snow vs. mountain agriculture and energy production)
Landscape and vegetation	Changes in tourism flows	Biodiversity World heritage Swiss Alps Jungfrau-Aletsch (SAJA) Pro Natura center Aletsch Unspoilt landscape	Disfigurement in summer Lacking cost transparency for landscape maintenance Sensitivity against interventions in the landscape	New habitats Promotion of summer and fall tourism Increase guests inflow, increase overnight stays, creation of working places	Desertification Interference in the nature due to the increase in visitors Lacking farmers' disposition for landscape maintenance Hindered basic conditions for the winter business
Increase In intensity and frequency of extreme events	Damages to infrastructure Changes in cases of emergency and injuries	Well organized crises managing group Well-structured rules, laws Solidarity in the region	Liability questions Bad image High costs	Catastrophe tourism Promote changes in consciousness More quality than quantity Granting of means via the canton and the confederation Promotion of economic activities and investments bounds	Emigration Customers behaviors could change Absence of tourists Injured people

5.6.5 The strategic options chosen and their settlement

In the second workshop, it appeared that some reflections on adaptation strategies had already been carried out in the region, but nothing concrete had been undertaken so far. Moreover, it appeared that no written strategy encompassing climate change existed. The main actions already undertaken were related to the maintenance of winter sport related activities, the encouragement of innovation and diversification during the summer, the reinforcement of technical measures related to natural hazard avoidance (during summer), and targeted marketing for the summer season. During the third workshop, people mentioned about 40 adaptation options as possible alternatives. In the end, they retained three of them:

1. Increase of water and energy efficiency for snow production;
2. A trail for pleasure hiking at 2000 m AMSL along the Aletsch glacier complemented with local gastronomic specialties;
3. A booklet regarding climate change effects and chances for adaptation, aimed for use in primary schools.

The first measure implies the elaboration of a specific snow-production model, making use for example of the JusteNeige tool mentioned in Section 3.1.2.2. This should lead to better management of water and energy consumption (Clivaz et al., in press). Directors of Fiesch-Eggishorn SA and of Belalp SA took the responsibility of implementing the measure. The second one was planned for implementation during the 2-3 years following the end of the workshops round. The trail should be designed for individual hiking as well as for accompanied hiking activities together with accommodation offers, and it should be suitable both for day-tours as well as for multi-day hiking activities. For the third measure no responsible person has yet been named. The HES-SO proposed to contact the person responsible for the different projects at the beginning of December 2010 and then once again in May 2011 in order to assess the advancement of the projects. From these contacts it emerged that none of the three measures has been implemented for the time being. Unfortunately, no progress can be observed; the projects are still on stand-by.

5.6.6 Discussion of the results of the participative process

In the pilot region, the importance of the involvement of the key regional stakeholders, namely from the UNESCO organization, the cable-car companies and the municipalities was apparent from the beginning. During the process, participation decreased as the project developed. However, it was also not very high from the beginning.

Luyet (2005) cited some factors that determine the success of a participative process, including the integration of all stakeholders from a very early stage in the process (in particular the key ones and the ones who are motivated, engaged and willing to act), sufficient financial means, trust among participants and in organizers, and a good moderator. These conditions were, in our opinion, fulfilled (with the exception, perhaps, of the integration of all stakehodlers). The main motive for weak solutions could be the fact that the region had already taken part in many participative processes in the past (Mattig and Zeiter 1984; Hill 2007), with some feeling of saturation. Another reason could be the fact that stakeholders changed from workshop to workshop, making it difficult to conduct the meetings. There was perhaps also the fact that there were just not easy to implement solution to be found.

But maybe the main problem was that the process should have come from within the region itself, and that it should become part of a longer process. Higher levels of involvement of all stakeholders and increased willingness to adapt will perhaps appear only when climate change becomes a serious threat for the tourism activity in the region.

5.7 General discussion on adaptation

The main goals of this chapter were to provide information on the state, the type, and the localization of adaptation measures in the tourism sector in Switzerland; to understand the processes that lead to adaptation and how they developed; and finally to analyze a newly initiated adaptation process.

Results of the three methods employed in this chapter show that climate change and its impacts are largely recognized by stakeholders in the different regions, but that there are also other factors, often equally important, that preoccupy and influence choices and actions made by stakeholders, such as globalization, changes in taste, population structure, mobility patterns, or the global economy. Stakeholders are modifying their offer in response to these combined factors and not only to climate change. Tourism is not a static sector, and adaptation processes have been taking place continually.

There exists a variety of adaptation actions being currently undertaken or planned. It is difficult to say which is better and which is worse because these are answers to different impacts. Sometimes they aim to protect; other times to accommodate, prevent, or retreat. Generally, the promotion of year-round tourism, innovation, and the diversification of the tourism offer are seen as the most implemented and most effective measures. The further development and securing of snow sport activities has also been largely implemented and is generally seen as effective. Nonetheless, in some areas this is only a short- and middle-term solution.

Adaptation can be made more successful through information dissemination, coordination, and participation. Joint work, coordination, and inclusion of the various stakeholders in the process from the beginning are good ways to succeed in the task. These are all elements of what could be defined as better governance (Stoker 2002). Stakeholders often indicate that the provision of honest and clear information by the scientific and the public sectors would help them in directing their decisions. Proactive adaptation can take place only when the uncertainties are low or when it creates benefits irrespective of current climate change impacts (no-regret actions).

Regarding private and public collaboration, private stakeholders indicated how politicians could help by providing information, economic help, and by showing a higher willingness to take action. The Innotour law (the federal law promoting innovation and cooperation in tourism),[100] and an online platform containing the best cases, workshops and tailored publications, could help in these directions. These are fortunately already planned elements of the Swiss Adaptation Strategy recently approved by the Federal Council.

Looking back at Figure 5.1, we can summarize as follow the action which the different public instances are already undertaking in the context of adaptation. The Federal Parliament and Federal Council

[100]'Loi fédérale encourageant l'innovation, la coopération et la professionnalisation dans le domaine du tourisme'. See also SECO programs for innovation, cooperation, and professionalizing of Swiss tourism offer. http://www.inno-tour.ch/web/. last accessed 15.02.2012.

with the information provided by the Parliamentary Group for Tourism and Transport and thanks to the work of the Climate Policy Section of the FOEN already consented and deliberated on the first part of the Swiss adaptation strategy (DETEC/FOEN 2010). This, as seen, covers the critical aspects discussed in this thesis particularly well. Climate change got also included in the new tourism policy (Swiss Federal Council 2010) and the Innotour law was approved. The cantonal and municipal authorities are already transposing the national strategy by implementing tailored policies and regulations (Bättig et al. 2010).[101] The Swiss Tourism Federation coordinated the elaboration of the Sustainable Development Charter[102] and collaborates with research. Cablecars Switzerland, the Swiss Society for Hotel Credit, SECO/Tourism, and Switzerland tourism already provide information and coordination, a common vision for the sector, optimization solutions, and create links among stakeholders and with other sectors (e.g. Müller and Weber 2008; Zegg et al. 2010; Lehmann Friedli and Müller 2011). As quoted by Hilpert (2007), adaptation and mitigation go hand in hand and should both be considered by the private and the public sectors. Only when both of them are tackled, will sustainable tourism be possible. For example, the public sector plays a critical role (Agrawala 2007) in regulating environmental and social externalities that might be created by the implementation of adaptation options (maladaptation). Mitigation is generally included in the measures mentioned above. A freshly published ARE report (ARE 2012) covers the topic.

Finally, awareness of environmental issues appeared in many regions. Stakeholders often seemed to be very concerned by the situation of the natural world and perhaps therefore already couple adaptation and mitigation measures. In any case, maladaptation should be avoided in the process. In addition, the consideration of other sectors and other countries should not be forgotten.

5.8 Limitations of the methods employed in relation to adaptation appraisal

The various methods used in this chapter face limitations. We present the main ones in Table 5.7 below.

Table 5.7: Limitations related to the various methods employed (the online survey, the face-to-face interviews, and the participative adaptation process) and measures taken to address them.

	Limitations	Measures taken
Method 1: online survey	- Representativeness of the sample - Subjective appraisal by a small number of people - Partiality of the answers (due to personal interests)	Survey sent to virtually all reachable tourism stakeholders related (8 416 email addresses). Reminder sent in order to raise the low response rate.
Method 2: face-to-face interviews	- Biased choice of stakeholders - Subjective appraisal by a small number of people - Partiality of the answers (due to personal interests)	

[101] See also http://www.bafu.admin.ch/klimaanpassung/11816/index.html?lang=fr. Last accessed 05.05.2010.
[102] http://www.swisstourfed.ch/files/tourismus/112_09f_01_plakat_ferientag_def_f.pdf. Last accessed 05.05.2010.

	Limitations	Measures taken
Method 3: participative adaptation process	- Time limited project - Not inclusion of all stakeholders	

As for Chapter 4, the results obtained have to be taken with caution. Even if we sent the survey to virtually all reachable stakeholders related to food and beverage serving services, passengers and transport services, accommodation, travel agencies, cultural services, or to communal and cantonal administrations (a total of 8 416 email addresses), only 566 people answered. Outcomes of the online survey were thus generated by the answers of a small number of respondents (6.72%), and probably by people particularly concerned by the climate change and adaptation. In is quite possible that the sector is less aware of the impacts of climate change and is taking fewer measures to adapt to it than what we see in the survey.

Another limitation comes from face-to-face interviews. Here also the small number of persons interviewed makes it difficult to generalize results to the entire sector in the country. Finally, the participative adaptation process suffers from the fact it could not be carried out in the ideal scientific manner. The choice of invited participants did not include all stakeholders. Moreover, the process was limited to a short period of time and was initiated by external actors. Additionally, the Aletsch region has already taken part in many participative processes and feels now some fatigue. This perhaps explains the decreasing interest from participants along the process.

5.9 Conclusion

The tourism sector is already aware of the changes happening in the country due to climate change and it generally acts to face its consequences. A shift towards innovation and diversification is going on all over the Alps and not only in the most vulnerable regions. Nonetheless, the sector asks for continual, high-quality, and honest information (written or visual) about the regional impacts of climate change and possible adaptation solutions. Adaptation sometimes leads to maladaptation, the most prominent example being perhaps artificial snowmaking. It facilitates the transition towards other forms of tourisms or activities, but it is not a long-term solution for most regions. Moreover, adaptation processes are riddled with barriers. This clearly appeared in the participative process carried out in the Aletsch case study region. There, adaptation options chosen never came to fruition and were perhaps more patches than complete solutions. In the next chapter, these barriers and possible ways of overcoming them are analyzed in greater detail.

6 Barriers to adaptation

These are the main findings of this chapter:

- Various families of barriers can hinder the adaptation process of the tourism sector in the different regions. The ones related to social and economic feasibility appeared to be the strongest inhibitors, whereas the ones related to technological feasibility to be the least relevant;
- Lack of willingness to act both from private and public stakeholders is seen as a possible challenge to the adaptation process, but not the greatest;
- Popular acceptability does not seem to be an issue since the population seems to understand the need to take action and to support measures taken; also because the measures generally affect their wellbeing rather positively;
- According to stakeholders, help from the public sector to facilitate the adaptation process and to avoid maladaptation could come mainly in the form of honest and clear information on the impacts of climate change and on possible solutions, of good examples, of financial help for the measures, and of a structure able to face and handle extreme events; this is fully in line with what is proposed in the Swiss adaptation strategy recently published by the government.

6.1 Abstract

In Switzerland the effects of climate change are increasingly evident, and the tourism sector has no choice but to react to its consequences. However, as seen in Chapter 5, these adaptation processes are being carried out with varying degrees of success. The present chapter analyses the different pathways through which the Swiss tourism sector has adapted or is adapting to climate change; it also considers the social, economic, technological, and institutional barriers which can arise during the various adaptation phases. We carried out phone and online surveys and face-to-face interviews among inhabitants and tourism stakeholders in Switzerland in order to assess these barriers and to define possible public and private strategies to overcome them. This chapter aims a fostering a smooth shift to less vulnerable and more sustainable tourism.

6.2 Introduction

The negative effects of climate change on Swiss tourism are becoming increasingly evident and the amount of knowledge on the possible impacts and on the potential adaptation measures is rising exponentially (Chapters 4 and 5). In many regions people, companies, and municipalities strive to effectively adjust to the impacts of climate change, yet they face barriers that hinder the adaptation process. General research on barriers to adaptation to climate change is still limited (Smit and Pilifosova 2001; Grothmann and Pratt 2005; Lorenzoni et al. 2007; Adger et al. 2009; Dessai et al. 2009; O'Brien 2009; Jones 2010; Moser and Ekstrom 2010; Nielsen and Reenberg 2010; Storbjörk 2010; Dupuis and Knoepfel 2011; Ekstrom et al. 2011; Gifford 2011; Huang et al. 2011; Jones and Boyd 2011; Measham et al. 2011; Gero et al. 2012; Moser and Ekstrom 2012; Productivity Commission 2012). Some of the studies provide exclusively a theoretical background (Smit and Pilifosova 2001; Adger et al. 2009; Dessai et al. 2009; O'Brien 2009; Moser and Ekstrom 2010; Ekstrom et al. 2011; Gifford 2011; Huang et al. 2011), while others additionally analyze specific case studies (Grothmann and Pratt 2005; Lorenzoni et al. 2007; Nielsen and Reenberg 2010; Storbjörk

2010; Dupuis and Knoepfel 2011; Jones and Boyd 2011; Measham et al. 2011; Gero et al. 2012; ; Moser and Ekstrom 2012; Productivity Commission 2012).

To our knowledge, only one study addresses the situation in Switzerland (Dupuis and Knoepfel 2011), and none deals specifically with barriers to adaptation in the tourism sector. Dupuis and Knoepfel (2011) analyzed how perceptions of climate change of decision-making actors can act as barriers to the implementation of adaptation policies. They found that adaptation is far from receiving the same attention as mitigation in the formulation of policy responses to climate change at the Swiss level. This was however before the approval of the revised CO_2 Act and the elaboration of the Swiss adaptation strategy (Section 5.3.3).

The purpose of this chapter is to recognize and identify potential barriers appearing in the adaptation process with regard to Swiss tourism. Recognizing these barriers and suggesting possible measures to overcome them could be useful for private and public stakeholders in the implementation of a more effective and sustainable adaptation process. This chapter aims therefore to answer the following questions:

i) What barriers hinder the adaptation process and what is their importance? In particular, what is the importance of social barriers?

ii) How can barriers be overcome? In particular, how can the public sector help?

iii) At which step of the adaptation process do barriers arise?

This chapter is organized as follows: Section 6.3 provides background information on barriers to adaptation. Section 6.4 presents respectively the data and methods exploited. Section 6.5 displays the obtained results and Section 6.6 discusses them. Section 6.7 mentions the limitations encountered and Section 6.8 concludes.

6.3 Background on established barriers hindering the adaptation process

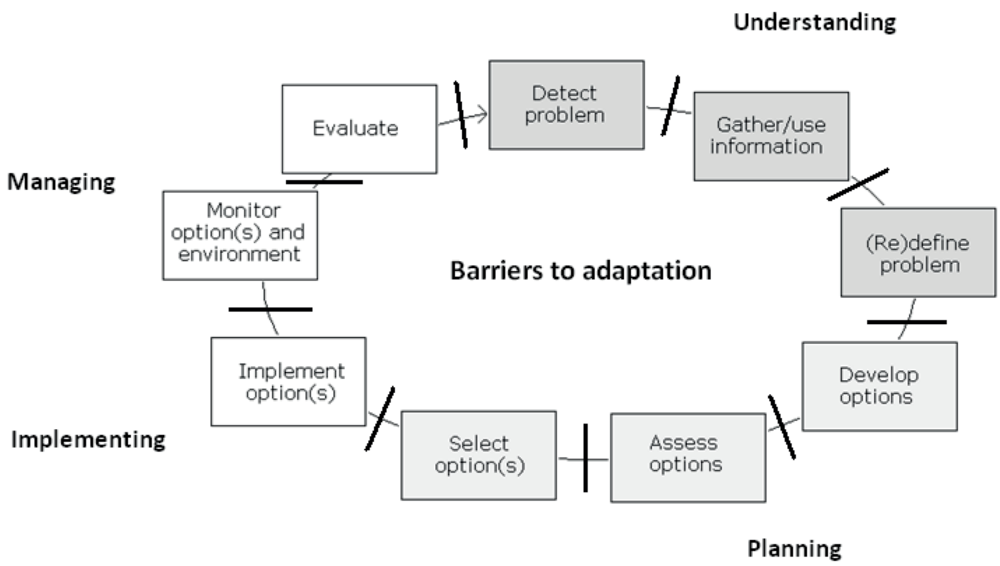


Figure 6.1: Barriers hindering the different phases and sub-processes throughout the adaptation process. Adapted from Moser and Ekstrom (2010).

Barriers to adaptation are defined by the IPCC (2007b) as '*obstacles to reaching a potential that can be overcome by a policy, program, or measure'.* These are in contrast to 'limits', which cannot be overcome. Barriers can intervene at each of the phases seen in Section 5.3.2 (Figure 6.1). They can therefore intervene in the understanding, the planning, the implementing, or the managing phase. They can intervene, in other words, either at the perception of changes, at the recognition of the impacts for the sector, at the decision to act, or in the planning or the action phase.[103]

There are different types of barriers (Smit and Pilifosova 2001; Adger et al. 2009; Huang et al. 2011; Jones and Boyd 2011; Productivity Commission 2012). Smit and Pilifosova (2001), for exemple. described the following six classes of determinants of adaptive capacity, which are limits or barriers when they are not sufficiently available: i) economic resources, ii) technology, iii) information and skills, iv) infrastructure, v) institutions, and vi) equity. Jones and Boyd (2011), on the other hand, split limits and barriers into three interrelated groups: i) human and informal (knowledge, economical, technological); ii) natural (physical, ecological), and iii) social (normative, cognitive, and institutional).

Social issues are generally important factors intervening in the adaptation process. This either because of their early emergence, their influence in many steps of the process, or the variety of barriers they can generate. Recent literature covered the topic (Grothmann and Patt 2005; Adger et al. 2009; Nielsen and Reenberg 2010; Gifford 2011; Jones and Boyd 2011). Grothmann and Pratt (2005) outlined the importance of risk perception and perceived adaptive capacity in the adaptation process. They presented a process model of private proactive adaptation to climate change, in which risk appraisal is first composed of the perceived probability of being exposed to the threat and then the perceived severity of the threat. Adaptation appraisal, by contrast, comes after the perception of the risk and takes place only if the person perceives the risk as important. Adaptation appraisal is thus composed of perceived adaptation efficacy, perceived self-efficacy, and perceived adaptation costs. Both adaptation and maladaptation can result. Hoffmann et al. (2009) looked more specifically at barriers linked to institutions and at adaptation in corporations. This can be understood as the result of measures that a company chooses to implement in order to adjust to changes. Hoffmann et al. outlined how a company can follow multiple strategies simultaneously, yet with different intensities (e.g. protect the affected business, expand beyond the affected business, and share the risks of financial impacts). They tested the positive influence of the awareness of possible climate change effects on the scope of corporate adaptation. Surprisingly, they could not find any significant relation between vulnerability and adaptation, which suggests that more vulnerable companies are not necessarily the ones that adapt most. Authors explained this by a U-shaped relationship, in which adaptation is lacking both among the least and the most vulnerable. This is in line with what we already discussed in Section 4.5.7.2.

6.4 Data and methods

Based on the literature, we decided to consider five families of barriers. These are very similar to the determinants of adaptation given by Smit and Pilifosova (2001) and the barriers cited by Jones and Boyd (2011), differing principally in naming. We considered that adaptive capacity and barriers are parallel but opposite concepts (barriers appear where adaptive capacity is lacking or is low and *vice versa*). Therefore barriers relate to the various classes of adaptive capacity presented in Section 4.4.2.

[103] For a more in depth discussion, see for example Moser and Ekstrom (2010).

We did, however, not consider elements linked to *environmental feasibility* because we considered them as limits that cannot be overcome. Environmental limits can arise, for example, from ecosystem thresholds and resilience, geographic and geological limitation, and also from restrictions in resource allocations (e.g. water availability). Nor did we consider the natural, fundamental, and irreducible uncertainty related to future demographic, socioeconomic, technologic, environmental, and climatic conditions (Dessai and van der Sluijs 2007; Huang et al. 2011). Natural uncertainty as well cannot be overcome directly. However, it can be an important factor interfering with adaptation processes.[104]

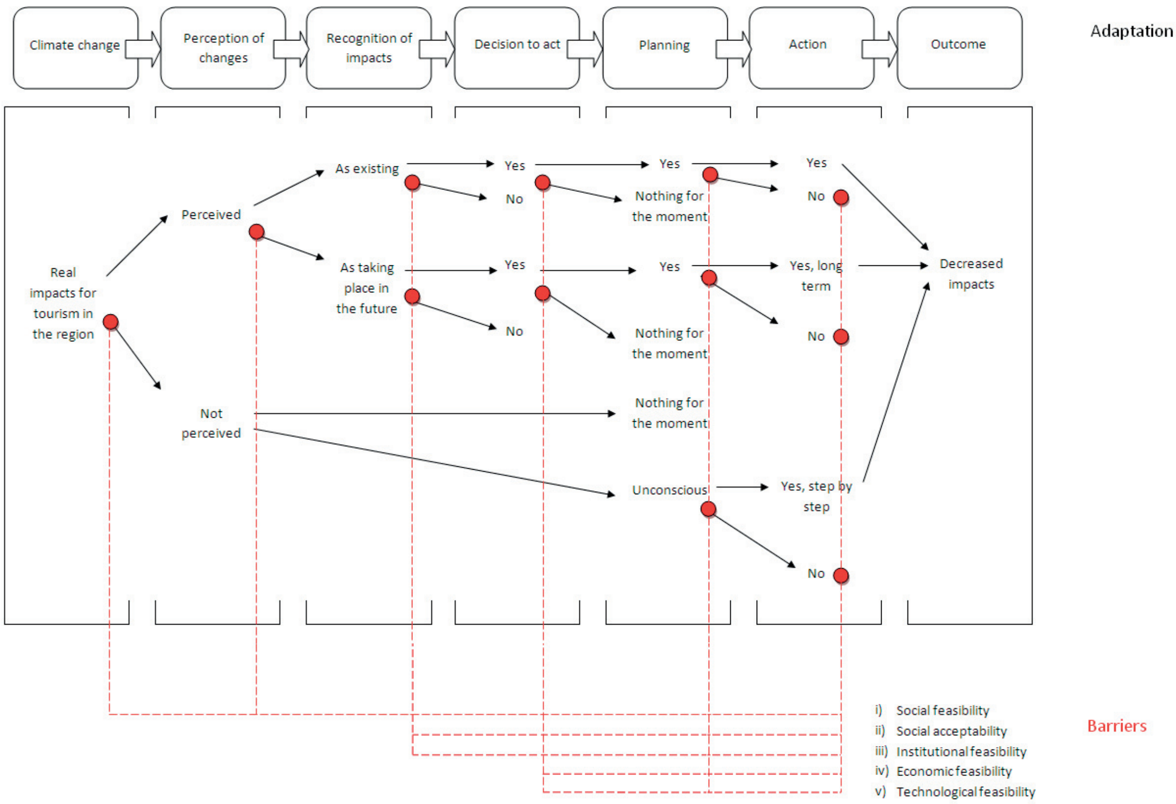


Figure 6.2: In the boxes: possible processes leading to adaptation and reduced impacts. Marked as red dots and described in the lower part of the figure: the five families of barriers that can intervene in the process and their temporal development.

Looking at the temporal development of an adaptation process, the emergence of barriers can be described as follows (Figure 6.2):

i) First, there are *barriers related to social feasibility*. These appear from, e.g., local stakeholders' lack of perception of changes caused by climate change in their region or their lack of recognition of the impacts on their sector. Local stakeholders' insufficient knowledge about their region or lack of knowledge about and familiarity with the scientific research on climate change impacts taking place in the area could be a cause. Barriers can also stem from the low capability of local stakeholders to collaborate and create a participative process, from the lack of knowledge about possible adaptation measures, or from the lack of social capital. So-

[104] Even if, as nicely stated by Dessai et al. (2009), successful adaptation can be developed in the face of irreducible uncertainty by selecting options that are sufficiently robust across alternative futures.

cial capital is linked to the productive benefits brought by social relations. A high level of social capital facilitates, e.g., collective initiatives of adaptation and, thus, enhances adaptive capacity (Huang et al. 2011).

ii) *Barriers related to social acceptability* intervene when stakeholders perceive the changes and recognize the impacts and are therefore in the position to take action but they choose not to do so. They also appear when the population does not accept the measures chosen. Social acceptability depends on both information and preferences (Jones and Boyd 2011) and is often strictly linked to psychological intrapersonal, interpersonal, and decision making factors (Gifford 2011). This is the case for example with stakeholders who see other, more day-to-day, problems as more important and decide to postpone adaptation to the impacts of climate change, or of stakeholders who underestimate these impacts on their business.

iii) *Barriers related to institutional feasibility* appear almost at the same time as the previous ones. They arise from institutional arrangements or weak institutional structures such as low institutional flexibility due to existing policies and the structure of the administration in place. These barriers can also be generated by low communication within the target locale. Moreover, it could happen that personal willingness to adapt does not lead to action because the structure of the institution in which the person finds himself does not allow him to do so.

iv) *Barriers related to economic feasibility* intervene towards the end of the process, when stakeholders have already decided to act and are in the planning or the implementation phase. They take typically the form of insufficient financing or an unfavorable cost-benefit ratio of planned measures.

v) *Barriers related to technological feasibility* also intervene towards the end of the process. They originate in the lack of know-how for, e.g., protecting areas from natural hazards or for building infrastructure on unstable soil.

When unplanned adaptation takes place, stakeholders do not perceive the existing changes or recognize the impacts on their business but nonetheless adapt. In that case, barriers are mainly related to institutional, economic, and technological feasibility.

To learn about real-world barriers to adaptation, we use again the online survey and the face-to-face interviews presented in Sections 3.1.3.3-3.1.3.4. We shall also draw on the Univox survey of 2011 (Section 3.1.3.2), and on unpublished work of Kruse et al., who performed an online survey among different experts in the country. With the online survey, we cover the following issues concerning barriers in tourism regions in which stakeholders operate: (1) the relative importance of barriers hindering the process and in particular the importance of social barriers; and (2) possible ways to overcome them and how decision makers and communal/cantonal/national policies can help in doing so. With the Univox survey, we also cover issue (1), focusing in particular on social components. Finally, with the face-to-face interviews, we address both issue (1) and a third issue: (3) at which step of the adaptation process do barriers arise.

In relation to issue (1), we asked stakeholders in the online survey to assess on a 1-10 scale the importance of different potential barriers to adaptation. We gave nine examples, belonging to the five families of barriers listes above. We additionally differentiated between the answers of public and private stakeholders.

Both the online survey and the face-to-face interviews allowed us to dig deeper into social acceptability barriers and to understand better their importance for the Swiss tourism sector. With the online survey, we looked at the willingness to act of stakeholders. We wanted to determine the degree of willingness to act in the country in general and of different types of stakeholders in particular. We measure willingness to act by the energy and time stakeholders invest in the process. In one of the questions of the online survey, we tried to assess to what extent they would be willing to initiate and carry forward an adaptation process: the more they declared themselves to be willing to carry the process regardless of the time and energy this requires, the more we considered them willing to adapt. We proposed five levels of engagement. These are, from the weakest to the strongest:[105]

- Level 0: I do not see the need to act; I would continue my business as usual;
- Level 1: I would start searching for information but would stop if this became too difficult;
- Level 2: I would not be the organizer of a meeting, but if someone else were gathering people in order to think about possible solutions, I would join for at least one meeting;
- Level 3: I would collect and review information, and I would then start planning possible solutions and eventually contact people; but I would stop if a possible solution did not clearly appear;
- Level 4: I would try to organize other concerned people in my region to find possible solutions until something is found; I would do so even if it were to take much time and energy and until a solution were found.

Here as well, we looked at differences in answers between private and public stakeholders. Additionally, we performed an analysis of deviance by fitting a Generalized Linear Model (GLM) with Poisson errors using as explanatory variables gender, age (six levels, <20, 20-39, 30-39, 40-49, 50-59, >60), language in which the survey was filled out, which indicated approximately the region of the respondent (Italian, French, German, English), geographical area (cities, Alps, Prealps, Jura, lakes, Plateau and Southern Ticino), sector of employment (food and beverage serving services, passengers and transport services, cable car, accommodations, travel agencies or mountain guides, retail trade, cultural services, public administration, public interest association, research), level the person works at (regional or not), and type of occupation (management or not).

With the Univox survey, we looked at the general acceptability of adaptation measures for the Swiss population. We asked here six questions in relation to this subject: 1) Will climate change have an impact in Switzerland? 2) What is the relative importance of each of the 6 proposed short term measures in the Swiss climate policy for addressing climate change? 3) If these impacts are taking place, should adaptation be taken immediately or should it be carried out step by step once the impacts have clearly emerged? 4) Who among the population, private, and public stakeholders should bear the main responsibility for these actions? 5) What is your personal opinion on future snowpack reduction? and 6) How do you evaluate the effectiveness of artificial snowmaking to combat climate change in the tourism industry?

To address the second issue presented at the beginning of this section, the online survey invited stakeholders in an open question to indicate what, in their opinion, could help overcome the barriers presented previously. Additionally, another open question asked them to define the principal way in which decision makers and communal/cantonal/national policies could help in the adaptation processes.

[105] Stakeholders also had the possibility to indicate other levels of action.

Finally, to address issue (3), the face-to-face interviews were used to assess at which step of the adaptation process barriers arise. We looked more in detail at aspects related to barriers encountered or avoided during the adaptation process carried out in the regions. As seen in Section 5.5.1, adaptation processes often follow a progression: perception of changes, recognition of impacts for the sector, decision to act, planning, action, and outcome. The face-to face interviews showed that in several regions, the process encountered barriers during one of these phases that hindered the course of action more or less. Sometimes, on the other hand, barriers were avoided. We look here at the different typologies of obstacles that emerged or were avoided and at temporal components. We moreover try to analyze the reasons behind this. We use the definition for barriers given in this section and in Figure 6.1 to move the discussion forward. When needed, we translate answers into English (marked with a * in the text). The quotes can be found in their original language in Annex A.16.

6.5 Results

6.5.1 The typology and importance of barriers

Average scores on a scale of 10 for each category of barriers varied between 6.58 for the low economic means available and costs of the adaptation measures, and 4.76 for the non-availability of technological solutions (Figure 6.3). Only the economic constraint was seen as significantly (p-value <0.05) more important than the lack of political willingness to act at the cantonal or national level (mean score $\mu=5.64$) (Student $t= 4.22$, p-value<0.001). Significant differences among other families of barriers were more difficult to identify: the lack of political willingness to act at the regional level ($\mu= 5.49$) preceded the lack of information about the regional impacts of climate change, possible adaptation measures, and strategies among stakeholders ($\mu= 5.42$), the lack of feasible solutions ($\mu= 5.35$), the lack of coordination and interaction in the tourism sector in the region ($\mu= 5.34$), the lack of willingness to act of people working in the tourism sector in the region ($\mu= 5.10$), and the resistance or even blocking by the local population of adaptation measures. Results differed therefore considerably with what the Swiss experts in climate change and tourism had assessed in the context of the Multicriteria Analysis (Section 4.5.1). There, social acceptability components accounted for 79% of the adaptive capacity, followed by economic (6.3%); technological (4.8%), institutional (3.6%), environmental (3.2%), and social (3.1%) feasibility components.[106]

We also asked stakeholders to indicate other possible barriers. Among these we found mainly the lack of long-term vision (cited 5 times), sometimes due to pressure of other stakeholders and to the need to obtain short-term results (1). Respondents also mentioned other (short-term) conditions to which a higher priority is given (such as the strong Swiss franc) (1), the lack of action at the international level (1), and the need to maintain employments and a source of income in the region (e.g. modifying the tourism offer will have an impact on these two aspects) (1).

[106] As said, we considered adaptive capacity and barriers as two parallel but opposite concepts.

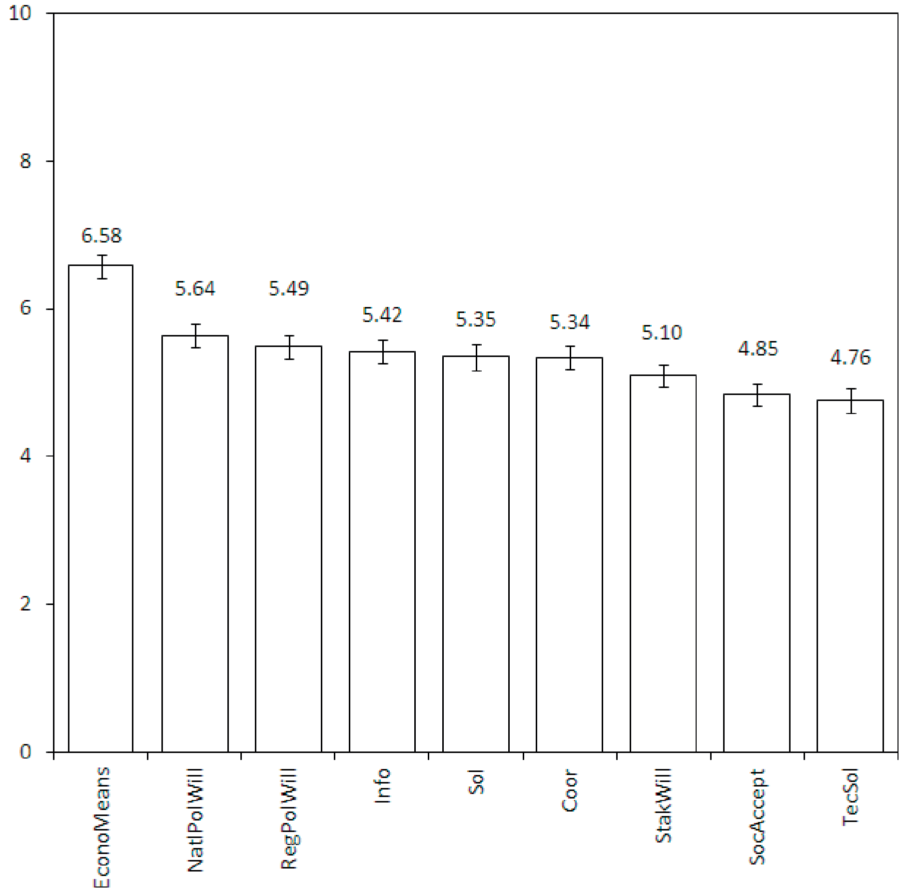


Figure 6.3: Average score of the different answers to the question "Which do you think are the most important obstacles to the implementation of measures and strategies that help facing climate change in the tourism sector in your region?" For each of the 9 types of barriers proposed, a weight of 1-10 could be given (1: not important; 10: very important). EconoMeans: The low economic means at disposal and the costs of the adaptation measures; NatPolWill: The lack of political willingness to act at the cantonal or national level; RegPolWill: The lack of political willingness to act in the region; Info: The lack of information about the regional impacts of climate change and possible adaptation measures and strategies among stakeholders; Sol: The lack of feasible solutions; Coor: The lack of coordination and interaction in the tourism sector in the region; StakWill: The lack of willingness to act of people working in the tourism sector in the region; SocAccept: The resistance or even blocking by the local population of adaptation measures; TecSol: The lack of technological solutions. Vertical lines indicate mean standard errors.

Looking more in detail at the answers given by public and private stakeholders, it is not possible to detect any significant differences (Table 6.1). We considered as belonging to the private sector (N=161) people working in the food and beverage serving services (N=33), passengers and transport services (N=37), accommodation (N=51), and people working in more than one of these sectors (N=40). We attached to the public sector (N=208) people working in the cultural services (N=5), public administration (N=169), in public interest associations (N=28), and in more than one of these three categories (N=6). 141 respondents in the private sector had relatively high power of action (directorate, head of department/section, administrator, or independent), 18 worked as employees. For 2 persons the information did not exist. For the public sector, 183 respondents had relatively high power of action, 16 worked as employees, and for 9 the information was missing. Moreover, 164 respondents in the public sector worked at the communal or regional level and 41 at the cantonal or national level; 3 did not specify at which level they worked. We did not include in the comparison respondents working in the research field (N=8) and in travel agencies or as mountain guides (N=73). We excluded the last category because it mixes private (mountain guides, travel agencies) and public (tourism offices) stakeholders. Nor did we include in the comparison respondents working both in the private and in the public sector (N=15) or those who did not specify their employment (N=101).

Table 6.1: Mean ratings (μ), standard deviation (S.D.), and two tailed t-test comparisons (t, p-value<0.01) for both responses of public and private stakeholders in relation to barriers. Scores were given on a 1-10 scale. For an explanation of the acronyms, see the legend of Figure 6.3.

Variables	Public		Private		
	μ	S.D.	μ	S.D.	t
SocAccept	4.31	2.23	5.12	2.59	-2.22
RegPolWill	5.09	2.43	5.86	2.84	-1.94
NatPolWill	5.64	2.36	6.07	2.64	-1.15
StakWill	4.90	2.40	5.17	2.46	-0.75
Coor	5.08	2.38	5.66	2.66	-1.54
EconoMeans	6.58	2.55	6.67	2.66	-0.23
TecSol	5.07	2.74	4.99	2.60	0.19
Info	5.43	2.68	5.55	2.68	-0.29
Sol	5.46	2.71	5.63	2.86	-0.40

6.5.2 The willingness to act of the different stakeholders

The answers to the online survey showed a generally rather high willingness to act, with 38% of the respondents indicating that they would continue to act until a solution were found, even if this cost them much time and energy. A further 30% indicated that they would at least take part in a meeting if someone organized it. Interestingly, fewer people (14%) seemed to be ready to start an adaptation process and then stop if a solution did clearly appear. Only 9% and 5% respectively did not see the need to act or would stop early in the process if this became too difficult (Table 6.2).

Table 6.2: Levels of willingness to asked, as definced in Section 6.4, based on the answers to the question “How would you react if you started to see the impacts of climate change on your business, considering all the time and energy the different actions would imply?” (N=566).

	Count	Percentage of the respond-ents
Level 0	51	9%
Level 1	26	5%
Level 2	170	30%
Level 3	79	14%
Level 4	212	38%
Others (please specify)[1]	28	5%

[1] Respondents did not specify other possible reactions.

By looking more in detail at differences among categories of employment, there appeared a rather high level of willingness to act in the different categories independently of whether they belong to the private or the public sector. A particularly high willingness to address the topic and to find a solution, independently of time and energy constraints, appeared in the research group, in public interest associations, in the public administration, and at cable car companies. We did not find significant differences of willingness to act among private and public sector stakeholders (Table 6.3): both showed a relatively high score (respectively $\mu_{private}$=3.62, and μ_{public}=3.74 on a scale of 5). In the public sector, we found a tendency of people working at the cantonal or national level to express higher willingness to act ($\mu_{public,\ cantonal}$=4.03, against $\mu_{public,\ regional}$=3.66). Respondents in the private sector with leading tasks tended to be more willing to act than employees ($\mu_{private,\ direction}$=3.66 against $\mu_{private,\ employee}$=3.17). Yet, the GLM did not reveal any significant explanatory variable for willingness to take action for adaptation, nor any significant interaction among the various explanatory variables examined.

Looking at other variables and at whether answers differed among the private and the public sector, we did not find differences in perception of future impacts of climate change on the tourism sector, nor in perceived adaptive capacity. Private stakeholders had, on the other hand, a significantly higher perception of current problems caused by climate change in the region ($\mu_{private}$=3.39, μ_{public}=3.05, Student t=2.77, p<0.01) and of the regional vulnerability in relation to tourism ($\mu_{private}$=2.60, μ_{public}=2.35, Student t=2.93, p<0.01). Moreover, private and public stakeholders had a different perception of the possible impacts affecting their region in a 2030-2050 time horizon, with the private sector indicating more melting of permafrost ($\mu_{private}$=0.65, μ_{public}=0.48, Student t=3.22, p<0.01) and melting of glaciers ($\mu_{private}$=0.81, μ_{public}=0.61, Student t=4.44, p<0.001) (Figure 6.4).

Looking at differences among people working for the public sector respectively at the communal/regional and at the cantonal/national, it appeared that the latter perceive possible future problems for tourism in the region significantly higher than the ones working locally ($\mu_{cantonal/national}$ =4.08, $\mu_{communal/regional}$ =3.51, Student t=2.95, p<0.001).

Table 6.3: Mean ratings (μ), standard deviation (S.D.), number of responses (Nb), and t-test comparisons (t) for willingness to act, perception of current and future (2030-2050) problems caused to the tourism sector by climate change in the region, regional adaptive capacity, and vulnerability.

Variables		Willingness to act[a]	Current problems[a]	Future problems[a]	Adaptive capacity [b]	Vulnera-bility[b]
Public (N=208)	μ	3.74	3.05	3.65	2.97	2.35
	S.D.	1.29	1.12	1.09	0.89	0.73
	Nb	201	200	193	195	194
Private (N=161)	μ	3.62	3.39	3.83	3.09	2.60
	S.D.	1.27	1.18	1.14	0.82	0.84
	Nb	156	158	155	160	156
	t	0.89	-2.77**	-1.47	-1.30	-2.93**
Public regional (N=164)	μ	3.66	2.93	3.51	2.96	2.30
	S.D.	1.35	1.08	1.07	0.94	0.73
	Nb	160	156	150	151	152
Public cantonal or national (N=41)	μ	4.03	3.41	4.08	3.00	2.49
	S.D.	1.03	1.16	1.07	0.71	0.72
	Nb	38	41	40	41	39
	t	-1.84	-2.42	-2.95**	-0.30	-1.48

Note: on a) a 1-5 scale, b) a 1-4 scale,** p<0.01 (two-tailed), *** p<0.001 (two-tailed).

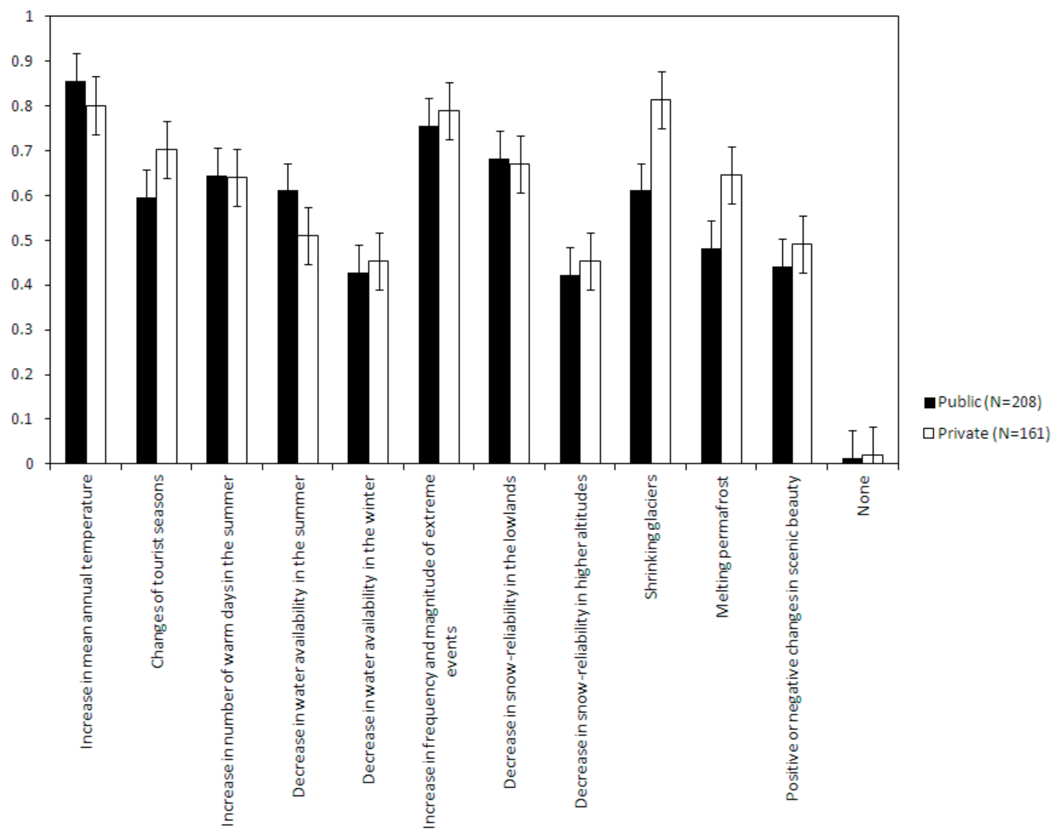


Figure 6.4: Average perception in respectively the public (black) and the private (white) sector of possible regional changes due to climate change for a time horizon 2030-2050. Vertical lines indicate mean standard errors.

6.5.3 Are social acceptability related barriers relevant in the country? Results of the Univox survey

The Swiss population appears to be particularly aware of the impacts of climate change in the country: 53% of the respondents in the Univox survey think that in the future there will be strong impacts and that measures have to be taken (no sector being specifically addressed). An additional 37% think that there will be an impact, but that it will not be so strong. Only 5% of the respondents think that there will be no real impacts (Figure 6.5).

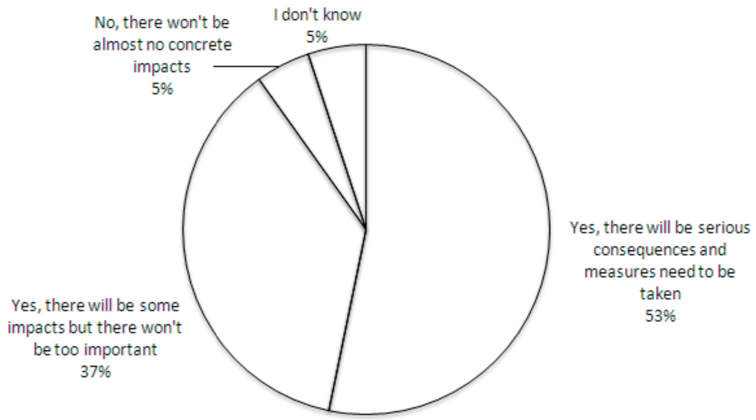


Figure 6.5: Answers to the Univox question “In your opinion, will climate change have a real impact in Switzerland?” (N=1007).

When enumerating a list of possible measures that Swiss climate policy should take in the short term in relation to climate change, either related to mitigation or to adaptation, and asking interviewees to evaluate them, they place particularly high importance on emissions reductions, both in Switzerland and abroad: 47% of the respondents think that it is a priority and 46% that it is important to act in this way in the country versus only a small 4% who think that it is not important to do so (Figure 6.6). In addition, 55% of the respondents think that is a priority and 41% that it is important to persuade the international community to reduce global emissions. Only 3% said that this measure is not important. The Swiss population seems then to be quite aware and sensitive to the issue.

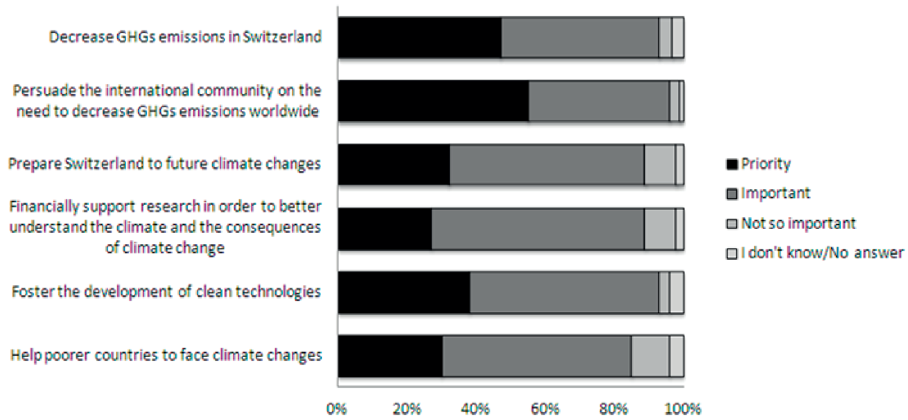


Figure 6.6: Answers to the Univox question “Please define the relative importance of the following measures in the short term for Swiss climate policy” (N=1007).

Coming back to our subject, adaptation, both technical and behavioral measures are felt as very important by the interviewed group of people: 32% answered that it is generally a priority to prepare Switzerland for changes in climate that will take place in the future, while for 57% this is important; only for 9% it is not important (Figure 6.6). Moreover, 27% think that it is a priority and 62% that it is important to finance research in order to better understand the climate and the consequences of climate change, against 9% for whom this is not important. Finally, 38% and 55% respectively are of the opinion that it is a priority or important to foster the development of clean technologies, whereas 3% do not see it as an important measure. According to the interviewees, Swiss climate policy should not only address adaptation inside the country but also abroad: 30% and 55% of the respondents respectively think that it is a priority or that it is important to help poorer countries face climate changes; for 11% this is not important.

Concerning timing and responsibility in preparing Switzerland to the impacts of climate change, the survey showed a clear preference for proactive measures. When accepting that climate change will soon have important consequences in the country, 73% of the interviewed population thinks that it is important to take measures immediately and to prepare by anticipation, against 22% who think that it would be preferable to wait for more information and to react case by case.

Moreover, when accepted that it becomes necessary to take very soon measures to prepare Switzerland for climate changes, the interviewees principally said that the main responsibility lies with federal and local authorities (55% of the respondents), which can then coordinate the different measures and offer financial support (Figure 6.7). A great responsibility should additionally be taken by the population itself (38%), as it is best placed to prepare itself to address these impacts. Interestingly, a smaller responsibility was given to private enterprises: only 5% of the interviewees saw them as responsible of action.

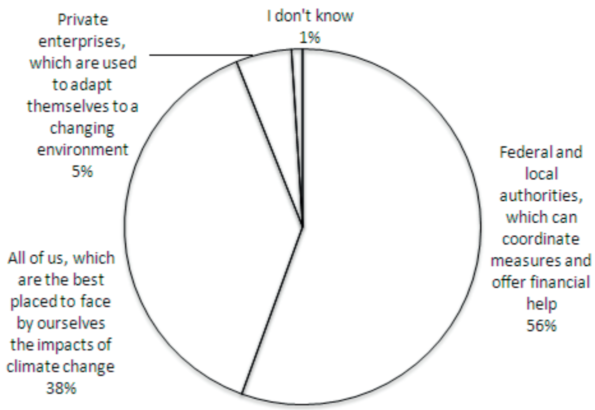


Figure 6.7: Answers to the Univox question "If it becomes necessary to take measures soon in order to prepare Switzerland to address climate change, who should take the main responsibility?" (N=1007).

Finally, in specific relation to winter sports and possible adaptation measures, people perceived this sector as particularly affected. Only 7% of the respondents think that there will not be significant changes on snow availability in ski resorts in the future. This is in contrast to the 48% who believe that all ski resorts will have less snow in the future and 35% who believe that only low- and middle lying ski resorts will be affected. Artificial snowmaking is, however, not generally seen as an adequate adaptation measure: only 24% think that it has a positive impact overall, against 62% who believe that the economic costs and the environmental damages are too high for artificial snowmaking to be considered an efficient and appropriate measure (Figure 6.8).

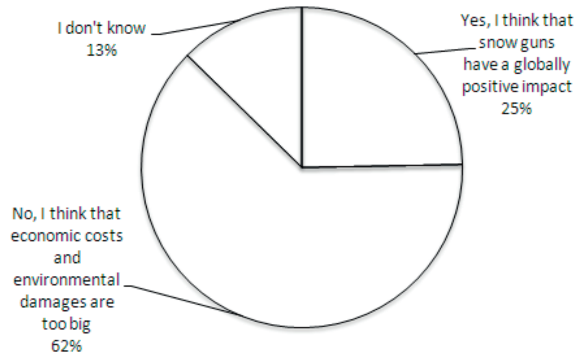


Figure 6.8: Answers to the Univox question "Do you think that artificial now production is an effective and appropriated measure to address the impacts of climate change in ski resorts?" (N=1007).

Answers are not significantly different between genders or among age classes. However, the German-speaking part of the country appeared to be significantly more sensitive to the impacts of climate change, with 58% of the interviewees believing that there will be strong impacts against 33% who believe otherwise, compared to respectively 40% and 45% in the French-speaking part. Significant differences appeared also among income classes: while only 45% of the respondents whose monthly income is lower than 4 000 CHF foresaw important impacts and the necessity to take measures, the shares among those with incomes between 4 000 and 7 000 CHF and incomes higher than 7 000 CHF are respectively 52% and 62%. Logically, 79% of respondents in the highest income class attributed more importance to immediate action, compared to 65% in the lowest income class. The latter expressed a stronger preference for reactive action and step-by-step adaptation (28% against 17% in the highest income class). A last difference worth mentioning is the different weight attributed in the French and the German-speaking parts of the country to the responsibility for action: in the German-speaking part, respondents attributed more responsibility for action to the Confederation (59%) and less to individuals (35%), while the reverse is true in the French-speaking part (44% and 46% respectively).

6.5.4 Possible ways to overcome barriers and increase adaptive capacity

In an open question of the online survey, we asked stakeholders to indicate what, in their opinion, could help overcome the barriers presented in Section 6.4. 124 people answered the question and made different proposals (Table 6.4). The main measure has to do with the 4th barrier cited in Section 6.5.1, namely the lack of information among stakeholders about the regional impacts of climate change and possible adaptation measures and strategies (cited 44 times). Stakeholders frequently cited the need for more and/or better information and communication about the consequences of climate change and about possible adaptation measures. Other answers included better cooperation among stakeholders and among political parties, and higher public participation (19), and innovation and work on other conceptions of tourism and other target groups (12). Respondents also cited changes in mentality and a shift towards a more sustainable way of living and of thinking, in particular among policy makers (12), a higher willingness to act and adapt, in particular among decision makers and in the population (12), a higher awareness of the impacts and the consequences of climate change, and of the importance of tourism in the region in the population and among stakeholders and decision makers (10).

Table 6.4: Main answers to the (open) question "What do you think could help in overcoming these barriers?"(N=124). The complete list of answers can be found in the wiki (Annex A.18).

Proposed actions	Number of times cited
More and/or better information and communication on the consequences of climate change and on possible adaptation measures, as also support from the scientific world	44
Better cooperation among stakeholders and among political parties, and higher public participation	19
Innovation and work on other conceptions of tourism and other target groups	12
Changes in mentality and a shift towards a more sustainable way of living and of thinking, in particular among policy makers	12
A higher willingness to act and adapt, in particular among decision makers and in the population	12
A higher awareness of the impacts and the consequences of climate change, and of the importance of tourism in the region in the population and among stakeholders and decision makers	10
Greater help from the state	10
Both general and climate change related strategies in the tourism sector and for the region	9
More research and knowledge on climate changes	5
More and better directed financial means	4
Other actions	33

We asked participants to define the principal way for decision makers and communal/cantonal/national policies to help adaptation processes. Here too, interviewees mainly indicated that this could be done by providing continual, high-quality, and honest written or visual information on climate change and on possible adaptation measures, both to stakeholders and to the population (cited 55 times, Table 6.5). Other suggestions included the promotion of sustainable and long-term solutions (44), the provision of financial help (33), and the collaboration and discussion with stakeholders and scientists (18).

Table 6.5: Main answers to the open question "In your opinion, how could decision makers and communal/cantonal/national policies help adaptation processes?" (N=211). The complete list of answers can be found in the wiki (Annex A.18).

Possible actions	Number of answers
Provide continual, good-quality, and honest written or visual information to stakeholders and the population (through e.g. symposiums, seminars, and continuing education)	55
Promote sustainable and long-term solutions, in particular in relation to energy consumption and mobility	44
Provide financial help (e.g. subsidies)	33
Collaborate and discuss with stakeholders and scientists	18
Recognize climate change, be informed on the impacts, the possible adaptation strategies and the costs	18
Define an action plan/a common strategy or support its elaboration	16
Collaborate among different policy levels (municipalities/cantons/confederation) and among parties	11
Adapt legal setting	11
Act instead of discussing	8

Possible actions	Number of answers
Create (or sustain if already existing) a early warning system for disasters and a disaster management concept; create hazard vulnerability maps	7
Sustain and promote targeted adaptation actions that could be transposed to other regions	6
Promote collaboration among stakeholders	4
Monitor the evolution of the impacts and of the adaptation measures (at the cantonal and national level)	4
Nothing	11
Other actions	40

Regarding what kind of information is perceived as lacking, stakeholders indicated principally regional climate change scenarios (55% of the respondents), regional climate impact studies (39%), and vulnerability assessments (38%) (Figure 5.9 in Section 5.4.2). What also emerged from the survey is that stakeholders get information primarily from newspaper (87% of the respondents), television (70%), and radio (56%) (Figure 5.7 in Section 5.4.2).

Considering more specifically ways to overcome the lack of willingness to act, we asked stakeholders in the online survey to indicate in an open question what could make them change their ideas and their behavior. Figure 6.9 and Figure 6.10 show respectively the general answers and the differences among respondents who positioned themselves on the five levels of willingness to act. Respondents saw more cooperation among stakeholders (35% of the 228 persons who answered the question), higher levels of leadership and direction from above (22%), higher levels of general willingness to act, and more political actions (21%) as the principal possible solutions. 59 people said that they were already engaged in adaptation measures.

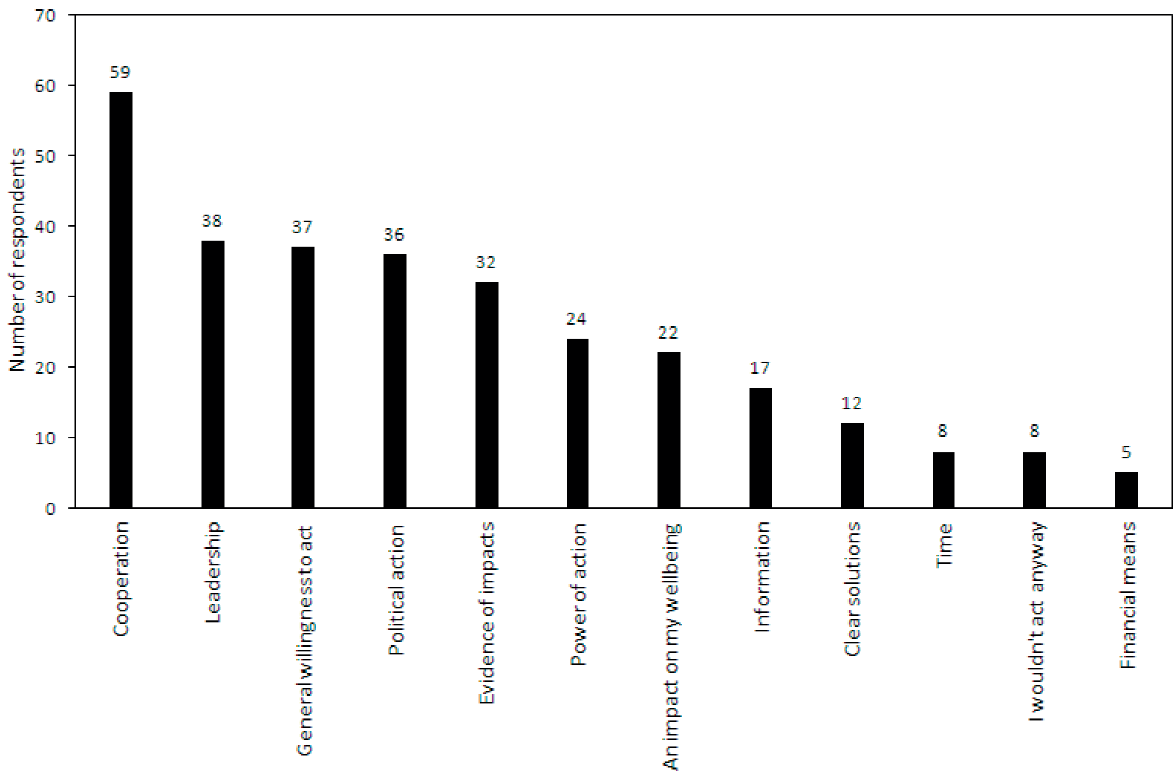


Figure 6.9: Number of answers for different categories of responses to the open question "Please explain your choice. What could make you change your ideas and your behavior?" (N=228).

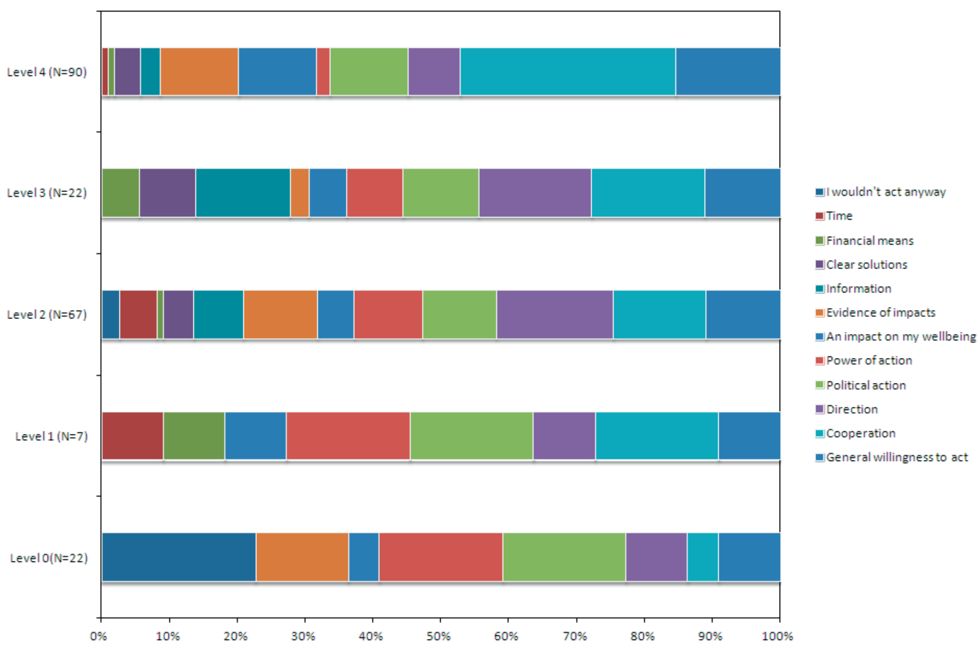


Figure 6.10: Number of answers for different categories of responses to the open question "Please explain your choice. What could make you change your ideas and your behavior?" in relation to the levels of willingness to act (N=228).

By looking at differences among levels of willingness to act (Figure 6.10), we can see that more cooperation and general willingness to act are sought mainly among people showing high levels of motivation. On the other hand, people showing less willingness mostly claimed that if they had more power to act and if there was enough political action, this might lead them to get involved.[107] In addition, evidence of the impacts could make them change their private and public behavior.

Finally, we looked at the relationship between willingness to act and several variables, including present and future potential impacts affecting the region, adaptive capacity, and vulnerability (Figure 6.11). It appeared that a highly significant but weak correlation exists between both willingness to act and perceived present and future potential impacts (the stronger the perceived impacts, the higher the willingness to act). For adaptive capacity the relation is U-shaped: willingness to act appears to be very low when adaptive capacity is low (because perhaps there is no space for maneuver), but also when adaptive capacity is perceived as very high. This may be the case because the adaptation process is already under way and there is no need to do more. Concerning vulnerability, it also appears that willingness to act is low when vulnerability is low (because there is no need for it) but increases quickly once vulnerability is perceived; it then hits a ceiling at middle vulnerability perception. The correlation is significant at 5%.

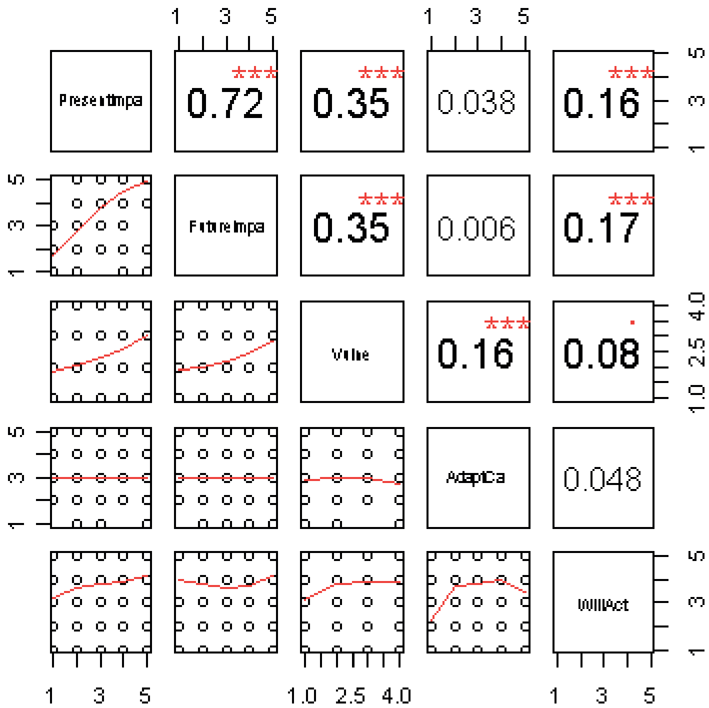


Figure 6.11: Representation of Pearson's correlation among perceived present (PresentImpa) and future impacts (FutureImpa), perceived adaptive capacity (AdaptCa), perceived vulnerability (Vulne), and willingness to act (WillAct). In the lower diagonal, a scatter plot matrix. In the upper diagonal the correlation coefficients are reported (N=481) (*significant at 5%; **significant at 1%; ***significant at 0.1%). For each of them, different numbers of people replied.[108]

[107] Here 23% wouldn't act anyway and 23% already act.

[108] For present and future potential impacts: 1) I strongly disagree with the assertion that climate change causes problems in the tourism sector in my region, 2) I disagree, 3) I neither disagree nor agree, 4) I agree, 5) I strongly agree. For adaptive capacity: 1) not existing at all, 2) low, 3) average, 4) high, 5) very high. For vulnerability: 1) not vulnerable at all, 2) partly vulnerable, 3) quite vulnerable, 4) vulnerable. For willingness to act: 1) level 0, 2) level 1, 3) level 2, 4) level 3, 5) level 4.

6.5.5 Overcoming barriers: barriers encountered or avoided in the adaptations processes

As presented in Section 6.4, we grouped the different types of barriers into 5 families: *social feasibility, social acceptability, institutional feasibility, economic feasibility, and technological feasibility.* Environmental aspects were considered as limits. This was mentioned during the interview in Grindelwald, in which the limits given by nature were cited:

> *"So that's what we feel directly. We can see what nature does in such moments and I think these natural changes had happened before, many many years ago. But these days we tend to build very close to the rivers. Not only here in Grindelwald but also lower down in the valleys. We used to maintain the land close to rivers and in the flat land nearby. We used to build houses very close to the rivers. Now almost nobody is ready to give back the land to the nature. And these are the things we have to deal with now. […] I think that we had to do this tunnel, mainly because of the possible damages not only in Grindelwald but also in the lower situated communities. [...] On the other hand, I think we have to accept nature, we have to learn how nature works. We know that the glaciers were as far back as they are now once in history. […] The problem is time! It is impressive how fast it goes nowadays and how fast the glacier retreats. […] We know that it had happened before, that it will happen again and that we cannot change nature."*
>
> Grindelwald (part of the Grindelwald region), 20.09.2011 – A member of the municipality

If local stakeholders do not perceive changes and recognize impacts, this could be due to the insufficient knowledge about their region or lack of knowledge about and familiarity with the scientific research on climate change impacts taking place in the area. However, once changes are perceived and impacts are recognized, barriers can appear from inability of the population or of stakeholders to take coordinated action or to collaborate. We previously called this kind of barriers social feasibility barriers. An example is given in Cardada, where the interviewee mentions the potential difficulty to find a consensus among the stakeholders.

Another type of barriers linked to the social sphere can emerge once the impacts are recognized: the population or stakeholders can, for various reasons, reject the planned measure. During the discussions, people mentioned social acceptability barriers several times, in particular in Cardada, St. Moritz, Sattel, Grindelwald, and Campo Blenio. There, people depend largely on tourism, which seems to be the reason that they want to preserve the sector and they accept the proposed actions generally well. In St. Moritz, for example, a member of the tourism office said that there is a high willingness to accept adaptation measures because nature is the main asset of the region, with 80% of the jobs related to the sector. People understand therefore the importance of protecting the sector and its assets, and for this reason they also show high levels of public support. Sattel is also a particularly good example of barriers avoided. In the village much is done proactively and in quite an innovative way. The region works together with other domains and other municipalities and with universities, shares problems and ideas. The citizens are integrated in the process from the beginning. Social-acceptability barriers seem to be almost inexistent and local people appear to be rather proud of the measures taken. However, these barriers cannot always be avoided. One example is given in Cardada, where the interviewee mentioned the possibility that stakeholders may block the proposed strategy:

> *"To make all stakeholders agree on a topic, this is the most difficult thing. It's not really carrying out a project, but it's first making all people agree, then finding the money, and then carrying it out. It's for this reason that we started with this master plan. We showed it to everybody and if someone had something to say about that, he or she could say it from the beginning. In reality, thus, we didn't get that*

much opposition. Because it's clear that this master plan is not binding on a planning level and therefore perhaps some opposition could rather arise at the time of implementation. […] Up to now, we tried to include everybody, even if not everybody lets himself get involved. For now, we have not met that much resistance, except […] in some circles. But the thing doesn't go further than these problems. Nevertheless, these are also things that shouldn't be underestimated, because, depending on who you are addressing, you can provoke reactions that will not allow you to carry on the work in the future."

Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 - The president of the cableway company*

"The municipality defined the general orientation for collective work and this affects also finances, social issues, schools, and so on. And here the municipality sets the general framework. Then, there is a general orientation for tourism, which is based on that. There is a working group which encloses the municipality, the cable car company, the local folks, and the restaurants … a participative process then. In this one here 10-12 persons took part. […] There are barriers that are not so big. There are certainly people who say that climate change doesn't exist. But this is also politically-driven, isn't it? Rather conservative people say that climate warming always existed. But no oppositions, on the contrary, for this wind turbine … people are almost proud of it. […] We have to be a bit innovative; it must appear in a positive way. It's also a strategy to say that we want to be pioneers, to go a step further. As a municipality, but also as tourism operators."

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

Citizens in Grindelwald did not oppose the construction of the tunnel because of the imminent threat that the glacier lake represented for the population in the region and for tourists. In Campo Blenio as well, people understood the benefits that the measure would have on them and on the economy of the region:

"The fact was that Grindelwald had the problem that people, tourists, were afraid to come to Grindelwald because the problem with the glacier lake was obvious. And when you heard of Grindelwald, you thought about the glacier lake and the flood damages. People didn't know that the danger of flooding was just in the valley, whereas the village here is on the slopes; […] the biggest part of the commune wouldn't be flooded. So they were afraid that tourists wouldn't come back to Grindelwald because of this danger, and so people looked forward to protection measures and they weren't concerned about which was the best solution, they were happy that a solution was found."

"We try to discuss even normal projects. It's easier when you have a lot of time to plan and you can take really all the stakeholders interested in the project and discuss with them. Here, the time was short, but the interest was big to do something."

Thun (for Grindelwald) (part of the Grindelwald region), 25.07.2011 – A member of the cantonal office (office director of the construction, transport and energy department)

In Campo Blenio, the interviewee was asked how people and environmental associations react to the project:

"I would say well. Just to tell you ... last year the municipal council approved I think unanimously to support us. And the population also reacts well in the sense that they understand that if, for example, someone has a flat to rent, he will rent it more easily. And someone who works here, if there is the opportunity to work, he could get some more money. But still, you always have the odd one who doesn't agree. […] In relation to environmental associations, up to now we didn't face particular problems. It's true that in the first phase, back in 1996, we had to overcome a bit all of that. [...] But they understood the issue, and it went well. But you know, we also have the luck not to have protected areas here. If it were on the

Lukmanier, for example, where you have a protected area even at the national level, well, it wouldn't have been possible."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – a member of the cableway company*

Involving stakeholders very early in the process seems to have avoided many acceptability problems. The same was mentioned in Thun and Adelboden in relation to institutional feasibility. There barriers were avoided by including the political level in a very early stage:

"What I didn't say was that we informed very early on the high political level in the canton of Bern. The top officials were informed at the beginning, and they have big interests to take measures in this case, and we had their support, which was very precious for us."

Thun (for Grindelwald) (part of the Grindelwald region), 25.07.2011 – A member of the cantonal office (office director of the construction, transport and energy department)

"The chance is bigger if we start with the domain of Adelboden and then we invite the others to join and work with us than to say 'You have to do that'. Then you have barriers that appear. In this way we can address these barriers and talk with everybody. Because for us then it's clear that we are the ones who define the strategy, otherwise it doesn't work. We saw that if the canton of Bern says 'You have to do this, this, and this' it never works."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

Finally, some interviewees mentioned barriers that could have or actually did come up due to the lacking economic and technological feasibility. The most manifest example was given by Adelboden, in which the main center of the new wellness strategy never came to life due to the withdrawal of the main investor:

"It was a process. Already before, we said that we have to do more alpine wellness. I don't know if you heard about it, we also had the plan to build a big resort. And then at the moment we are looking for money, for someone who really makes the big investments. And then clearly all the other measures were in relation to this one. […] The problem is that we had a family from Kuwait that wanted to finance it. But then, last year they withdrew because of the economy. So we have to start again with the search and at the moment we don't have a name to tell."

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

And the second person interviewed in Adelboden added:

"In relation to ski, there is not much to say. We are strong, the product works well. In relation to the wellness product, we need the Alpenbad. It's not blocked but the world financial crisis now doesn't help us very much. And neither does the Euro. It doesn't help the investors to invest. Clearly, because for investments made from abroad this means that the product Alpenbad, the building and all that, increased by some 25%. […] The Alpenbad was the core, or still is the core, that we absolutely need for this idea of summer wellness. But the other aspects, they are also needed, because otherwise we have a product like everybody else."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

Zermatt does not experience economic barriers at the moment in relation to adaptation and mitigation measures, being at the present time in a positive cycle of investments:

> *"Zermatt has the luck of being a well demanded destination. So size matters. […] For sure it is in their interest to have the slopes ready when the market demands for skiing. […] Whoever has the best slopes will have the most clients and will make the most money. It's a circle that runs in Zermatt positively. Because we have the money to invest, we invested it. We have good slopes and more people are coming and then again the return pays the investment back. But in many places I know this is going backwards. Fewer clients, less money to invest, a lesser offer, fewer clients ... so this is the backwards spin."*
>
> Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

Cooperation and support among resorts also appear to be good way to overcome some of these barriers, with long-terms benefits for all the stakeholders involved. Zermatt, for example, has a tradition of helping smaller, low-lying resorts like Cardada with e.g. technical services, control of the engines, or revisions. Zermatt possesses a big infrastructure with more than 100 employees and a capacity 10-20 times greater than all Ticino ski resorts put together. Small ski resorts are obviously not rivals for them. On the other hand, these smaller resorts would have many more difficulties without the technical and financial help of these bigger resorts. For the bigger ones, in the same way, it is important to keep the low-lying small resorts alive. Indeed, they are often the first places where many kids go to get acquainted with winter sports. Like Zermatt, St. Moritz also offers a system of technical and financial support to the smaller Engadinese ski resorts:

> *"Yes, we have partnerships in the Zürcher Oberland … and then of course we have partnerships in Engadin itself with all the little skilifts in the villages, because there is not one single company in Engadin. Now we had to merge, but we are still 11-13 resorts. We are the biggest today, but there are many small ones with only one ski lift. But they are also important for the same reasons I mentioned before, for the kids, for families coming to ski with small kids. For them it is OK to have a small skilift in the village. So we give technical and also financial support."*
>
> St. Moritz (part of the Engadin St. Moritz region), 25.08.2011 – A member of the cableway company

6.6 General discussion on barriers to adaptation

One of the aims of this chapter was to define which barriers can hinder the adaptation process and what their importance is. It also aimed to assess how barriers could be overcome and adaptive capacity be increased. Finally, it wanted to assess at which step of the adaptation process these arise.

From the online survey, we saw how all types of barriers are generally perceived as relevant, economy-related barriers more than others. Nonetheless, adaptation processes could also face other problems. For example the ones linked to natural uncertainty mentioned in Section 6.4. These affect e.g. economic feasibility (they make it harder to finance adaptation measures), social feasibility (they make it harder to convince stakeholders to act), or institutional feasibility (they make it harder to change institutions). As stated by Dessai et al. (2009), even if natural uncertainty represents a limit, successful adaptation can be developed in the face of it by selecting options that are sufficiently robust across alternative futures.

Concerning barriers related to social acceptability (both coming from the population and from stakeholders), these do not seem to particularly threaten the adaptation process. As seen above, the resistance or even blocking by the local population of adaptation measures does not seem to be a relevant barrier to adaptation for tourism in Switzerland. In this sense, the acceptance of the population appears to be high. Face-to-face interviews showed that social acceptability rarely hindered the processes investigated since people were often favorable to the action undertaken. The online survey showed that this kind of barrier is not a problem for the sector in the country; stakeholders gave it the second-lowest score among the different families of barriers proposed. However, it has to be remembered that both the interviews and the survey rely on a small number of respondents and, in the case of the interviews, on a biased sample (we contacted mainly people in regions in which adaptation was successful). Is it therefore always so? Does the population not represent a threat to the implementation of adaptation actions chosen? According to the results of the Univox survey, carried out among 1007 Swiss inhabitants, the answer seems to be positive.

As appeared in the Univox survey, Swiss inhabitants are aware of the impacts of climate change and of its consequences on the tourism sector and believe that action should be taken in relation to adaptation. In places in which adaptation is most needed, the population is often very closely linked to the sector as the backbone of the local economy. An additional reason explaining the high acceptability is simply that often these measures do not directly affect the populations' economic or physical well-being. This explains why people are seldom opposed to projects that are already planned or developed, as revealed in the face-to-face interviews. The Univox survey also showed that the population is conscious of mitigation aspects, which perhaps explains the existing low acceptability of artificial snowmaking. The production of artificial snow is often seen as maladaptation rather than adaptation, not only because it is not a solution in the long term and it is particularly costly, but also because it requires significant amounts of water and energy, and therefore has an impact on the environment and on climate.

A second component entering in the definition of social acceptability, which experts so highly weighted in the Multicriteria Analysis, is the willingness to act of stakeholders, both from the private and the public sector. Here as well, from the perspective of the sample of stakeholders that took part in the online survey, willingness to take action in order to adapt appeared to be relatively high. No significant difference appeared in the responses of private and public stakeholders, nor between stakeholders working at the regional and the ones working at the cantonal or national level. We did not find any significant difference among the explanatory variables chosen and any significant interaction among them.

Significant differences in perception of barriers appeared however among people who expressed different levels of willingness to take action in order to adapt. Respondents who affirmed that they would continue their business as usual gave significantly less weight to the various barriers. Moreover, respondents who would only take some steps in the adaptation process seemed to give more importance to barriers related to social acceptability, national political willingness to act, and information than respondents who expressed their willingness to invest energy and time in order to adapt. These seemed, on the other hand, to give more importance to the lack of possible solutions, economic means, coordination, and stakeholders' willingness to act.

If social acceptability aspects do not seem to be a problem with both a population supportive of the measures and stakeholders who are relatively strongly willing to act, one could ask why more action is not taken. This has probably to do with barriers related to social feasibility. People are willing to act but the steps bringing about the action are often lacking. As showed by the online survey, stakeholders are particularly willing to take action when they have a high level of knowledge on the topic and when they are particularly affected by the impacts of climate change. High willingness to act is, however, often hindered by the lack of cooperation and by the critical mass of people willing to act. Another possible reason (not included in our survey, but which came up in some face-to-face interviews) is the difficulty to coordinate two neighboring municipalities or two near cable car companies. Adaptation options are often local public goods, benefiting not only the municipality or the company that invests in order to adjust to the impacts but also the near and related ones. Stakeholders are then faced with issues of collective action, allocation of costs, free riding, and trust.

As it appeared during the face-to-face interviews, barriers intervene at different phases of the adaptation process (Figure 6.12). In general terms, a threshold has to be reached to move, for example, from the recognition of the impacts to the decision to act, from the decision to act to planning, and from planning to action. Barriers related to economic- and social feasibility are therefore so critical because they have the power to delay stakeholders from reaching these stages. For example, the lack of information and communication can hinder the perception of changes and the recognition of the impacts ((1) in Figure 6.12). Stakeholders can perceive the impacts of climate change on their region. However, until they feel that their business or wellbeing is threatened, they will not decide to act. In the same way, once the decision to act has been taken, if there is not enough information on the impacts and the possible adaptation options and if the capacity to collaborate and communicate among stakeholders' is lacking, then the planning and the action phases will never be reached (2). Starting from the planning phase, the lack of financial resources begins to represent a serious threat to the advancement of the process (3). If not enough money is available, then the project cannot be carried out effectively and the options chosen cannot be implemented. Summing up, our results confirm the hypothesis of Alberini et al. (2006): economic resources are not the only key factor influencing adaptive capacity, nor is access to information. Yet, both elements play an important role.

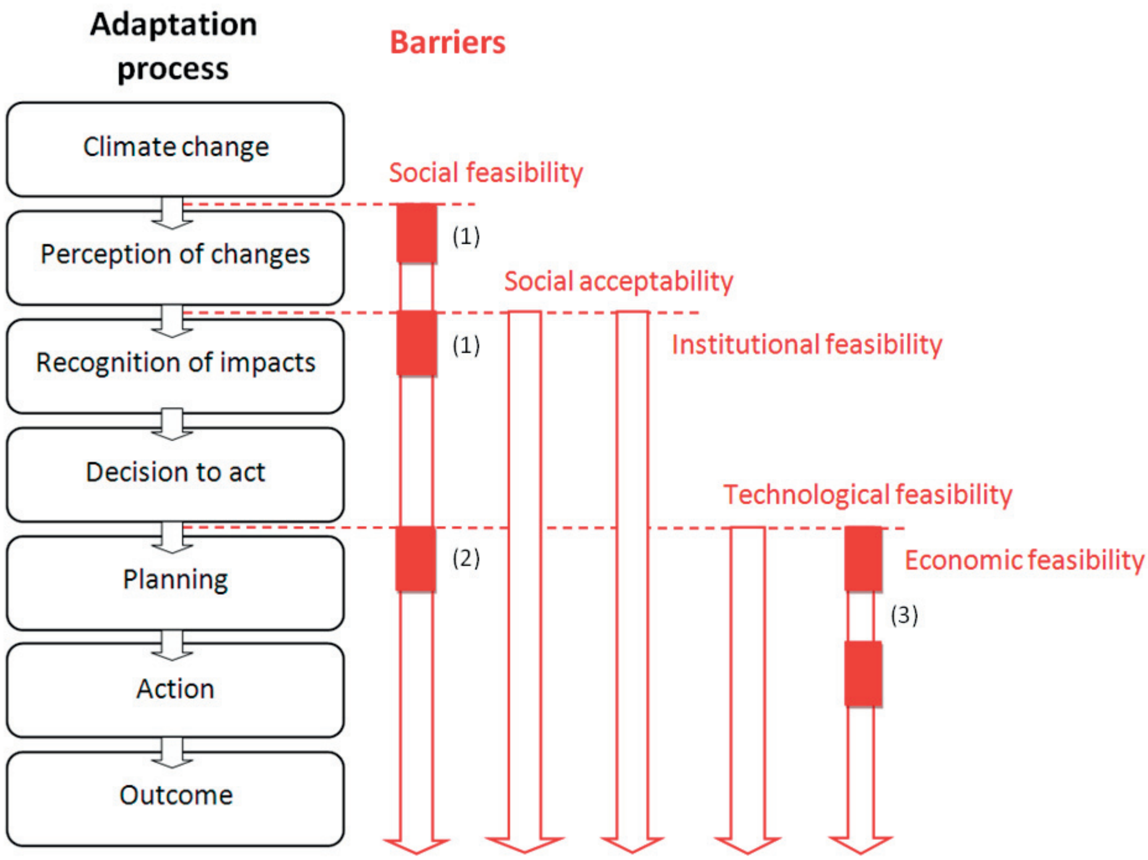


Figure 6.12: Among the different existing types of barriers, two principal types appeared in the adaptation process of the Swiss tourism sector: social feasibility and economic feasibility. The first appears at the levels of the perception of changes, at the recognition of the impacts, and at the decision to act (1;2); the second, at the planning and action phases (3).

Ways to overcome barriers should, therefore, deal primarily with social feasibility and economic aspects. Proposed measures were mainly related to social feasibility and less to other aspects. More and better information and communication on both impacts and adaptation options are seen as the main measure, both in general terms and as actions taken by the political world. Providing information is seen as the main instrument for overcoming barriers, perhaps because it is easily applicable (it is easier than finding direct ways of overcoming economic hurdles or lack of willingness to act). In addition, the face-to-face interviews and the online survey showed that stakeholders sometimes mistrust the information provided, which came mainly from the media. Respondents mentioned that they primarily used newspapers, television, and radio as sources of information. This means that they primarily get information through second-hand channels. This could explain why people ask for more and/or better information and communication on the consequences of climate change and on possible adaptation measures. More and better information could additionally be a way to increase political and stakeholders' willingness to act and to encourage coordination and interaction in the tourism sector in the region.

As suggested by stakeholders in the online survey, the Confederation and the cantons could then have a role to play by, for example, further disseminating the available scientific information and by organizing workshops and conferences aimed at informing the various stakeholders. What also appeared both from the face-to-face interviews and from the online survey is the importance of including all the concerned stakeholders from the beginning in the adaptation process. Fundamental components of the success of an adaptation process are therefore participative processes, transparent information, and effective communication among stakeholders, collaborative work, and a common strategy.

In addition, in order to lower economic barriers, the public sector can have a role to play with, for example, financial support in the form of subsidies and interest-free loans. These are mechanisms already in place, which could be further focused or improved. The new bases of the Innotour law,[109] which were launched by the Confederation on 01.02.2012, are a step in this direction. The Innotour law aims, moreover, to promote collaboration, innovation, and professionalization inside the sector.

In sum, barriers could be overcome in three different ways: (1): by providing more and/or better information and communication on the consequences of climate change, (2) by fostering better cooperation among stakeholders, among political parties at the different levels, and higher public participation, and in general by putting stakeholders willing to adapt in contact, and (3) by providing financial support and more and/or better information and communication on possible adaptation measures. The three points can be put under the same umbrella, which is the definition of an action plan or a common strategy which also considers the implementation of sustainable solutions.

The Swiss adaptation strategy to climate change is being elaborated at the DETEC (FOEN 2012). In relation to tourism, three objectives are being discussed: 1) development of the offer, 2) minimizing the hazards, and 3) improvement of communication. The bases on which the strategy lies are the fostering of knowledge development on tourism adaptation to climate change and the reinforcement of the transversal tasks between tourism and climate policies (in particular the coherence between climate and tourism policies). In relation to the first, the strategy aims to promote both publications on the subject and events on the topic (e.g. Swiss Tourism Forum). It also aims to foster national Innotour projects, which encourage the sector to adapt to climate change and foster best local and regional projects both top-down and bottom-up. The new conception of the federal tourism policy sets the legal framework. The framework seems to fulfill particularly well these conditions as also stakeholders' suggestions.

Action proposed by the Confederation matches well what was suggested by Lehmann Friedli and Müller (2011) after discussions with experts. Here too the conception and coordination of strategical (legal) bases for adaptation, the dissemination of information about climate change and adaptation to the tourism sector, financial support of the process, and the promotion of research on the topic were seen as possible actions that the Confederation should undertake.

In sum, conditions for the effective implementation of adaptation processes in the Swiss tourism sector exist. Often, however, thresholds have to be reached for action to be taken. When climate change affects a region, impacts must be perceived as threatening enough for stakeholders to decide to act. Furthermore, in order to pass from the willingness to act to real action, a critical number of persons disposed to taking action have to be reached. Moreover, these need to enter in contact by, for example, the establishment of cooperative networks strong enough to allow the process to be carried out. Finally, action leads to results when enough financial means are available for the networks.

[109] http://www.seco.admin.ch/innotour/index.html?lang=fr. Last accessed 27.04.2012.

6.7 Limitations of the methods employed

This chapter relied on results obtained from three different methods: the online survey, the Univox survey, and face-to-face interviews. The three methods generated data which are different in terms of quality and which tackle different aspects of barriers to adaptation. All three methods possess limitations and carry uncertainties. For example, the response ratio in the online survey is so small that it is difficult to infer general results for the entire tourism sector. Respondents most sensitive to the topic probably self-selected. Another limitation is linked to the representativeness of the small sample of stakeholders chosen for the face-to-face interviews. Moreover, results can be biased because interviews were carried out in regions in which the adaptation process mainly succeeded. What about regions that are very vulnerable, but in which no adaptation processes were yet carried out or regions in which the adaptation process failed? They may have faced other types of barriers.

This chapter and the three method used make it possible to shed some light on the possible barriers hindering the adaptation process in the Swiss tourism sector, on their relative importance, and on their emergence in the adaptation process. However, its results and general conclusions should be taken with care given the complexity of the topic, the limitations of the methods employed, and the heterogeneity of the stakeholders involved.

6.8 Conclusion

As seen in this chapter, the best ways to overcome existing barriers are to tackle social and economic feasibility. These include more and better information and communication about the consequences of climate change and on possible adaptation measures, better cooperation among both stakeholders and political parties at the different levels, and more public participation. In other words, adaptation is more effective and many barriers can be overcome when stakeholders possess clear and effective information on regional impacts of climate change and on possible adaptation measures, when all stakeholders, both from the private and from the public sector, join the process from the beginning, and when enough financial means exist. As stated by stakeholders, the public sector has an important role to play in the process by coordinating these measures, and generally, by designing a common strategy, which must promote sustainable and long-term solutions, in particular in relation to energy consumption and mobility.

At the same time, the private sector appears to be aware of the threat that climate change is to its business and is not sitting idly by. Climate change is not the only challenge that the sector is facing; the world economy and societal changes, among others, also preoccupy the sector. It should not be forgotten that, at least in the short term, climate change could also bring some benefits to Swiss tourism. Barriers are not absolute limits, they can be overcome. Mitigation and sustainability should however not be forgotten in the process. A freshly published report by the Federal Office for Spatial Development (ARE) (‘*Tourism and sustainable development - Good practices and possible plan for action*’,[110] ARE (2012)) emphasizes the action undertaken by the Confederation to promote sustainable solutions.

[110] ‘Tourisme et développement durable - Bonnes pratiques et pistes d'action’.

7 General conclusion and future research

As seen in the introduction, this thesis was built around three main objectives: i) to assess the distribution of the vulnerability of tourism in Switzerland to climate change and the subsequent determination of vulnerability hotspots; ii) to analyze possible adaptation measures on the regional and national scales; and iii) to identify and evaluate the barriers to adaptation and how these can be overcome.

In relation to the first objective, it appeared that climate change affects Swiss tourism in many ways, the most important impacts being in the experts' opinion snowpack reduction, melting glaciers, and water scarcity. According to their judgment, it also appeared that the adaptive capacity of a region is a significant determinant of its degree of vulnerability. In their view, the most exposed regions are therefore not necessarily the most vulnerable ones. On the other hand, stakeholders' perceptions of regional vulnerability assigned a higher importance to exposure, and in particular to current conditions (like snowpack reduction and the increase in frequency and intensity of natural hazards). As a consequence, results based on stakeholders' perception indicated that the Prealps and the Rhine Valley are particularly vulnerable, whereas the map derived from the criteria of the experts showed instead that mainly the Canton of Valais and northern Ticino are the most vulnerable regions. This difference is perhaps due to the stronger emphasis of stakeholders on the present situation. Impacts already taking place are easier for stakeholders to estimate (Hinkel 2011; Holsten and Kropp 2012).

Apart from the temporal component (stakeholders relating more to the present situation and the map more on the 2020-2050 horizon), these differences force us to question how feasible it really is to effectively assess the vulnerability of a region. How can we define and measure vulnerability objectively? What does the vulnerability of a region mean as opposed to the vulnerability of a company or a local authority? What is the role played by exposure in defining the concept? What is the role of adaptive capacity? In the end, is it really the adaptive capacity and not the climate that determines the future of a tourism region under climate change (Agrawala 2007)? Other aspects that make the exercise particularly complicated are feedback loops, scale issues, and interactions among indicators. These are sometimes difficult to consider in a model. Moreover, data and knowledge gaps still exist, in particular concerning the influence of climate change on water availability and natural hazards for the Swiss tourism sector, and the economic weight of the sector in the different regions.

Because of these and the many other limitations that the method faces, we believe that it is nearly impossible for the moment to portray real regional vulnerability. The map we developed should be seen more as an instrument allowing stakeholders to compare results with their own subjective perceptions of vulnerability in their region. It should allow them to discuss and share information and to define where more research is needed. The exercise will be a success if it raises stakeholders' awareness and entices them to initiate local adaptation processes. Vulnerability maps are 'boundary objects' that facilitate communication and learning among and between stakeholders and researchers (Lynch et al. 2008; Preston et al. 2011).

In relation to the second aspect, namely adaptation, it appears that Swiss tourism stakeholders are generally aware of the impacts of climate change and are taking measures to adapt to it. Adaptation options are various, address different impacts and follow different goals. Moreover, these actions are often not just a simple direct answer to climate change. Other factors also drive them, such as changes in taste, competition, or globalization. As cited by an interviewed stakeholder, while there are actions that can clearly be labeled as adaptation to climate change, others lie in a rather grey zone, in which the direct influence of these changes is more difficult to determine. Nonetheless, we can group the different actions in three categories: 1) development of the offer, 2) reduction of risks, and 3) communication.

It is interesting to examine the temporal evolution of these options. What appeared in the face-to-face interviews is that a first 'wave of adaptation' started in the 1990s' (after some successive years of very bad winter conditions). This mainly concerned the further development and securing of snow sports activities. Now, a new wave seems to take place. This one mostly focuses on the promotion of year-round tourism, innovation, and diversification of the tourism offer. However, as for the securing of winter sport activities, it should be remembered that this trend is not only determined by climate change. Others determinants such as changes in tastes, globalization, population structure, and mobility patterns also play a role.

In addition to innovation and diversification, there is a growing amount of research and of monitoring of the impacts in the sector. In the same way, both tourists and the Swiss population (including stakeholders) alike are more and more informed about the consequences of climate change. Lastly, there is a long history of natural hazards management and the use of insurance instruments. Being an alpine country, Switzerland has always been exposed to extreme events and has learnt to deal with them. As a result, ways of addressing extreme events have been developed before and will continue to be in the future, independently from climate change. This activity will only be strengthened and possibly reoriented by it.

According to stakeholders, the public sector can facilitate the adaptation process and help avoid maladaptation mainly by providing honest and clear information on the impacts of climate change and on possible solutions, by disseminating good examples, by providing financial support and a structure capable to address and handle extreme events. This is fully in line with what is already being undertaken at the different levels and with the Swiss adaptation strategy freshly published by the government. It appears that almost all measures necessary to effectively and sustainably tackle climate change and the framework for their implementation have already been defined (with the exception, perhaps, of better monitoring and continual revaluation of the options). The real effectiveness of the adaptation of the tourism sector depends now on the successful implementation of these measures and on their continual monitoring, evaluation, and adjustment.

Adaptation is a cross-cutting issue which affects a multitude of stakeholders (Hilpert 2007). Due to its origins, Swiss tourism has always been a composite of activities, facilities, services and industries that deliver the travel experience. For example, a ski resort does not generate profits only for the cableway company that operates the slopes, but also for hotels, restaurants, and transport services in the region. Hotels and restaurants will benefit more from seasonal diversification than cableways companies, but it is often the latter that carry out the investments (Agrawala 2007). The interviews also showed the interdependence between small low-lying and big high-lying and renowned ski resorts, the first providing a place for kids to get accustomed to the sport, the latter providing financial and technical support to the first. In addition, the private and public sector are intertwined. The first provides often an economic and social pillar to many mountain regions and helps, in its way, keep many mountain regions alive. Therefore collaboration and interaction among different public and private stakeholders at the different levels (communal, regional, cantonal, national, and international) is particularly relevant.

The public sector can, as seen, design a common strategy and tailored policies and regulations (also to avoid maladaptation), raise public awareness through information and communication, and provide natural hazards monitoring and financial support in the form of subsidies and interest-free loans. It can also help overcome operational constraints for the more vulnerable while supporting research and development. The various private stakeholders should be involved in the process from the beginning. We see as necessary a mix of top-down and bottom-up approaches, public support to initiatives, cooperation, information, and public participation. The key issue for effective adaptation is finally the improvement of regional governance capacity, i.e. the capacity of a region to work on issues and solve problems collectively (Pütz 2004; Grothmann and Pütz 2009).

Finally, regarding barriers to adaptation, we found that these can be social, economic, technological, and institutional. Social barriers are linked both to acceptability and feasibility. Looking at the results of the Univox and of the online survey, as also at the face-to-face interviews, barriers related to acceptability, seen both as the inhabitants' acceptability of the adaptation measures and the stakeholders' willingness to act, do not seem to be major problems in Switzerland. This is true if the adaptation measures proposed are not maladaptation and they are sustainable. As stated by stakeholders, the lack of technological solutions does not seem either to be a particularly relevant barrier to adaptation for Swiss tourism. Other barriers are perhaps more relevant, such as economic and social feasibility. Both private and public stakeholders who took part in the online survey showed relatively high willingness to act; nonetheless this can be hindered by both the lack of cooperation and information to stakeholders. The lack of social feasibility has therefore the power to hinder social acceptability. There are, moreover, limits that cannot be overcome and which could affect the adaptation process. These are principally linked to environmental aspects and to the uncertainty concerning the future.

As mentioned in the introduction, never up to now have all the important impacts of climate change for the Swiss tourism sector been considered within a single study. Neither was the assessment of relative regional vulnerability and of possible barriers hindering the adaptation process. This thesis tried to fill these gaps. The reseach provided information on possible regions particularly affected by climate change. It also gave information on data gaps, areas where more research is needed. It defined which adaptation mesures are planned or already implemented and which are seen as more effective. It discussed their temporal developpement and tried to establish which factors are more capable to hinder the adaptation process.

The various methods used, and their interrelation suffer, however, from important limitations. We used different sources and types of data that carry a certain amount of epistemic uncertainties. These mainly relate to the small sample of people interviewed and on stakeholders' possible lack or partial knowledge on the different topics. The response rate in the online survey, in particular, is so small in some regions that it is not really possible to infer general results for that region. Moreover, it might be questionned whether stakeholders can speak for their region as opposed to their company or local authority. Further research should try to consider these elements. It should also look more closely at the interrelations inside and with different systems and among different spatial scales. It could look, for example, at the consequences of the combined vulnerability of the tourism and the agricultural sector in moutain regions or the influence of the impacts of climate change in other regions and countries. Additional research should moreover look more in detail at the reasons for the difference between perceptions and calculations (as for example in the case of Verbier) and analyze more deeply what mechanisms would ensure the monitoring and the successful implementation of adaptation strategies. Finally, it should analyze possible adaptation processes which consider other solutions for the socio-economic viability of their region than the preservation of the tourism sector. It should not be forgotten that before the development of tourism, agriculture was the main source of employment and income in many mountain regions. Perhaps in the future another sector should take the place of tourism.

Finally, the initial hypotheses of Section 1.2 can be rephrased in lessons:

Lesson 1: *Climate change is already producing effects on weather patterns, landscapes and natural hazards in Switzerland. This affects the tourism sector particularly, since it is highly exposed to these factors. Both private and public stakeholders are generally aware of these changes and have started to adjust to the new conditions.*

The hypothesis that stakeholders' awareness on the subject is high was confirmed both by the online survey and by the face-to-face interviews (Sections 4.5.7 and 4.5.8.1). In the online survey, 45% of the respondents affirmed that climate change does already have high or very high impacts on tourism in their region and 62% expected this for the 2030-50 time horizon. We did not find any significant difference among private and public actors. Also, during the face-to-face interviews almost every interviewee mentioned changes in the region due to climate change that were already visible.

As a consequence of this recognition of climate impacts, the sector started to take action. As appeared in the online survey, almost all (87%) of the respondents indicated at least one adaptation measure that was or is currently being implemented in their region. As the face-to-face interviews presented in Section 5.5.2 confirmed, it appears that a first wave of adaptation started in the 1990s following some years of very unfavorable winter conditions. This was mostly aimed at ensuring snow sports activities but was not only determined by climate change. Other aspects like changes in tastes, globalization, population structure, and mobility patterns also played a role. Now, a new wave of adaptation is taking place. This mainly aims to promote year-round tourism and innovation and diversification of the tourism offer. However, as for the securing of winter sport activities, it has to be remembered that this trend is not only determined by climate change. Parallel to this, an increasing amount of research, in addition to the monitoring of the impacts in the sector, is being carried out in the country. In the same way, tourists and the population (including stakeholders) are more and more informed on the consequences of climate change. Lastly, there is continuous management of natural hazards and use of insurance instruments.

Lesson 2: *The vulnerability of tourism in a region is not only determined by its exposure, but also by its sensitivity and adaptive capacity. Therefore, the regions most exposed to the effects of climate change are not necessarily the most vulnerable ones.*

As it appeared in the vulnerability map, and was confirmed by the face-to-face interviews, regions highly exposed to the effects of climate change, like Zermatt, Saas-Fee, or St. Moritz, are ultimately not the most vulnerable. This can simply be due to the fact that the regions considered do not depend very strongly on tourism (low sensitivity), or (as for the three mentioned regions) due to their high adaptive capacity. Zermatt, Saas-Fee, and St. Moritz have, at least partly, the economic, technological, social, environmental, and institutional means to address the consequences of climate change and to adapt.

Lesson 3: *Adaptation processes are often part of a larger process of restructuring and do not happen deliberately, though not necessarily less efficiently.*

The Swiss Alps are particularly affected by climate change. Snowpack reduction, glacier, and permafrost melting are, for example, already observed impacts. The use of snowmaking and the shift to summer tourism are two common answers. Often, however, these are not adaptation measures specifically for the consequences of climate change. Many examples of that appeared during the face-to-face interviews in selected tourism regions like Cardada and Sattel. We selected these regions mainly because of the action undertaken in order to adapt to the changing conditions. However, stakeholders frequently described these more as step-by-step responses to other, more general, social, economic, and ecological changes (like changes in tastes, globalization, population structure, and mobility patterns), and only partly as responses to climate change.

Lesson 4**:** *The most exposed regions are not only among the ones that are most likely to adapt but also among the ones that are most likely to initiate mitigation initiatives.*

Often stakeholders in very exposed regions (like Grindelwald, Saas-Fee, or St. Moritz) said in the face-to-face interviews that they see the impacts of climate change in their everyday life and that this moved them to find more sustainable solutions.

Lesson 5: *Social feasibility-related barriers, like the lack of information and coordination, are elements that can strongly hinder adaptation processes in the Swiss tourism sector. Social acceptability, both among stakeholders and the population, on the other hand, does not appear to be a problem in the country.*

The online and the face-to-face interviews only partially confirmed the initial hypothesis. Social issues have effectively the potential of hindering adaptation processes. Nonetheless, it seems that it is mainly the lack of social feasibility (like the lack of information and coordination) and less the lack of social acceptability that is a barrier to the implementation of adaptation processes for Swiss tourism. Stakeholders seem generally willing to take action and the Swiss population seems willing to accept the measures taken if these are sustainable. It should be remembered, however, that our results are based on a small number of respondents.

Lesson 6: *Further research and effective communication on both climate change and possible adaptation measures increase awareness and understanding among stakeholders. Stakeholders do not seem to ask for more but instead for better information. They demand in particular honest, high-quality, and specific information on the regional impacts and on the possible adaptation measures in order to better evaluate the potential impacts they are facing and to be able to implement targeted adaptation measures.*

The online survey seemed to indicate that stakeholders do not feel that they lack information. Nonetheless often the information received is second hand. As it appeared in the face-to-face interviews, stakeholders frequently judge this to be not objective. Therefore information is indeed important, but now more effort should be put on its quality and on regional aspects.

Lesson 7**:** *Participative processes are not always strong instruments in ensuring the success of an adaptation process. Different conditions have to be fulfilled so that the process can bring about the effective implementation of adaptation measures.*

The participative process carried out in the Aletsch region showed the limitations of the method. Participative processes are indeed strong tools that allow for the implementation of adaptation options. However, they alone do not ensure success. Participative processes are perhaps only efficient if a member of the community leads the process or if this comes from inside, if impacts already show their effects on the sector, if there is a high level of social capital (seen as network among stakeholders), and if no other more pressing problems take priority.

Lesson 8: *Leadership can help overcome barriers to adaptation. Lack of or ineffective leadership can also itself create barriers.*

This statement could only be partly addressed. From the participative process, it appeared that having the head of the UNESCO heritage site on board together with the main stakeholders helped the process. Nonetheless, this was not a sufficient condition for success. Other barriers, such as perhaps the lack of coordination among stakeholders, but perhaps more, the lack of perceived vulnerability (or the perceived irrelevance of the climate change impacts in comparison to other, more pressing challenges faced by the region) hindered the adaptation process.

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A Annexes

A.1 Changes in climate suitability – The Tourism Climate Index (TCI)

The attractiveness of a region for tourism activities depends strongly on the local weather and climate. That is why changes in climate suitability can modify seriously the tourism flow (Hamilton et al. 2005a,b). The Tourism Climate Index (TCI) developed by Mieczkowski (1985) is a composite index that assesses climate elements relevant to the quality of tourism and it is one of the most recognized indexes to depict changes in climate suitability for tourism. The index assesses the climatic elements most relevant to the quality of the 'average' tourist and includes the five following climatic variables (or sub-indices): daytime thermal comfort (CID), average thermal comfort (CIA), sunshine (Ss), precipitation (P), and wind appreciation (W) (Table A 1).[111]

Table A 1: Sub-indices within the Tourist Climate Index. Adapted from Mieczkowski (1985), Scott and McBoyle (2001), and Perch-Nielsen (2008).

Sub-Index	Variable required (daily)	Influence	Weight
Daytime thermal comfort (CID)	Maximum 2-m temperature Minimum 2-m relative humidity	Represents thermal comfort when maximum tourism activity occurs	40 %
Average thermal comfort (CIA)	2-m temperature 2-m relative humidity	Represent thermal comfort over the full 24 hour period, including sleeping hours	10 %
Sunshine (Ss)	Sunshine duration	Acknowledged can be negative because of the risk of sunburn and added discomfort on hot days	20%
Precipitation (P)	Precipitation	Reflects the negative impact that this element has on the outdoor activities and holiday enjoyment	20%
Wind appreciation (W)	10-m wind speed	Variable effect depending on temperature (evaporative cooling effect in hot climates rated positively, while 'wind chill' in cold climates rated negatively)	10 %

A standardized rating system, ranging from 5 (optional) to -3 (extremely unfavorable), provides a common basis of measurement for each of the sub-indices. They are then aggregated by the following Equation (6):

$$TCI = 2(4CID + CIA + 2Ss + 2P + W) \tag{6}$$

The final score (from >10 to 100) eventually designates the climate suitability (Table A.2). Nonetheless, although devised on the basis of available biometeorological literature, the rating systems of the five sub-indices and their relative weightings within the TCI are ultimately subjective (Amelung 2006; Perch-Nielsen 2008). A revised version of the index could be found in Scott and McBoyle (2001), and

[111] Mieczowski first identified 12 monthly climate variables. Because of meteorological data limitations, he could only retain seven of them, clustered in five sub-indices.

Perch-Nielsen (2008). In Figure A 1, a visualisation of the data used (at the European level) is shown. Amelung (personal communication) kindly provided the data.

Table A 2: Climate resources are rated using a scale (-20 to 100) divided into 11 categories (Mieczkowski 1985).

Scale for climate resources rating	Signification
< 10	Impossible
10-19	Extremely unfavorable
20-29	Very unfavorable
30-39	Unfavorable
40-49	Marginal
50-59	Acceptable
60-69	Good
70-79	Very good
80-89	Excellent
90-100	Ideal

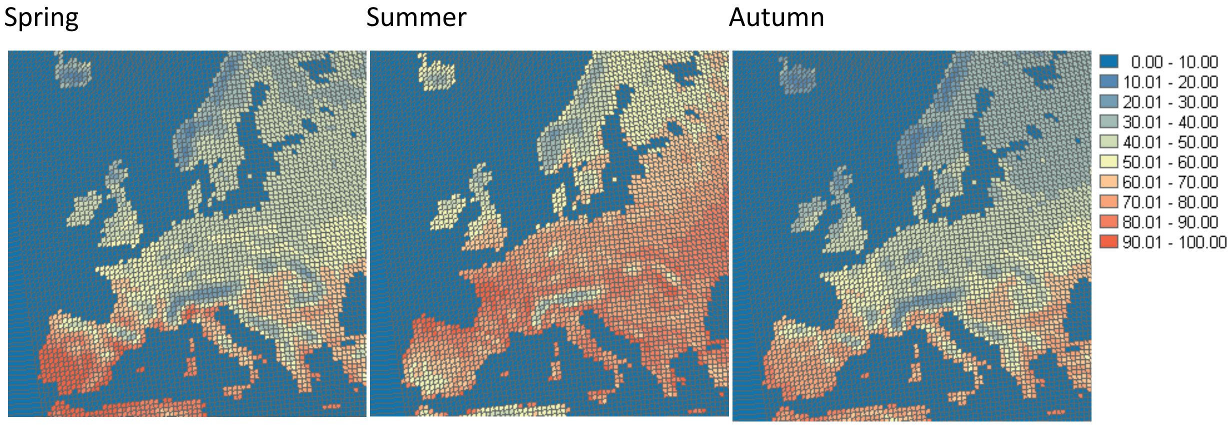


Figure A 1: The calculated TCI for Europe for the 2011-2040 period (data obtained from Amelung, personal communication). The higher the score, the redder the region; the lower the score the bluer the region.

A.2 Set of criteria for the choice of indicators used in the frame of the vulnerability analysis

Table A 3: Explanation of the different criteria used for the selection of the indicators (based on Atkins et al. (1998), OECD (2002), Kaly et al. (2003), Esty et al. (2006), and Perch-Nielsen (2008)).

	Validity			Use	Type			Data	
Criterion	Well-founded	Accurate	Non-ambiguous	Comprehensible	Relevant	Responsive to changes	High information content	Available	Homogeneous and periodical data
Explanation	Based on a tested theoretical framework	Really measuring what it should	Agreement on the direction of influence between the indicator and vulnerability	Relatively easy for users to understand	Applicable to many geographic and economic conditions	Can be influenced by action	No yes/no indicators, and preferably actual performance data instead of model-based data	Data that is publicly and easily available	Data that is collected homogeneously, making it suitable for international comparisons

Table A 4: Set of criteria for the selection of indicators (based on Atkins et al. (1998), OECD (2002), Kaly et al. (2003), Esty et al. (2006), and Perch-Nielsen (2008)). +++: very good; ++: good; +: sufficient; –: negative. The sign (–) next to the indicator represents an impact bringing beneficial effects to the region. This was then subtracted for vulnerability. When no sign is given, the indicator implicitly increases vulnerability.

	Validity			Use	Type			Data	
Criterion	Well-founded	Accurate	Non-ambiguous	Comprehensible	Relevant	Responsive to changes	High information content	Available	Homogeneous and periodical data
Indicator									
Exposure									
Changes in climate suitability									
Changes in climate suitability for light outdoor activities 2011-2040 vs control (1961-1990) (-)	+++	+++	+++	++	+++	+	+	++	+++
Share of mountainous area in the region (-)	+++	++	+++	+++	+++	-	+++	+++	+++
Share of lakes in the region (-)	+++	++	+++	+++	+++	+	+++	+++	+++
Snowpack reduction									
Share of the region located between the current and the future snow reliability line	+++	++	+++	+++	+++	-	++	+++	+++
Share of the region located above the future snow reliability line (-)	+++	++	+++	+++	+++	-	++	+++	+++
Glaciers melting									
Future glaciers surface loss	+++	+++	+++	+++	+++	+	+	++	+++
Permafrost melting – rockfall									
Share of the region surface with potential permafrost melting	+++	+++	+++	+++	+++	+	+	++	+++

	Validity			Use	Type			Data	
Criterion	Well-founded	Accurate	Non-ambiguous	Comprehensible	Relevant	Responsive to changes	High information content	Available	Homogeneous and periodical data
Natural hazards									
Number of past natural hazards (1972-2007)	+++	+	+++	+++	+++	-	+++	++	+++
Cost of past natural hazards (1972-2007)	+++	+	+++	+++	+++	-	+++	++	+++
Cost on infrastructure of past natural hazards (1972-2007)	+++	+	+++	+++	+++	-	+++	++	+++
Share of the region with 100-year flood probability	+++	++	+++	+++	+++	+++	+	++	+++
Water scarcity – drought									
Future water availability[3]	+++	+++	+++	+++	+++	++	+	+++	+++
Scenic beauty changes									
Share of the region which will be conquered by forest because of climate change	+++	+	++	+++	+++	++	+	++	+++
Sensitivity									
Tourism demand									
Tourism intensity	+++	+++	+++	+++	+++	++	+++	+++	+++
Guest nights/one-day tourists ratio	+++	+++	++	+++	+++	+++	+++	-	+++
Length of stay	+++	+++	++	+++	+++	++	+++	+++	+++
Skiers visits	+++	+++	++	+++	+++	++	+++	+++	+++
Winter seasonality	+++	+++	+++	+++	+++	+++	+++	+++	+++
Summer seasonality	+++	+++	+++	+++	+++	+++	+++	+++	+++
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry'	+++	+++	+++	+++	+++	++	+++	+++	+++
International attractiveness (share of foreign tourists)	+++	+++	++	+++	+++	+++	+++	+++	+++
Tourism supply									
Density of beds in hotels and health resorts and in the ‘parahotel industry’ (warm beds)	+++	+++	+++	+++	+++	+++	+++	+++	+++
Tourism supply structure (big vs. small hotels and restaurants)	+++	+++	++	+++	+++	+++	+++	+++	+++
Secondary homes (cold beds)	+++	+++	++	+++	+++	+++	+++	+++	+++
Proximity to substitute ski destinations	+++	+++	++	+++	+++	+	+++	+++	+++
Length of activity of ski resorts	+++	+++	+++	+++	+++	++	+++	++	+++
Artificial snow production	+++	+++	+	+++	+++	+++	+++	+	+++
Total capacity of ski domains located under the future snow-reliability line	+++	+++	+++	+++	+++	++	+++	++	+++
Total capacity of ski domains located over the future snow-reliability line (-)	+++	+++	+++	+++	+++	++	+++	++	+++
Length of infrastructure located on possible/probable permafrost melting	+++	+++	+++	+++	+++	+++	+++	++	+++
Media and communication on snow condition	+++	+++	+++	++	+++	+++	+++	-	+++

	Validity			Use	Type			Data	
Criterion	Well-founded	Accurate	Non-ambiguous	Comprehensible	Relevant	Responsive to changes	High information content	Available	Homogeneous and periodical data
Local population									
Density of resident population	+++	+++	++	+++	+++	++	+++	+++	+++
Share of the population born on place (collective knowledge on areas subject to natural hazards)	+++	+++	+++	+++	+++	+	+++	+++	+++
Age structure (age-dependency ratio)	+++	+++	++	++	+++	+	+++	+++	+++
Local economy									
Share of jobs (full-time equivalents) in the hotel and catering sector	+++	+++	+++	+++	+++	++	+++	+++	+++
Share of jobs (full-time equivalents) in the transportation sector	+++	+++	+++	+++	+++	++	+++	+++	+++
Job seasonality	+++	+++	+++	+++	+++	++	+++	-	+++
Share of jobs in the agriculture sector	+++	++	++	++	+++	++	+++	+++	+++
Average net income pro person in private dwellings	+++	+++	+++	+++	+++	++	+++	+++	+++
Average financial health of municipalities	+++	+++	+++	+++	+++	++	+++	-	+++
Average per capita cantonal income	+++	+++	+++	+++	+++	++	+++	+++	+++
Local infrastructure									
Accessibility	+++	+++	++	+++	+++	+++	+++	++	+++
Accessibility to services	+++	++	+++	+++	+++	+++	+++	++	+++
New or renovated buildings (after 1990)	+++	+++	+++	+++	+++	+++	+++	++	+++
Density of transport network (existence of replacement routes)	+++	+++	+++	+++	+++	++	+++	++	+++
Water storage capacity	+++	+++	+++	+++	+++	++	+++	-	+++
Energy use in destination in the tourism sector	+++	+++	+++	+++	+++	+++	+++	-	+++
Local institutions									
Left vs. right	+++	+++	+	++	+++	++	+++	++	+++
Ecologists vs. liberals	+++	+++	++	++	+++	++	+++	++	+++
Size of the municipalities - municipalities aggregation	+++	+++	++	+++	+++	++	+++	+++	+++
Local environment									
Land use protection	+++	+++	+++	+++	+++	+++	+++	+++	+++
Landscape beauty	+++	+++	+++	++	+++	+	+++	-	+++
Water availability	+++	+++	+++	+++	+++	++	+++	-	+++
Adaptive capacity									
Feasibility									
Social									
Existence of studies on climate change impacts for the region	+++	+++	+++	+++	+++	+++	+++	++	+++
Public participation actions in the region	+++	+++	++	+++	+++	+++	+++	-	+++

	Validity			Use	Type			Data	
Criterion	Well-founded	Accurate	Non-ambiguous	Comprehensible	Relevant	Responsive to changes	High information content	Available	Homogeneous and periodical data
Economy									
Average net income pro person in private dwellings	+++	+++	+++	+++	+++	++	+++	++	+++
Average financial health of municipalities	+++	+++	+++	+++	+++	++	+++	-	+++
Average per capita cantonal income	+++	+++	+++	+++	+++	++	+++	+++	+++
Subsidies	+++	+++	++	+++	+++	+++	+++	-	+++
Technological									
Density of transport network (existence of replacement routes)	+++	+++	+++	+++	+++	+++	+++	++	+++
Possibility of self-green energy development	+++	+++	+++	+++	+++	++	+	-	+++
Institutional									
Past actions taken from the tourism sector in this direction	+++	+++	+++	+++	+++	-	+++	+	+++
Part of an official tourist region (Swiss tourism)	+++	+++	+++	+++	+++	+++	++	+	+++
Destination communication	+++	+++	+++	+++	+++	+++	+++	-	+++
Left vs. right	+++	+++	+	++	+++	++	+++	++	+++
Ecologists vs. liberals	+++	+++	++	++	+++	++	+++	++	+++
Environmental									
Land use protection	+++	+++	+++	+++	+++	+++	+++	+++	+++
Water availability	+++	+++	+++	+++	+++	+	+	-	+++
Acceptability									
Social									
Political framework: results of a vote on right of appeal of organizations	+++	++	++	++	+++	-	+++	+++	+++
Past actions taken from the tourism sector in this direction	+++	+++	+++	+++	+++	-	+++	+	+++

A.3 Detailed description of the indicators

Table A 5: Explanation of the indicators used in the vulnerability map. ↑: the higher the score, the higher the exposure/sensitivity/adaptive capacity; the opposite for ↓. The (-) sign signifies that the region will presumably benefit from the impacts. The indicator was then subtracted for vulnerability. The sign (+) signifies the opposite. The indicator was then summed to the total vulnerability. When no sign is given, the indicator implicitly increases vulnerability.

Exposure

Indicator	Control for	Influence on vulnerability	Trend	Data source	Remarks
Changes in climate suitability					
Changes in climate suitability for light outdoor activities 2011-2040 vs control (1961-1990) 2020	DEMAND: Changes in tourists flow (-)	The higher the score, the higher the future climate suitability, the higher the attractiveness for light outdoor activity, and therefore the lower the exposure.	Linear ↓	PESETA Project (Amelung and Moreno 2009). Data kindly provided by Amelung (personal communication).	[Δ average weighted TCI score for spring, summer, and fall] PESETA: PRUDENCE data: A2 and B2 IPCC SRES scenario storyline (IPCC 2007a,b): HIRHAM model, driven by the HadAM3 GCM, and the RCA model, driven by the ECHAM4 GCM. 50 km resolution.
Share of mountainous area in the region 2010	DEMAND: Changes in tourists flow (-)	Climate change shifts international tourists towards the poles and up to the mountains (OcCC/ProClim 2007). Alps are seen as an alternative for tourists in search of coolness and as an escape from the heat of the lowlands (Serquet and Rebetez 2011). The higher the share, the lower the exposure of the region.	Linear ↓	Personal calculation using a digital height model (DHM25) (Swisstopo 2004).	[hectares/hectares tourism region] Mountainous areas are considered areas over 1200 m AMSL (according to the vegetation belts definition). We take this indicator because possibly more appropriate than the TCI. Besancenot (1990) defines nine types of tourism. Light activities (on which the TCI is based) are typically associated with nice and sunny weather or nice weather partly clouded. Whereas hiking and similar activities are associated to cool and sunny weather or nice weather with strong wind. Therefore a good TCI score does not necessarily imply good conditions for mountain hiking.
Share of lakes in the region	DEMAND: Changes in tourists flow (-)	As above. Lakes regions are seen as an alternative in summer for tourists in search of coolness and as an escape from the heat of the lowlands. The higher the score, the lower the exposure of the region.	Linear ↓	Personal calculation using the VECTOR25 GWN digital stream network layer (Swisstopo 2007).	[meters of lake perimeter/hectares tourism region]

Snowpack reduction					
Share of the region located between the current and the future snow reliability line 2050	DEMAND: Changes in tourists flow (+) SUPPLY: Changes in monetary and employment flows (+)	With the increase in temperatures, the length of snow cover and the number of days with snowfall will decrease at low altitude (Agrawala 2007; Beniston 2009). It could therefore be foreseen that many low-altitude ski domains will be particularly affected. The higher the score, the higher the exposure.	Linear ↑	Personal calculation referring to Haeberli and Beniston (1998), Frei (2004), Agrawala (2007), OcCC/Proclim (2007) and using a DHM25.	[hectares/hectares tourism region] The current snow reliability line is set at 1200 m AMSL for the North of Alps and at 1500 m AMSL for the South of Alps. In a mountainous region, an increase of 1°C implies, on average, a shift of 150 m upwards of the snowline (Haeberli and Beniston 1998). Taking an increase of +1.8°C in winter over 1990 (Frei 2004; OcCC/ProClim 2007), the lower snow line would rise of 270 m by 2050. Therefore, at the 2050 time horizon, this is calculated to be at respectively 1470 and 1770 m AMSL. However, it should be considered that, even if there is a strong linear relation between snow duration and altitude (Beniston et al. 2003), also exposure, topography and other characteristics of regional climate do play a role in determining snow conditions (Baeriswyl and Rebetez (1996) in Jungo and Beniston (2001)).
Share of the region located over the future snow reliability line 2050	DEMAND: Changes in tourists flow (-) SUPPLY: Changes in monetary and employment flows (-)	Because of the possible higher level of precipitations and the relatively cold temperatures, high altitude locations will enjoy more snowfall in the near future (Agrawala 2007; Beniston 2009). Because of the potential of good snow cover and because of the relative good situation in comparison to lower Alpine regions, these areas will benefit from the situation at a 2050 time horizon (Agrawala 2007). The higher the score, the lower the exposure.	Linear ↓	As above	[hectares/hectares tourism region] Regions considered are located over 1470 m AMSL in the North and over 1770 m AMSL in the South of the Alps

Glaciers melting					
Share of future glaciers surface loss 2050	DEMAND: Changes in tourists flow (+)	Glaciers melting will impact tourism in different ways. One of them is the change of alpine landscape because of glaciers retreat and subsequent change in scenic beauty. The higher the share of future glaciers surface loss the higher the regional exposure. This because glaciers play an important role in defining landscape beauty and attractiveness (by creating diversity, uniqueness, and naturalness) (Haeberli et al. 2007).	Linear ↑	Personal calculation, starting from Paul et al. (2007); Paul (2007), and from Paul (personal communication) using the GLIMS glacier database (Armstrong et al. 2011) and a DHM25. The methodology has been simplified.	[hectares/hectares tourism region] We use a non-varying ELA_0 sensitivity of 140 m per 1°C. This means a shift upwards of the ELA_0 of 350 m in comparison of 1990 (average annual temperature increase of 2.1°C by 2050 with the IPCC SRES A1 scenario). In some cases, however, and at a first moment at least, glaciers melting could attract tourists ('Visit it before it disappears').
Permafrost melting – rockfall					
Share of the region surface with potential permafrost melting 2050	SUPPLY: Changes in monetary flows (+)	The higher the share of the region surface with potential permafrost melting, the more the region is exposed because of the high costs of intervention or the abandon of the site (Kneisel et al. 2007; Vonder Mühll et al. 2007; Larsen et al. 2008).	Linear ↑	Personal calculation, starting from Frei (2004), Bader and Kunz (2000), and using a DHM25. Data on possible/probable permafrost distribution kindly delivered by the FOEN (personal communication).	[hectares/hectares tourism region] It is foreseen, with an increase of 1-2°C, that the lower limit of permafrost will shift 200-700 m upwards (Bader and Kunz 2000). We consider here a shift of 600 m (in comparison to the year 2000 and a subsequent warming of 1.75 °C up to 2050). The lower limit is set at 2400 m AMSL, even is permafrost appears in small areas already at 2036 m AMSL. In addition, permafrost melting could become a danger for mountain trails in summer (Braun 2009).

Natural hazards					
Number of past natural hazards (1972-2007)	DEMAND: Changes in tourists flow (+) SUPPLY: Changes in monetary and employment flows (+)	The higher the risks of natural hazards, the lower the number of tourists visiting the region, and the higher the costs on infrastructure and buildings.	Linear ↑	Calculated from data delivered by Hilker (Swiss Federal Research Institute WSL - Storm Damage Database of Switzerland.)	[number of past natural hazard events (1972-2007)/hectares tourism region] Natural hazards considered are: naturally triggered flood, debris flow, landslide (since 1972) and rockfall (since 2002) events. We counted events taking place the same day in the same region as one event, and attributed the ones taking place on more regions (e.g. on the cantonal level) to the different regions. These will very probably a change in frequency, intensity, and distribution in the future due to climate change (Bader and Kunz (2000); Hilker et al.(2009)). However, as stated in Hilker et al. (2009), no statistically significant trend has been found until now for the Swiss Alps. The Climate Change Adaptation by Spatial Planning in the Alpine Space (CLISP) project is looking at the question.
Cost of past natural hazards 1972-2007	DEMAND: Changes in tourists flow (+) SUPPLY: Changes in monetary and employment flows (+)	The higher the risks of natural hazards, the lower the number of tourists visiting the region. The higher the possible costs of natural hazard occurring, the higher the exposure of the region.	Linear ↑	As above	[Mio. CHF/hectares tourism region] As above. We attributed costs of events taking place on more regions (e.g. on the cantonal level) to the different regions in relation to their surface. We considered inflation in the calculation.
Cost on infrastructure of past natural hazards 1972-2007	DEMAND: Changes in tourists flow (+) SUPPLY: Changes in monetary and employment flows (+)	The higher the risks of natural hazards, the less the number of tourists visiting the region. The higher the possible costs of natural hazards on infrastructure, the higher the exposure of the region.	Linear ↑	As above	[Mio. CHF/hectares tourism region] As above.

Share of the region with 100-year floods events probability 2010	DEMAND: Changes in tourists flow (+) SUPPLY: Changes in monetary and employment flows (+)	The higher the probability of flood events, the smaller the number of tourists visiting the region and the higher the possible costs on infrastructure and buildings.	Linear ↑	Data generated by the Acquaprotec[112] project (Swiss Flood Zones, developed by Swiss Reinsurance Company Ltd, Zurich (copyright); on behalf of BAFU, 2008).	[hectares/hectares tourism region] We use data generated by the Acquaprotect project on the cartography of flooding events with distribution of flows (100-year return). We assume that the regions more affected in the past will also be the more affected in the future, if the intensity and the frequency increase. It has however to be kept in mind that distribution will probably change as well (Bader and Kunz 2000).
Share of the region classified as dangerous because of natural hazards (floods, etc.) by the FOEN (data not available at the moment)	DEMAND: Changes in tourists flow (+) SUPPLY: Changes in monetary and employment flows (+)	The higher the risk of natural hazards, the smaller the number of tourists visiting the region. The higher the risk of natural hazard (and the surface classed as dangerous because of natural hazards) the higher the possible costs on infrastructure and buildings.	Linear ↑	(data not available at the moment) Data generated by the ShowMe project, but not available at the moment for the entire Switzerland.	The PLANAT project is also working on the topic.[113] The 'Share of the region classed as dangerous because of natural hazards (floods, etc.) by the BAFU' indicator was not included in the matrix being a substitute to the ones presented.
Water scarcity – drought					
Future water availability 2021-2050	SUPPLY: Changes in monetary and employment flows (+)	The less water is available for the tourism sector, the more the region is exposed because of conflicts for water usage and because of water scarcity for tourism-related activities. See for example Reynard (2000) and EEA (2009).	Linear ↑	We used data calculated in the frame of the CCHydro project[114] (Zappa, personal communication) (resolution 200*200 m). We considered here only the negative aspects due to a decrese in water availability and not the positive ones that could be brought by a higher runoff. Moreover, we considered only the annual mean and not possible droght peaks during the year.	[Δ mm/year 2021-2050 vs 1980-2009] Tourism in Switzerland depends on water in many ways: other than for basic needs, water fills swimming pools and spas, irrigate golf fields and produces energy. In addition, it is frequently used for artificial snow production. If water becomes scarce, this could create conflicts with others sectors for its use (Bréthaut 2010), as for example agriculture or energy production. Many projects are analyzing the subject, in addition to the CCHydro one. The PNR 61[115], the Assessing Climate Impacts on the Quantity and quality of WAter (ACQWA),[116] and the Water-Alp Scarce[117] projects are some example among others.

[112] http://www.bafu.admin.ch/naturgefahren/01916/06598/index.html?lang=en. Last accessed 22.12.2011.
[113] http://www.planat.ch/. Last accessed 22.12.2011.
[114] http://www.bafu.admin.ch/wasser/01444/01991/10443/index.html?lang=de. Last accessed 22.12.2011.
[115] http://www.nfp61.ch/E/Pages/home.aspx. Last accessed 22.12.2011.
[116] http://www.acqwa.ch/. Last accessed 22.12.2011.

Scenic beauty changes					
Share of the region which will be conquered by forest because of climate change 2050	DEMAND: Changes in tourists flow (+)	The higher the share of the region that will be conquered by forest, the more the region is exposed because supposed to lose attractiveness due to the loss of scenic beauty.	Linear ↑	Data calculates using the VECTOR25 PRI Primary Surfaces Layer (Swisstopo 2007), Frei (2004), Gehrig-Fasel (2007), and a DHM25.	[hectares/hectares tourism region] Scenic beauty is subjective. We can, nonetheless, suppose that it depends on five characteristics (Haeberli et al. 2007): 1) its complexity (and variety); 2) its uniqueness; 3) the visibility from the site; 4) its pristinity; 5) its suitability. We already considered the impact of glaciers melting; we look here at the “simplification” of the landscape (reduced complexity and variety) due to the closure of open spaces (Hunziker 1995). A critic on the subject is given in Lundström et al.(2007). We considered areas between 2450 and 2782 m AMSL. The first is the current supposed treeline limit, which does not match necessarily with the real treeline limit because of human influence (e.g. alpine pasture). The second is the supposed treeline limit at a 2050 time horizon. The calculation of the surface did consider only areas that could be potentially conquest by forest, and not for example areas occupied by glaciers, lakes, dwellings, etc. We didn’t consider open areas located under the current supposed treeline limit, which could also potentially be reforested because of land abandonment (Rickebusch et al. 2007). Finally, it has to be kept in mind that in reality current treeline advance is considerably time-lagged. This is due to the slow regeneration process and anthropogenic influences (Gehrig-Fasel 2007).

[117] http://www.alpwaterscarce.eu/. Last accessed 22.12.2011.

Sensitivity

Indicator	Influence on vulnerability	Trend	Data source	Remarks
Tourism structure				
Tourism demand				Statistics for municipalities with less than three establishments are not available because of confidentiality reasons. The added value generated by tourism, because not available for all the regions, was substituted by proxies (tourism demand and supply)
Tourism intensity 2008	The higher the tourism intensity in the region, the higher its dependence on the sector and therefore the higher its sensitivity.	Linear ↑	FSO (personal communication)	[guest nights in hotels, health resorts, and in the 'parahotel industry'/inhabitants] [118] It would have been interesting to analyze as well the evolution of the tourism intensity over time (constant, growing, or decreasing).
Guest nights/one-day tourists ratio 2008	The dependency on one-day tourists is an important factor of vulnerability (Luthe 2009). This is due to the fact that one-day tourists act very spontaneously and stay at home if weather or snow conditions are not adequate. Overnight guests do, on the other hand, normally book in advance.	Linear ↓	Not available data. Statistics on the number of one-day tourists are not available at this level of analysis.	As discussed in Luthe (2009), however, a high dependency on one-day tourists can also create opportunities. If snow conditions are good, there can be a very high number of visits.
Length of stay 2009	As above. Long stays from overnight guests assure less dependency on weather and snow conditions. This is due to the fact that normally overnight guests book in advance.	Linear ↓	FSO (personal communication)	[guest nights in hotels and health resorts/arrivals in hotels and health resorts]
Skiers visits 2006-2009	The higher the number of skier visits, the higher the sensitivity to snowpack reduction.	Linear ↑	Vanat (personal communication) and direct information from ski resorts. We considered regions with 0 ski resorts as not sensitive (score 0).	[sum skiers visits/hectares tourism region] It should however be noted that ski-related tourism does not represent the whole winter-tourism sector. Snowboarders, snowshoers, etc. should be also counted. More complete data are not available at the moment. Additionally, not all the ski resorts are represented. Only resorts which delivered data are included (the smaller often did not).

[118] Group accommodation was not considered in the calculation.

Winter seasonality 2009	The higher the seasonality, the less the tourism industry is robust and the more the region is sensitive (Baum and Lundtorp 2001; Jang 2004).	Linear ↑	FSO (personal communication)	[guest nights in hotels and health resorts in winter (DJF)/total guest nights in hotels and health resorts] Seasonality causes difficulty in gaining access to capital, fluctuating returns on investment, and subsequent high risk of investment. This is primarily due to the instability of tourism revenues over seasons and under-or-over utilization of the same resources and facilities (Jang 2004).
Summer seasonality 2009	As above.	Linear ↑	FSO (personal communication)	[guest nights in hotels and health resorts in summer (JJA)/total guest nights in hotels and health resorts] As above.
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry' 2003-2005	The lower the occupancy rate, the more the infrastructure is overdimensioned and the more the region is sensitive.	Linear ↓	FSO (personal communication)	[guest nights/(number of bed-places*365)] Group accommodation was not considered in the calculation
International attractiveness (share of foreign tourists) 2008	The more the region has a high ratio of foreign tourists, the more it is sensitive. We suppose that distance increases risks of external factors affecting tourism flow (the exchange rate, variations in oil prices or wars, etc.). For example, with taxes on fuel or oil scarcity, the price of oil could increase. Therefore fewer foreign tourists could afford to come to Switzerland for holidays.	Linear ↑	FSO (personal communication)	[guest nights of foreign tourists/total guest nights] On the other hand, a higher international attractiveness of a region signifies generally smaller seasonality because tourists' arrival is more split over the year (different holiday calendars) and it generates a higher guest nights/one-day tourists' ratio. A differentiation could have been made between e.g. tourists coming from the neighboring countries, the rest of Europe and the rest of the world.
Tourism supply				
Density of beds in hotels, health resorts, and in the 'parahotel industry' (warm beds) 2002-2003	The higher the density, the more the region is sensitive because depending on tourism.	Linear ↑	FSO (personal communication)	[beds available/hectares tourism region] Concerning the 'parahotel industry', we considered youth hostels, holiday houses and camping places. It would have been interesting to make a differentiation among the various types of establishments (1-5 stars, etc.) seeing that different types bring different revenues. (Rütter et al. 1996). We did not consider group establishments in the calculation.
Tourism supply structure (big vs. small hotels and restaurants) 2008	Small scale structures are more sensitive because of the smaller capital and resources available for adapting. Therefore, the higher the ratio, the smaller the sensitivity of the region.	Linear ↓	FSO (personal communication)	[(1*very small scale +2*small scale +3*medium scale +4*big scale)/(total+1)] Very small scale hotels and restaurants possess <9 employments, small scale 10-49, medium scale 50-249 and big scale (>250 employments).

Secondary homes (cold beds) 2000	The higher the number of homes temporarily inhabited, the more the region depends on tourism and the more sensitive it is.	Linear ↑	Schuler 2010 – personal communication, Schuler et al. (2007).	[number of rooms in homes temporarily inhabited/total number of rooms in homes] With homes with 6 rooms or more calculates as 6-room homes (because of the data available). This value captures information on arrivals other than in hotels, health resorts, and in the 'parahotel industry'. Cold beds in the destination are mostly privately owned, secondary homes that most of the years are empty. It would have been interesting to analyze the development over time (stagnant construction or expansion). Nonetheless, secondary homes have the positive aspect of creating a 'dependency' on the domain (inhabitants will return there year after year) and make the region therefore less sensitive. It has to be noted that this indicator does not bring information on the cold/hot bed ratio (no statistics exist on the occupancy rate of these residences).
Proximity to substitute ski destinations 2010	The more a ski resort is surrounded by other resorts, the more its competitiveness has to be high for one-day tourists and therefore the more it is sensitive.	Linear ↑	Self-calculation. The 210 ski resorts analyzed have been provided by Vanat (2010) – personal communication. We brought them to 198 after considering ski resorts that merged (the merging was done considering the various websites – some merging could have been forgotten). We considered as not sensitive regions with 0 ski resorts (score 0).	[average number of ski resorts in a 25 km-radius] On the other hand, it could be an advantage, because giving more choices to overnight tourists and therefore increasing the attractiveness of the region.
Length of activity of ski resorts 2009	The higher the number of days with enough good natural snow conditions, the more the ski resorts in the region are viable and the less the tourism sector is sensitive.	Linear ↓	Wispo (2009) and Vanat (2010) – personal communication. We analyzed only data available and analyzed 211 ski resorts. We considered regions with no ski resorts as not sensitive, being not dependent on ski activities.	[average number of open days with at least 50 cm of snow on the upper part of the resort pondered on the capacity of the stations] We tested two conditions (the number of days with at least 50 cm in the upper par and the average number of days with at least 30 cm of snow in the lower part of the resorts). Reasons of the choice are given in Gonseth and Matasci (2011). Results are similar with the length of activity given by Vanat, here however the effects of artificial snow condition are filtered.

Artificial snow production 2009	A ski area without snowmaking will have a much harder time to survive in the future than others. Therefore, the higher the share of slopes artificially snowed, the less the sensitive the region. Important comments are written beside.	Linear ↓	Wispo (2009) - personal communication. We analysed a set of 249 ski resorts. We consided regions with no ski resorts as not sensitive, being not dependent on ski activities.	[average km of slopes that can be potentially covered by artificially snow on a resort pondered on the capacity of the stations] Only data available considered. We took as reference the maximum km of slopes artificially snowed in 2009 for each resort. The ratio of km of slopes artificially snowed on the average total km of ski slopes could not be calculated because information on the total length of the slopes was not provided. Areas with a high share of slopes that can be artificially snowed will, on the other hand, incur much higher costs due to the investment, maintenance, and use of snowmaking machines and due to the production of artificial snow (Gonseth 2008). They are therefore more sensitive. Moreover, it has not to be forgotten that snowmaking carries important environmental impacts (Badré et al. 2009; Abegg 2011).
Total capacity of ski domains located under the future snow-reliability line 2009	The higher the capacity, and therefore the ski activity, located at low altitude, the higher the vulnerability of the region. This because domains are doomed to closure in the future (Abegg 1996; Agrawala 2007).	Linear ↑	Vanat (personal communication). Calculations made using a DHM25. We analysed 211 ski resorts. We considered regions with no ski resorts as not sensitive, being these not dependent on ski activities.	[hourly flow rate/(altitude difference*hectares tourism region)*1000] A definition of the capacity of a ski resort is given in Vanat (2005). For a definition of low altitude, see above ('Share of the region located under the future snow reliability line' in the exposure table). The gravity center was used as indication of the ski resort altitude.
Total capacity of ski domains located over the future snow-reliability line 2009	The higher the capacity, and therefore the ski activity, located over the future snow reliability line, the more the region will benefit from the vulnerability of lower regions and from better snow conditions in the near future (Abegg 1996; Agrawala 2007).	Linear ↓	As above.	[hourly flow rate/(altitude difference*hectares tourism region)*1000] As above.
Length of infrastructure located on possible/probable permafrost melting 2009	The more infrastructure, and therefore ski activity, is located in areas at risk of permafrost melting, the more the region is vulnerable because of the high costs of intervention or the abandon of the site (Kneisel et al. 2007; Vonder Mühll et al. 2007; Larsen et al. 2008).	Linear ↑	Data on possible/probable permafrost distribution delivered by the FOEN (2010). Data on infrastructure from VECTOR25 (layer on other traffic - abbreviation "Uvk") (Swisstopo 2007).	[meters of length of infrastructure/hectares tourism region] The layer Uvk of VECTOR25 includes additional line objects which are relevant to traffic (ski-lifts, ferries, cable ways) but which are not contained in the road and railway network layers. We also considered other types of infrastructure, both directly and not directly tourism-related.

Media and communication on snow conditions	The higher the communication, the less the region is vulnerable.	Linear ↓	Not available data	As cited in Luthe (2009), the media influence plays an important role in the vulnerability of a region. Bad media communication proved to be a main problem in the winter 2006/07, by reporting bad conditions which affected mostly day tourists.
Local population				
Density of resident population 2008	The higher the population density, the more the region is sensitive (more people affected by the impacts of climate change on tourism).	Linear ↑	FSO (personal communication).	[resident population/hectares tourism region] This indicator depicts from one hand the influence of natural hazards on human settlings and, on the other hand, the number of people related to the topic. However, as stated in Luthe (2009), fever people living in a mountain region can lead to environmental problems as a decrease in agriculture, forestry activities and in more landslides.
Share of the population born on place (collective knowledge on areas subject to natural hazards) 2000	The higher the share, the less the region is sensitive. People born on place are supposed to have a higher knowledge on the areas subject to natural hazards in the region and carry a collective memory of past events (information that is not always available otherwise) (Barbisch et al. 2006).	Linear ↓	FSO (personal communication), Schuler et al. (2007).	[people born on the same municipality/total number of inhabitants] In addition to this aspect, information flow plays an important role (we consider here a world of perfect information).
Age structure (age-dependency ratio) 2000	The higher the ratio, the more the region is vulnerable because of the higher number of people dependent on those in the working age group (lower work participation rate and greater economic dependency on the working age group).	Linear ↑	FSO (personal communication), Schuler et al. (2007).	[(kids (<15 years) + elderly people (>64 years))/(people between 15 and 64 years old)*100] On the other hand, the more the population is young, the more it is open to changes and to innovation. The more the population is old, the higher the knowledge on the areas subject to natural hazards and a higher collective memory on past events.
Local economy				
Share of jobs (full-time equivalents) in the hotel and catering sector 2001	The higher the share, the higher the rate of population living on tourism and therefore the higher the sensitivity of the region.	Linear ↑	FSO (personal communication)	[jobs in the hotel and catering sector/total number of jobs]
Share of jobs (full-time equivalents) in the transportation sector 2001	As above	Linear ↑	FSO (personal communication)	[jobs in the transportation sector/total number of jobs] However the transport sector does also include non-tourism related activities.

Job seasonality	The higher the seasonality, the higher the sensitivity. Local people working principally in other sectors also depend on tourism for their subsistence.	Linear ↑	Not available data	We use as proxy the share of jobs in the agriculture sector, seeing that often people working in winter in the tourism sector work in the agriculture domain the rest of the year. Immigrant seasonal workers do, however, also play a very important role.
Share of jobs in the agriculture sector 2001	In many regions, tourism and agriculture are strongly intertwined. Farmers that in summer work in the fields, often have a part-time job in the tourism sector during winter as a seasonal job (Shaw and Williams 1994). Therefore, the higher the share of jobs in the agriculture sector, the higher the possibility that it these people also depend on tourism for their subsistence and the more the region is sensitive.	Linear ↑	FSO (personal communication)	[jobs in the agriculture sector/total of jobs] This indicator is used as a proxy for job seasonality, even if it doesn't take into account inmigrant seasonal workers.
Average net income pro person in private dwellings 1997 - 1998	The higher the net income pro capita, the higher the wealth of the region and therefore lower its sensitivity to climate change impacts.	Linear ↓	Schuler (2010) – personal communication, Schuler et al. (2007).	[average annual income per person in 10^3 CHF] We suppose here a correlation between average income pro capita and the wealth of the tourism sector.
Average financial health of municipalities	The higher the average financial health of municipalities, the higher the wealth of the region and therefore the lower its sensitivity to climate change impacts.	Linear ↑	Not available data for the whole Swiss municipalities. Soft data was used instead. Soft data was however not used at the end.	[from bad (1) to very good (5)] Data are calculated for the main Swiss cities by the Swiss Graduate School of Public Administration (IDHEAP) institute (but data are not available for the totality of Swiss municipalities). Financial health is given from the charges cover, the autofinancing of the net investment, the net additional engagements and the weight of the net interests in relation to the tax revenue.
Average per capita cantonal income 2003	The higher the average per capita cantonal income, the higher the wealth of the region and therefore the lower its sensitivity to climate change impacts.	Linear ↓	FSO (personal communication)	[average annual per capita cantonal income in CHF]

Local infrastructure				
Accessibility 2001	The more the region is accessible, the less it is sensitive. For example, we can suppose that a higher number of one-day tourists will reach the location.	Linear ↑	FSO (personal communication)	[average minutes of travel from the nearest urban center (public transports and personal mobility) pondered on the population] It should however be pointed out that often the regions with the lower accessibility are also the ones with the highest scenic beauty and the best ski resorts. See also Luthe (2009) for a discussion on the subject. The impact of accessibility was considered here to be linear; it could however have a threshold. An explanation of the calculations' methodology can be found in FSO (personal communication).
Accessibility to services 2001	The more the region has access to services (shops, hospitals, etc.), the more it is self-sufficient and the less it will be affected in the short time if it is isolated because of natural hazards (low sensitivity). Moreover it depicts the degree of offer in the region.	Linear ↑	FSO (2001)	[average meters of travel from nearest service pondered on the population] We used the average distance to the different services for each municipality (for some municipalities the FSO didn't make the calculations because of data quality). Each service has the same weight. Services considered are: general public administration (General Classification of Economic Activities (NOGA) 7511A); food, tobacco and drinks shops (NOGAS 5211A-5211E); bakeries (NOGA 5224A); banks (NOGAS 6512B-6512G); post offices (NOGA 6411A); drugstores (NOGA 5231A); doctors' offices (NOGA 8512A); dentists' surgery (NOGA 8513A); hospitals (NOGA 8511A); schools (NOGAS 8010A-8021A, NOGAS 8021B, 8021C, 8022A, 8532A); restaurants (NOGAS 5530A + 5511A); sport facilities (NOGA 9261A); gas stations (NOGA 5050A); cinemas (NOGA 9213A); kiosks (NOGA 5247B); book stores (NOGA 5247A); museums; public transports stops (after calculations of the Federal Office for Spatial Development (ARE)). Data for Wengen-Mürren-Lauterbrunnental were not available. We took instead the score of Ferienregion Lötschberg (analogous situation).
New or renovated buildings (after 1990) 2000	The higher the rate of new or renovated building, the more the region will be resilient to natural hazards in the region.	Linear ↓	Schuler (personal communication), Schuler et al. (2007).	[number of new or renovated buildings/total of buildings] No distinction is made between tourism and non-tourism-related buildings.

Density of transport network (existence of replacement routes) 2006	The more the transport network is dense, the more in the case of natural hazards, substitute accesses exist.	Logarithmic ↓	Data calculated using information on the street and rail networks presented in VECTOR25 (Swisstopo 2007).	[log of kilometers of road and rail networks/hectares tourism region]
Current water storage capacity	The more the region can store water, the less it will be affected during periods of drought or of low water availability and therefore the lower its sensitivity. Moreover, less conflicts will be generated, e.g. in between farmers and tourism resorts or in between ski domains for artificial snow production and other users.	Linear ↓	Not available data	It depicts the sensitivity of the region to water scarcity and drought and to snowpack reduction.
Energy use in destination in the tourism sector	The higher the energy consumed, the more the region is sensitive in the case of higher energy prices or energy scarcity. The less the region is dependent from non-renewable and external energies, the less it is vulnerable.	Linear↑	Not available data	
Local institutions				
Left vs. right 1990 -2005	The higher the score for social topics, the higher the probably that more sustainable alternative are chosen.	Linear ↓	Schuler (personal communication), Schuler et al. (2007).	[average score of a Principal Component Analysis (PCA) for the opposition left vs. right in federal votes] More information on the method used can be found in Schuler et al. (2007). The thesis of Bornstein (2007) corroborates this assumption.
Ecologists vs. liberals 1990 -2005	The higher the score for ecological topics, probably the more sustainable alternative are chosen.	Linear ↓	Schuler (personal communication), Schuler et al.(2007).	[average score of a PCA for the opposition ecologists vs. liberals in federal votes] As above.
Size of the municipalities – municipalities aggregation 2009	The smaller the number of inhabitants in the municipalities, the smaller the municipalities themselves and probably the less effective the communication and the organization in the region.	Linear↓	FSO (personal communication) GEOSTAT data using a DHM25.	[average number of inhabitants of the municipalities/total number of inhabitants of the region] Concentration processes allows bundling resources and strategies and making the management more powerful, efficient and successful (Luthe 2009).

Local environment				
Land use protection 2007-2010	The more the land is protected, the more (it is supposed) its scenic beauty is high. Moreover, the more the land is under protection, the more its ecosystem is resistant and less sensitive to natural hazards.	Linear ↓	FSO (personal communication) GEOSTAT data using a DHM25.	[hectares of protected land/hectares tourism region] Considered protected land are: alluvial sites at the 2007 state; Federal Inventories of Landscapes and Natural Monuments of National Importance (BLN) at the 2001 state; swamps ('bas-marais/Flachmoore' and 'haut-marais/Hochmoore') at respectively the 2007 and the 2008 state, federal hunting reserves at the 2005 state, mire landscapes at the 2007 state; reserves for water-birds and migratory birds at the 2009 state; prairies and meadows at the 2010 state; sites of amphibians reproduction at the 2007 state; the Swiss National Park at the 2001 state; RAMSAR sites at the 2007 state; biogenetic reserves at the 2008 state; OCFH areas at the 2007 state; UNESCO sites at the 2008 state; Emerald Network sites at the 2010 state; biosphere reserves at the 2007 state; and parks of national importance at the 2010 state.
Landscape beauty	The more a landscape is complex, the more its scenic beauty is high (Hunziker and Kienast 1999; Tsouchlaraki 2006). Subsequently its sensitivity is lower.	Linear ↑	Data available (VECTOR25 PRI), but it was decided that results will be too approximate to be retained. Soft data was used instead.	[from very attractive (1) to very unattractive (5)] Scenic beauty depends on five factors. See 'Share of the region which will be conquered by forest because of climate change' in the exposure table for more details. Especially in summer, tourism profits from famous mountain scenery, and those without it need to be more creative and active in order to attract tourists (Luthe 2009). However, the positive relation between complexity and scenic beauty could be argued, depending on the kind of complexity (nature determined vs. anthropogenically determined).

Water availability	This higher the water availability, the less the region is sensitive, because having access to enough water for its activity.	Linear ↑	Data available, but not exhaustive (after discussion with experts). Soft data was used instead.	[from no problems (1) to very strong problems (3) in water availability] Data are presented in Freiburghaus (2009) and in the Swiss Hydrological Atlas (Spreafico 1992). Results in water availability presented in the Atlas are not plausible for many water basins. It has been therefore chosen not to consider them. Water availability is already a problem in many ski resorts (Reynard 2000). For example, water is a limiting factor for snowmaking in a rather dry places as St Moritz or the Dolomites in Italy (Luthe 2009). This is particularly true at the end of the winter season, when water availability is already low (EEA 2009). Almost all areas interviewed in Luthe (2009) are planning to build new and more water reservoirs, being water shortage the limiting factor of snowmaking. Low water availability also affects other touristic sectors and other periods of the year. It depicts the sensitivity of the region towards water scarcity and drought and towards snowpack reduction.

Adaptive Capacity

Indicator	Influence on vulnerability	Trend	Data source	Remarks
Feasibility				
Social				
Existence of studies on climate change impacts for the region 2009	The more studies were carried out on the impacts of climate change specifically on the region, the more knowledge is available to stakeholders to take the good decisions.	Linear ↓	SWIDCHI (at the February 2010 state)	[number of studies carried out in the region] However, this is only true in a word of perfect information (which is rarely the case). This information should be made available (digested and translated) to the concerned people.
Public participation actions in the region	The more the region is used to public participation, the more social networks, knowledge sharing and information flows exist.	Linear ↑	Not available hard data, soft data was used instead.	[from frequent (1) to inexistent (3) public participation actions] On the other hand, an overdose of public participation action (in particular if carried out by external people) could lead to aversion and to disinterest. The presence of a leading horse, a person that pushes and keeps the process active, in the region is also necessary. We can distinguish three types of public participation: (1) formal participation to the elaboration of a project (juridical-formal participation), (2) informal participation from associations and concerned citizens (informal participation), and (3) participation to the final decision via popular voting (political participation) (Stoker 2000). We consider here only public participation in the sense of informal participation.
Economic				
Average net income pro person in private dwellings 1997 - 1998	The higher the net income pro capita, the higher the wealth of the region and therefore the more it possesses capital to carry out adaptation measures.	Linear ↓	Schuler (personal communication), Schuler et al.(2007).	[average annual income per person in 10^3 CHF] We suppose here a correlation between average income pro capita and the capital that can be used to carry out adaptation measures in relation to tourism.
Average financial health of municipalities	The higher the average financial health of municipalities, the higher the wealth of the region and therefore its adaptive capacity.	Linear ↑	Not available data for the whole Swiss municipalities. Soft data was used instead.	[from bad (1) to very good (5)] Data are also calculated for the main Swiss cities by the IDHEAP institute (but data are not available for the totality of Swiss municipalities). Financial health is given from the charges cover, the autofinancing of the net investment, the net additional engagements and the weight of the net interests in relation to the tax revenue.
Average per capita cantonal income 2000	The higher the average per capita cantonal income, the higher the wealth of the region and therefore the adaptive capacity of the region.	Linear ↓	FSO (personal communication).	[average annual per capita cantonal income in CHF]

Subsidies	The higher the level of subsidies, the higher the cash flow and therefore the possible level of investments in the region. This could bring to a higher adaptive capacity.	Linear ↑	Not available hard data, soft data was used instead.	[from very (1) to not helpful (4) communal, cantonal, or federal subsidies] National, cantonal or regional subsidies would help tourism stakeholders in taking the investments to adapt to climate change. Concerning ski resorts doomed to closure, subsidies from the region or the destination (the gastronomy and the hotel sector for example) would be a fair way of supporting the ski areas in taking the investment sums and the risks associated with it (Luthe 2009).
Technological				
Density of transport network (existence of replacement routes) 2006	The more the transport network is dense, the more substitute accesses exist in the case of natural hazards.	Logarithmic ↓	Data calculates using information on the street and rail networks presented in VECTOR25 (Swisstopo 2007).	[log of km of rail and road networks[119]/hectares tourism region] This indicator is approximate. For a valley, a second road placed on the opposite slope could already grant accessibility. Moreover, no distinction is made between 1-line and bigger roads.
Possibility of self-green energy development	The more the site has the possibility (both political and technical) to develop self-green energy, the less it is dependent to foreign and fossil energy. This makes it more adaptive in the case of higher energy prices or energy scarcity.	Linear ↓	Not available data at the moment.	Repowermap[120] is creating a database on the existence of green energy development. The website inventories different types of renewable energies installations in the country (solar for energy and heating, earth pumps, energy from wood, other bioenergies, wind energy, dams, etc.). The list is incomplete at the moment and was therefore not used.
Institutional				
Past actions taken from the tourism sector in this direction	The more the tourism sector has already taken steps in this direction, the more it is prepared to face climate change impacts and therefore the higher is its adaptive capacity.	Linear ↓	Not available hard data, soft data was used instead	[number of actions pondered on the number of answers] We gave the weight of 1 to families of adaptation, and 0.5 to subfamilies. Abegg (2011) listed some of them.
Part of an official tourist region (Swiss tourism)	Being part of an official tourism region implies the possession of strong and coordinated governance, and a good information flow. All this makes the region more capable to adapt.	Boolean ↓	Precise hard data not available.	Concentration processes allow bundling resources and strategies and making the management more powerful, efficient and successful (Luthe 2009).
Destination communication	The higher the internal communication, the better the situation for all partners. The higher the external communication, the better the advertisement of new adaptive solutions in the region and therefore a higher adaptive capacity.	Linear ↓	Precise data not available.	

[119] Not considering walking tracks.
[120] http://www.repowermap.org/. Last accessed 22.12.2011.

Left vs. right 1990 -2005	The higher the score for social topics, the higher the probability that sustainable alternatives are chosen.	Linear ↓	Schuler (personal communication), Schuler et al.(2007).	[average score of a PCA for the opposition left vs. right in federal votes] More information on the methodology could be found in Schuler et al. (2007). The thesis of Bornstein (2007) partly corroborates this assumption.
Ecologists vs. liberals 1990 -2005	The higher the score for ecological topics, probably the more sustainable alternative are chosen.	Linear ↓	Schuler (personal communication), Schuler et al.(2007).	[average score of a PCA for the opposition ecologists vs. liberals in federal votes] As above.
Environmental				
Land use protection 2007-2010	The more a region is under protection, the more its ecosystem can be supposed to be in good health and therefore capable to adapt.	Linear ↓	FSO (personal communication) GEOSTAT data using a DHM25.	[hectares of protected land/hectares tourism region] See also above (Land use protection 2007-2010 in the sensitivity table). On the other hand, strict landuse protection rules could slow the innovation process.
Water availability	The less water is available for the tourism sector, the less the region has a high adaptive capacity because of conflicts for water and water scarcity for tourism-related activities.	Linear ↑		[[from not existing (1) to very strong (6) risk of water scarcity and/or drought] It depicts the sensitivity of the region towards water scarcity and drought and towards snowpack reduction.
Acceptability				
Social				
Political framework: results of a vote on right of appeal of organizations	The higher the score of the "No", the more the region accepts public participation.	Linear ↓	FSO (personal communication)	[negative votes/total of voting] This vote wanted to abolish the right of recourse of environmental organizations. In Switzerland, organizations for the protection of the environment acting at national level have the right of recourse against important construction projects when these violate environmental protection legislation. The initiative wanted to exclude the right of these organizations on projects required by the population or the parliaments. Participative processes are a key factor for a good adaptive process, in which all the stakeholders are involved.
Past actions taken from the tourism sector in this direction	The more the region is used to actions from the tourism sector in this direction, the more it is open to accept new projects (if the previous worked well).	Linear ↓	Not available hard data at the moment, soft data was used instead.	[number of actions pondered on the number of answers] We gave the weight of 1 to families of adaptation and of 0.5 to subfamilies. Abegg (2011) listed some of them.

A.4 Summary statistics of the indicators

Table A 6: Statistical information on the indicators

Exposure		Min	Max	Count	Mean	Median	Stand. dev.
Indicator							
Changes in climate suitability							
Changes in climate suitability for light outdoor activities 2011-2040 vs control (1961-1990) (-)	[Δ average pondered TCI score for spring, summer, and fall]	2.82	8.55	85	5.40	5.13	1.51
Share of mountainous area in the region	[hectares/hectares tourism region]	0.00	1.00	85	0.45	0.44	0.39
Share of lakes in the region	[meters of lake perimeter/hectares tourism region]	0.11	6.07	85	1.37	1.02	1.20
Snowpack reduction							
Share of the region located between the current and the future snow reliability line	[hectares/hectares tourism region]	0.00	0.41	69	0.10	0.09	0.08
Share of the region located over the future snow reliability line	[hectares/hectares tourism region]	0.00	1.00	85	0.36	0.23	0.37
Glaciers melting							
Future glaciers surface loss	[hectares/hectares tourism region]	0.00	0.04	40	0.01	0.01	0.01
Permafrost melting – rockfall							
Share of the region surface with potential permafrost melting	[hectares/hectares tourism region]	0.00	0.32	48	0.11	0.11	0.09
Natural hazards							
Number of past natural hazards (1972-2007)	[number of past natural hazards/hectares tourism region]	3.97 10^{-4}	6.72 10^{-3}	85	1.93 10^{-3}	1.54 10^{-3}	1.23 10^{-3}
Cost of past natural hazards (1972-2007)	[Mio. CHF/hectares tourism region]	5.81 10^{-5}	2.39 10^{-2}	85	2.80 10^{-3}	1.65 10^{-3}	3.60 10^{-3}
Cost on infrastructure of past natural hazards (1972-2007)	[Mio. CHF/hectares tourism region]	8.86 10^{-6}	6.41 10^{-3}	85	5.18 10^{-4}	2.29 10^{-4}	8.32 10^{-4}
Share of the region with 100-year floods events probability[2]	[hectares/hectares tourism region]	0.01	0.33	85	0.06	0.04	0.05
Water scarcity – drought							
Future water availability	[Δ mm/year 2021-2050 vs 1980-2009]	-48.18	34.86	85	9.98	16.82	19.92
Scenic beauty changes							
Share of the region which will be conquered by forest because of climate change	[hectares/hectares tourism region]	0.00	0.13	43	0.03	0.02	0.03

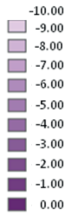
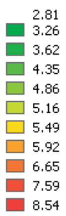
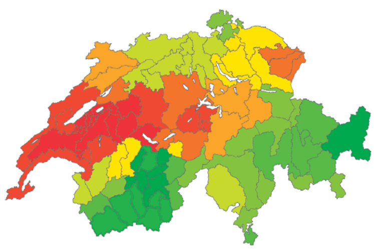
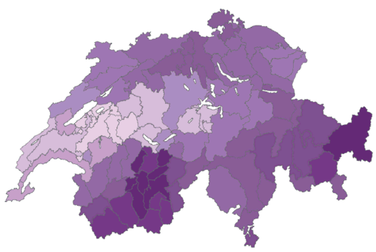
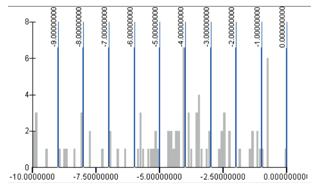
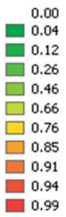
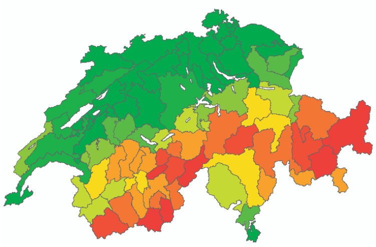
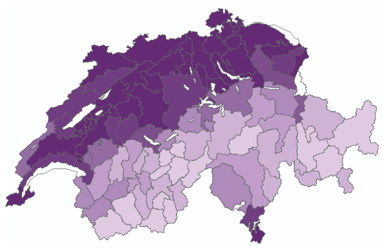
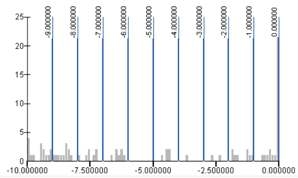
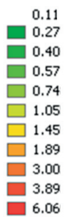
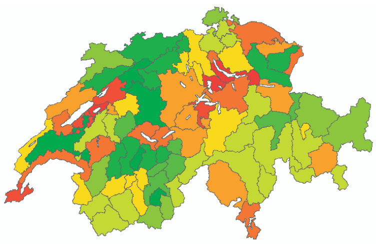
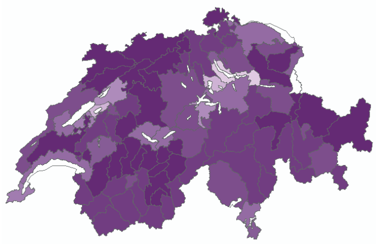
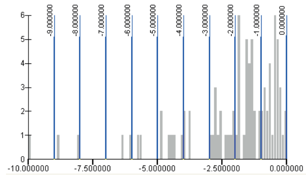
Sensitivity		Min	Max	Count	Mean	Median	Stand. dev.
Tourism structure							
Tourism demand							
Tourism intensity	[guest nights in hotels, health resorts, and in the 'parahotel industry'/inhabitants]	0.02	294.67	85	33.58	4.41	64.71
Guest nights/one-day tourists ratio	-	-	-	-	-	-	-
Length of stay	[guest nights in hotels and health resorts/arrivals in hotels and health resorts]	1.34	4.29	83	2.47	2.29	0.72
Skiers visits	[sum skiers visits/hectares tourism region]	0.39	394.51	62	64.09	26.77	92.56
Winter seasonality	[guest nights in hotels and health resorts in winter (DJF)/total guest nights in hotels and health resorts]	0.05	0.51	83	0.25	0.21	0.10
Summer seasonality	[guest nights in hotels and health resorts in summer (JJA)/total guest nights in hotels and health resorts]	0.21	0.49	83	0.32	0.31	0.05
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry'	[guest nights/(number of bed-places*365)]	0.08	0.55	83	0.34	0.34	0.10
International attractiveness (share of foreign tourists)	[guest nights of foreign tourists/total guest nights]	0.36	0.80	83	0.50	0.48	0.08
Tourism supply							
Density of beds in hotels and health resorts and in the 'parahotel industry' (warm beds)	[beds available/hectares tourism region]	0.01	1.55	85	0.18	0.08	0.25
Tourism supply structure (big vs. small hotels and restaurants)	[(1*very small scale+2*small scale+3*medium scale+4*big scale)/(total+1)]	1.01	1.50	85	1.14	1.12	0.10
Secondary homes (cold beds)	[number of rooms in homes temporarily inhabited/total number of rooms in homes]	0.04	0.58	85	0.20	0.13	0.16
Proximity to substitute ski destinations	[average number of ski resorts in a 25 km-radius]	1.00	10.00	62	3.39	3.00	2.11
Length of activity of ski resorts	[average number of open days with at least 50 cm of snow on the upper part of the resort pondered on the capacity of the stations]	16.00	175.57	58	121.16	133.6	37.36
Artificial snow production	[average km of slopes that can be potentially covered by artificially snow on a resort pondered on the capacity of the stations]	0.00	313.00	58	24.05	9.70	46.68
Total capacity of ski domains located under the future snow-reliability line	[hourly flow rate/(altitude difference*hectares tourism region)*1000]	0.00	0.19	61	0.02	0.00	0.04
Total capacity of ski domains located over the future snow-reliability line	[hourly flow rate/(altitude difference*hectares tourism region)*1000]	0.00	1.49	61	0.20	0.07	0.30
Length of infrastructure located on possible/probable permafrost melting	[meters of length of infrastructure/hectares tourism region]	0.01	1.26	38	0.35	0.22	0.36
Media and communication on snow condition	-	-	-	-	-	-	-
Local population							
Density of resident population	[resident population/hectares tourism region]	0.07	41.59	85	2.56	1.22	5.06

Share of the population born on place (collective knowledge on areas subject to natural hazards)	[people born on the same municipality/total number of inhabitants]	0.21	0.74	85	0.37	0.34	0.12
Age structure (age-dependency ratio)	[(kids (<15 years)+elderly people (>64 years))/(people between 15 and 64 years old)*100]	31.32	66.24	85	50.26	50.04	5.64
Local economy							
Share of jobs (full-time equivalents) in the hotel and catering sector	[jobs in the hotel and catering sector/total number of jobs]	0.02	0.50	85	0.12	0.06	0.12
Share of jobs (full-time equivalents) in the transportation sector	[jobs in the transportation sector/total number of jobs]	0.02	0.25	85	0.06	0.05	0.04
Job seasonality	-	-	-	-	-	-	-
Share of jobs in the agriculture sector	[jobs in the agriculture sector/total of jobs]	0.00	0.36	85	0.07	0.06	0.06
Average net income pro person in private dwellings	[average annual income per person in 10^3 CHF]	34.78	88.31	85	49.93	47.64	9.50
Average financial health of municipalities	[from bad (1) to very good (5)]	-	-	-	-	-	-
Average per capita cantonal income	[average annual per capita cantonal income in CHF]	3.58 10^4	8.96 10^4	85	4.54 10^4	4.35 10^4	9.67 10^4
Local infrastructure							
Accessibility	[average minutes of travel from the nearest urban centre (public transports and personal mobility) pondered on the population]	0.00	171.66	85	66.85	57.19	40.11
Accessibility to services	[average meters of travel from nearest service pondered on the population]	936.31	1.73 10^4	83	4.73 10^3	3.93 10^3	3.02 10^3
New or renovated buildings (after 1990)	[number of new or renovated buildings/total of buildings]	0.28	0.43	85	0.36	0.37	0.04
Density of transport network (existence of replacement routes)	[log of kilometers of road and rail networks/hectares tourism region]	-2.25	-0.88	85	-1.41	-1.36	0.34
Water storage capacity	-	-	-	-	-	-	-
Energy use in destination in the tourism sector	-	-	-	-	-	-	-
Local institutions							
Left vs. right	[average score of a Principal Component Analysis (PCA) for the opposition left vs. right in federal votes]	-1.97	3.97	85	0.05	-0.29	1.47
Ecologists vs. liberals	[average score of a PCA for the opposition ecologists vs. liberals in federal votes]	-6.23	2.32	85	-0.81	-0.47	1.71
Size of the municipalities - municipalities aggregation	[average number of inhabitants of the municipalities/total number of inhabitants of the region]	0.01	1.00	85	0.12	0.05	0.20
Local environment							
Land use protection	[hectares of protected land/hectares tourism region]	0.00	0.74	85	0.25	0.21	0.19
Landscape beauty	[from very attractive (1) to very unattractive (5)]	1.00	4.00	80	1.98	2.00	0.72
Water availability	[from no problems (1) to very strong problems (3) in water availability]	-	-	-	-	-	-

Adaptive capacity		Min	Max	Count	Mean	Median	Stand. dev.
Feasibility							
Social							
Existence of studies on climate change impacts for the region	[number of studies carried out in the region]	0.00	10.98	85	2.86	2.00	3.06
Public participation actions in the region	[from frequent (1) to inexistent (3) public participation actions]	1.00	3.00	84	2.13	2.13	0.40
Economic							
Average net income pro person in private dwellings	[average annual income per person in 10^3 CHF]	34.78	88.31	85	49.93	47.64	9.50
Average financial health of municipalities	[from bad (1) to very good (5)]	-	-	-	-	-	-
Average per capita cantonal income	[average annual per capita cantonal income in CHF]	3.58 10^4	8.96 10^4	85	4.54 10^4	4.35 10^4	9.67 10^4
Subsidies	[from very (1) to not helpful (4) communal, cantonal, or federal subsidies]	-	-	-	-	-	-
Technological							
Density of transport network (existence of replacement routes)	[log of km of rail and road networks/hectares tourism region]	-2.25	-0.88	85	-1.41	-1.36	0.34
Possibility of self green energy development	-	-	-	-	-	-	-
Institutional							
Past actions taken from the tourism sector in this direction	[number of actions pondered on the number of answers]	0.00	0.49	83	0.23	0.23	0.10
Part of an official tourist region (Swiss tourism)	-	-	-	-	-	-	-
Destination communication	-	-	-	-	-	-	-
Left vs. right	[average score of a Principal Component Analysis (PCA) for the opposition left vs. right in federal votes]	-1.97	3.97	85	0.05	-0.29	1.47
Ecologists vs. liberals	[average score of a PCA for the opposition ecologists vs. liberals in federal votes]	-6.23	2.32	85	-0.81	-0.47	1.71
Environmental							
Land use protection	[hectares of protected land/hectares tourism region]	0.00	0.74	85	0.25	0.21	0.19
Water availability	[from not existing (1) to very strong (6) risk of water scarcity and/or drought]	-	-	-	-	-	-
Acceptability							
Social							
Political framework: results of a vote on right of appeal of organizations	[negative votes/total of voting]	0.47	0.74	85	0.62	0.63	0.05
Past actions taken from the tourism sector in this direction	[number of actions pondered on the number of answers]	0.00	0.49	83	0.23	0.23	0.10

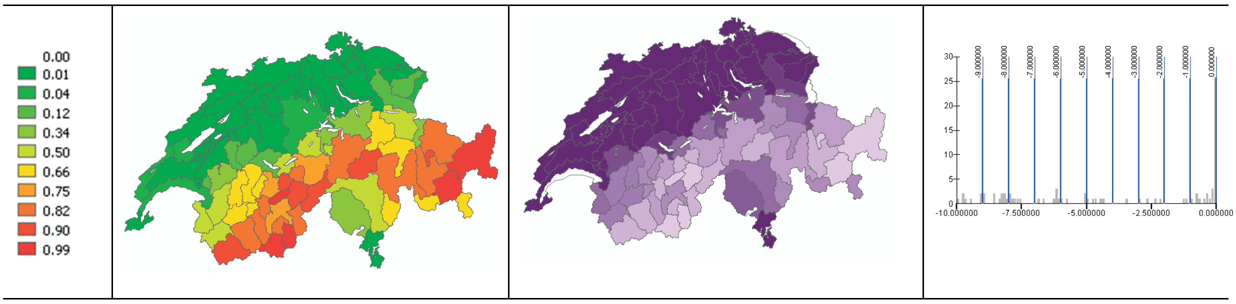
A.5 Graphic representation of the indicators with regional distribution

Table A 7: Graphical representation of the various indicators with (on the right) the regional distribution. The darker the region, the higher the exposure, the sensitivity, and the lower the adaptive capacity.

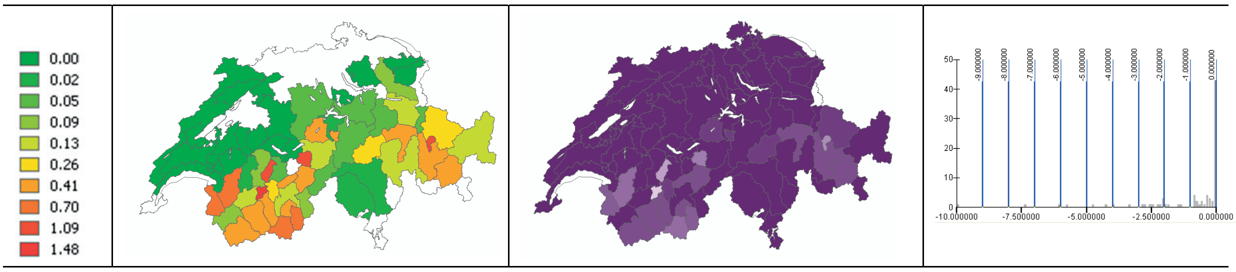
Decreasing vulnerability			
Natural breaks (jenks)[121]		Equal intervals	
			
Changes in climate suitability for light outdoor activities (-) 2011-2040 vs control (1961-1990) [Δ average pondered TCI score (Mieczkowski 1985) for spring, summer, and fall]			
			
Share of mountainous area in the region (-) [hectares/hectares tourism region]			
			
Share of lakes in the region (-) [meters of lake perimeter/hectares tourism region]			
			

[121] Classes are based on natural groupings intrinsic in the data. ArcMap identifies break points by selecting the class breaks that best group similar values and maximize the differences between classes. The features are divided into classes whose limits are set where there are relatively big jumps in the data values.

Share of the region located above the future snow reliability line (-) [hectares/hectares tourism region]

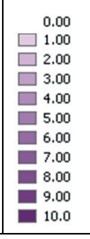


Total capacity of ski domains located over the future snow-reliability line (-) [hourly flow rate/(altitude difference*hectares tourism region)*1000]

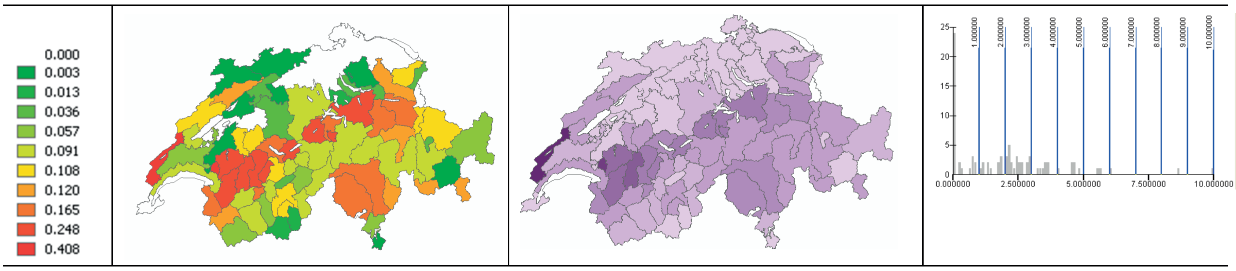


Increasing vulnerability

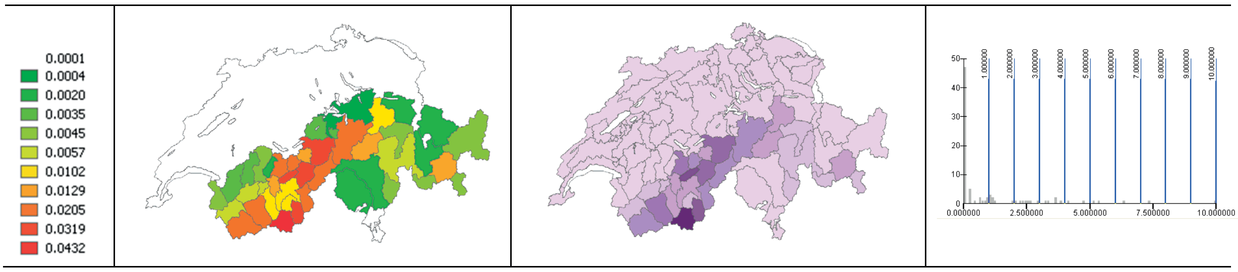
Natural breaks (jenks)	Equal intervals



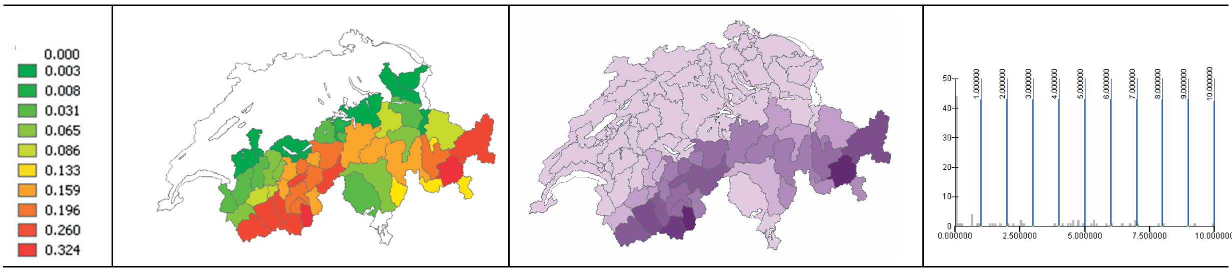
Share of the region located between the current and the future snow reliability line (+) [hectares/hectares tourism region]



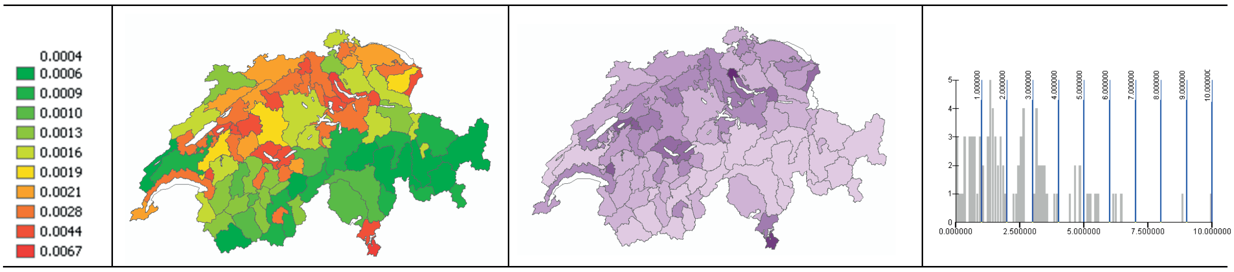
Future glacier surface loss [hectares/hectares tourism region]



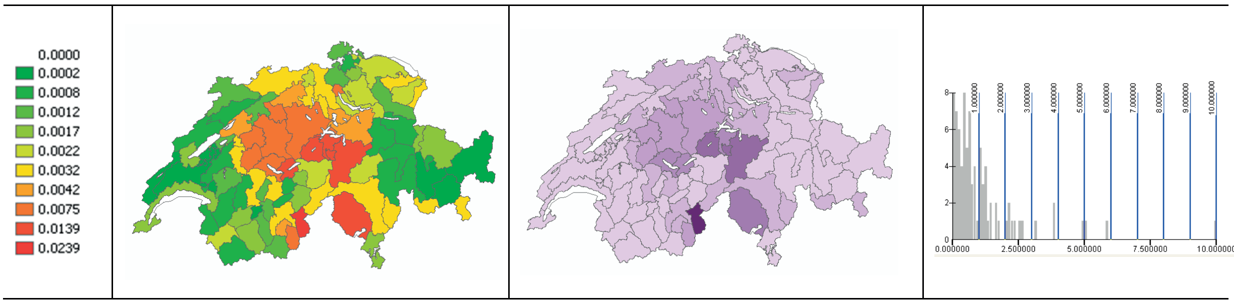
Share of the region surface with potential permafrost melting [hectares/hectares tourism region]



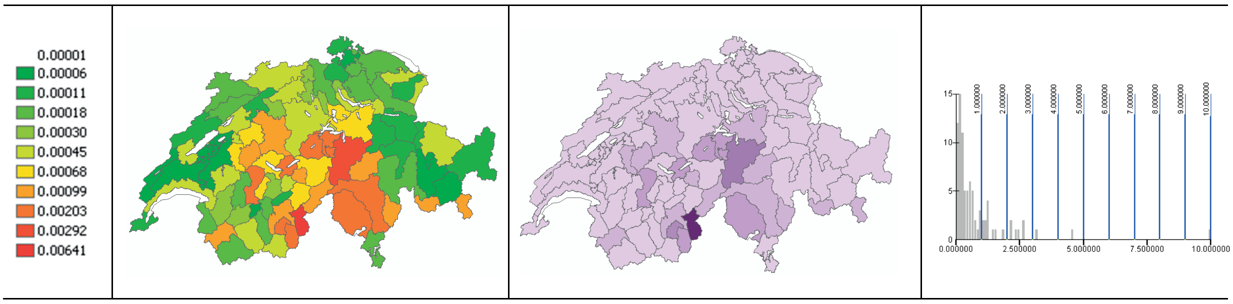
Number of past natural hazards (1972-2007) [number of past natural hazards/hectares tourism region]



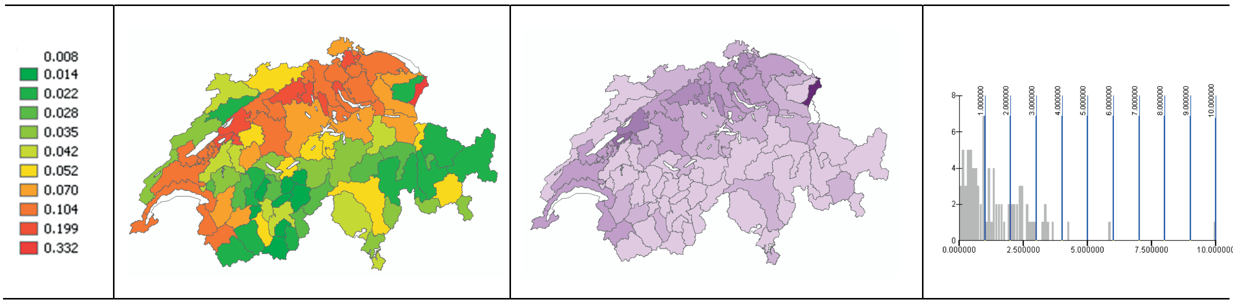
Cost of past natural hazards (1972-2007) [Mio. CHF/hectares tourism region]



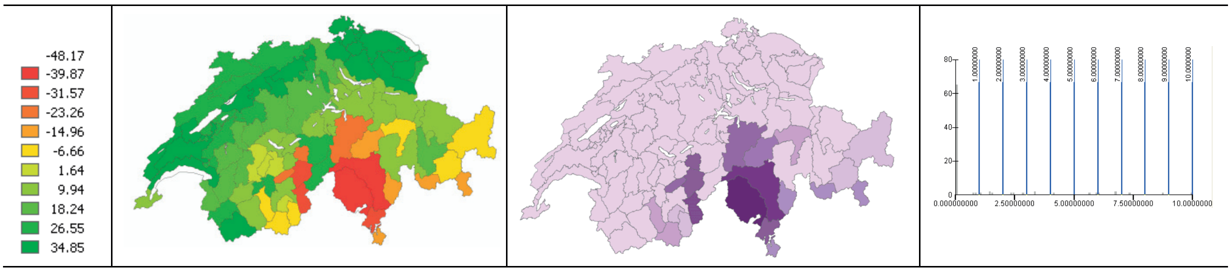
Cost on infrastructure of past natural hazards (1972-2007) [Mio. CHF/hectares tourism region]



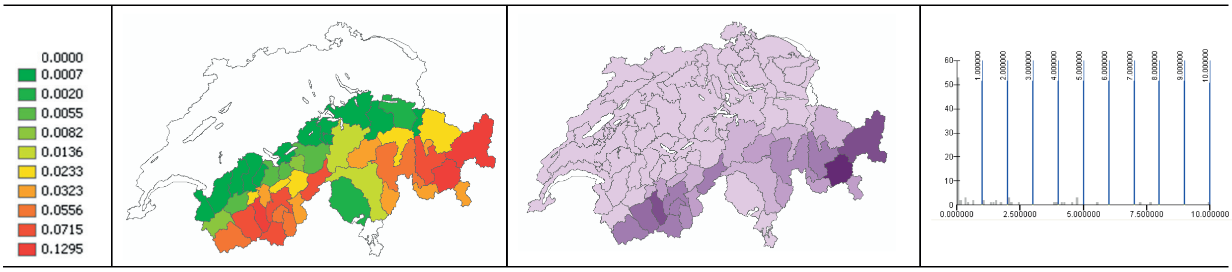
Share of the region with 100-year flood probability [hectares/hectares tourism region]



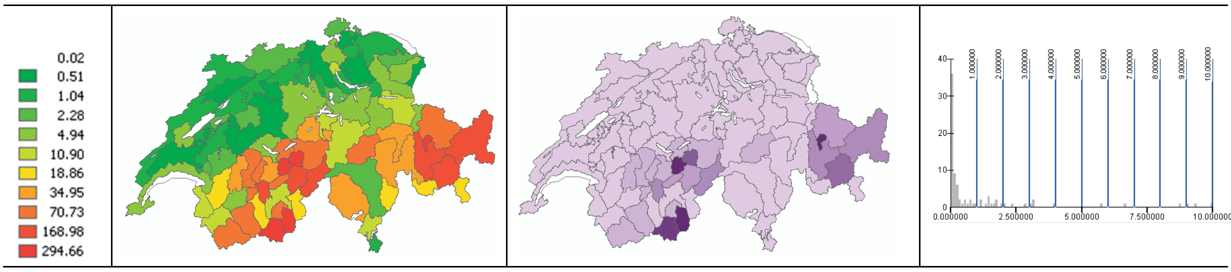
Future water availability [Change in runoff 2021-2050 vs control (1980-2009) in mm/year]



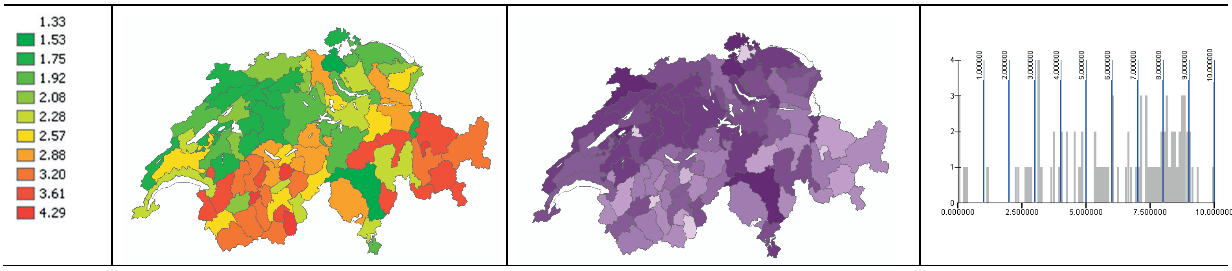
Share of the region which will be conquered by forest because of climate change [hectares/hectares tourism region]



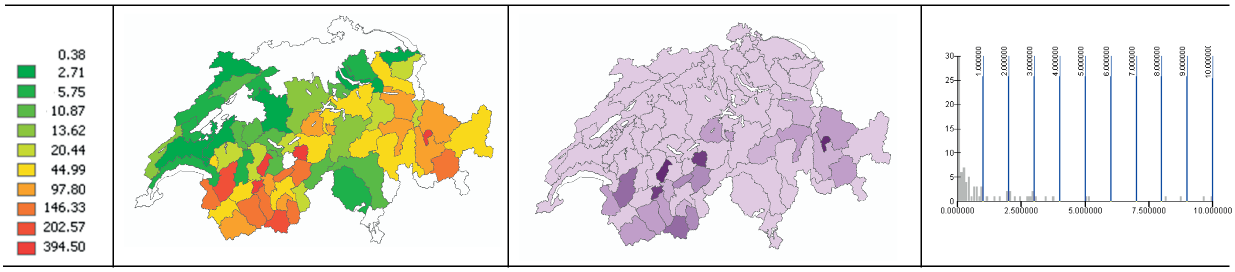
Tourism intensity [guest nights in hotels, health resorts, and in the 'parahotel industry'/inhabitants]



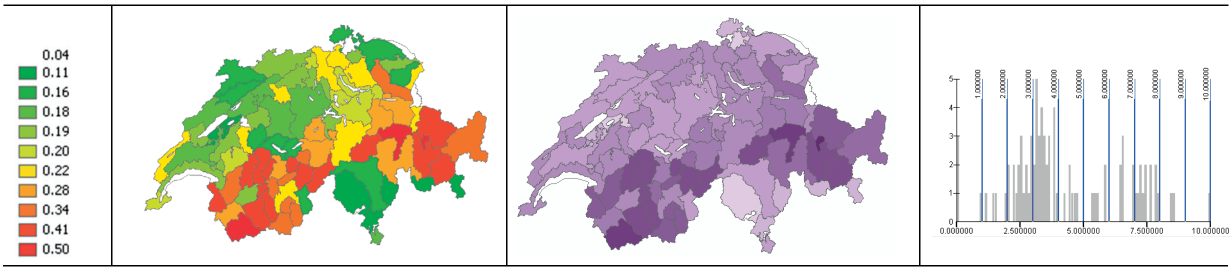
Length of the stay [guest nights in hotels and health resorts/arrivals in hotels and health resorts]



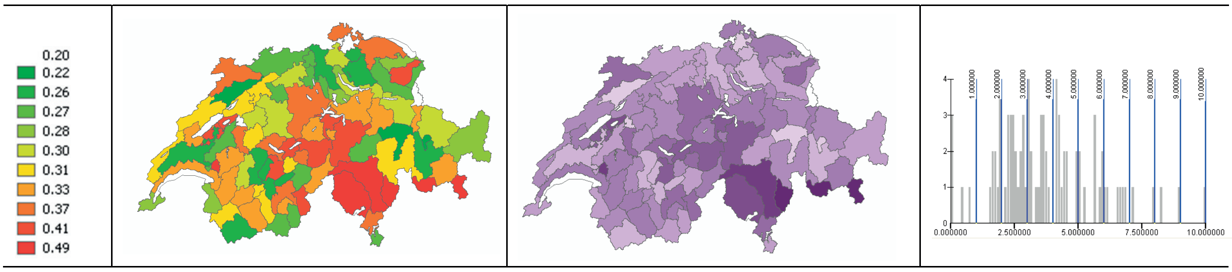
Skiers visits [sum skiers visits/hectares tourism region]



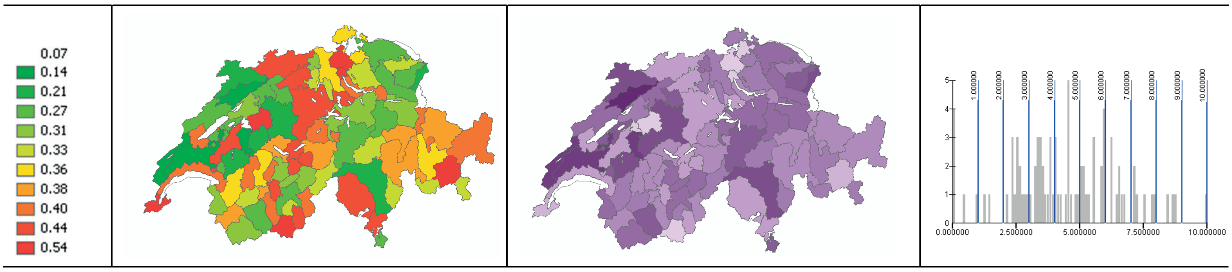
Winter seasonality [guest nights in hotels and health resorts in winter (DJF)/total guest nights in hotels and health resorts]



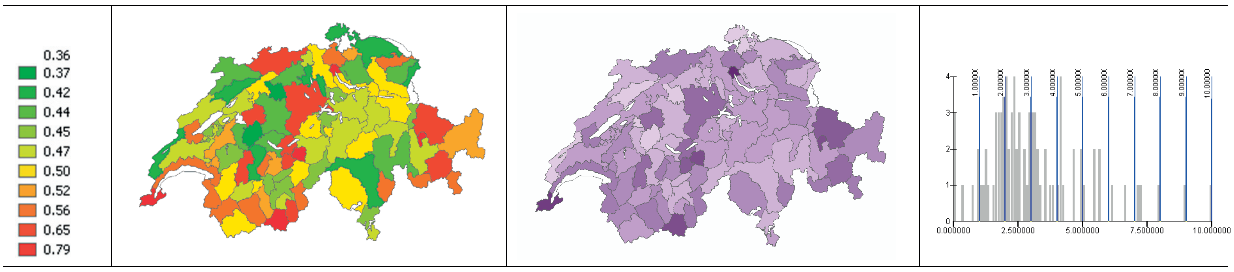
Summer seasonality [guest nights in hotels and health resorts in summer (JJA)/total guest nights in hotels and health resorts]



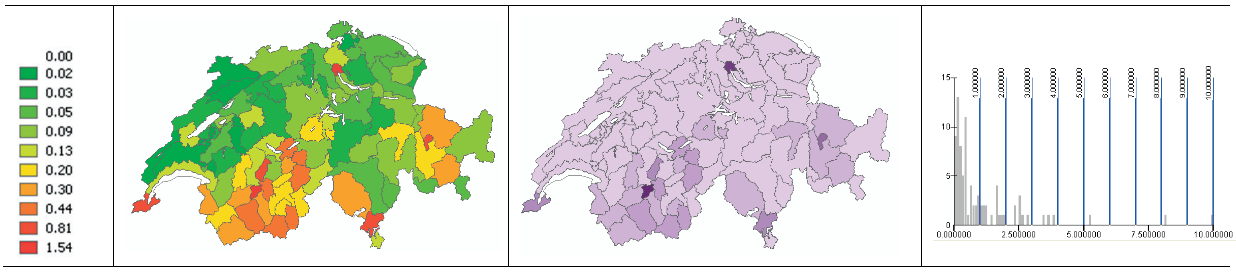
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry' [guest nights/(number of bed-places*365)]



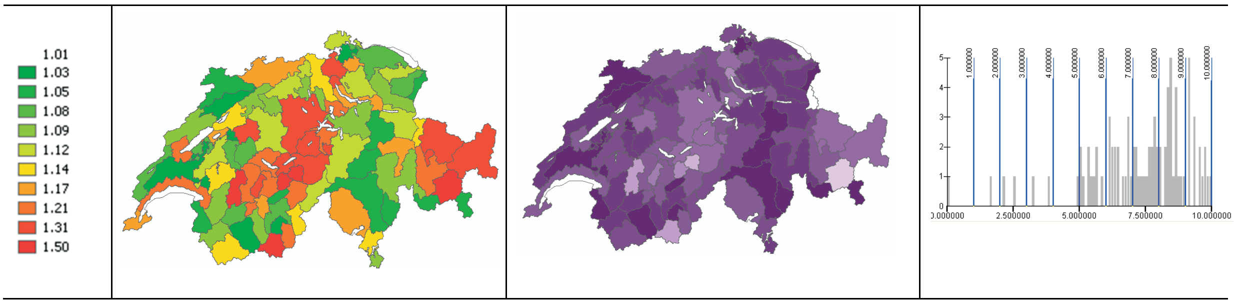
International attractiveness (share of foreign tourists) [guest nights of foreign tourists/total guest nights]



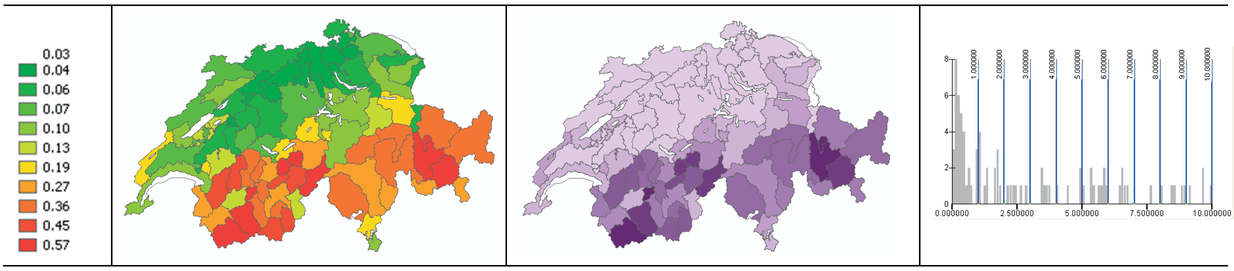
Density of beds in hotels, health resorts, and in the 'parahotel industry' (warm beds) [beds available/hectares tourism region]



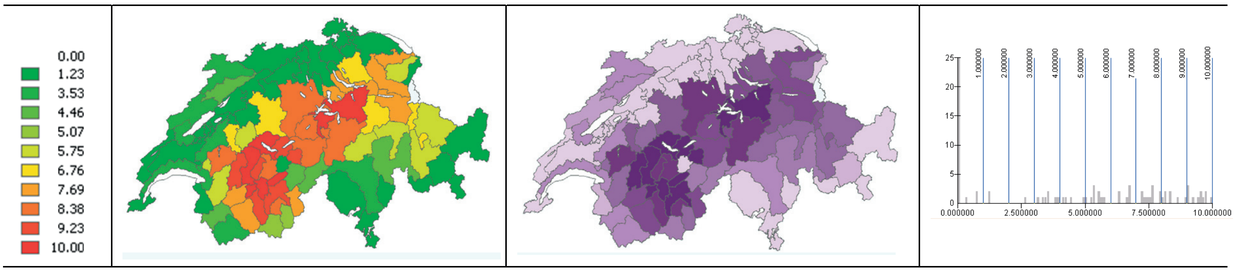
Tourism supply structure (big vs. small hotels and restaurants) [(1*very small scale+2*small scale+3*medium scale+4*big scale)/(total+1)]



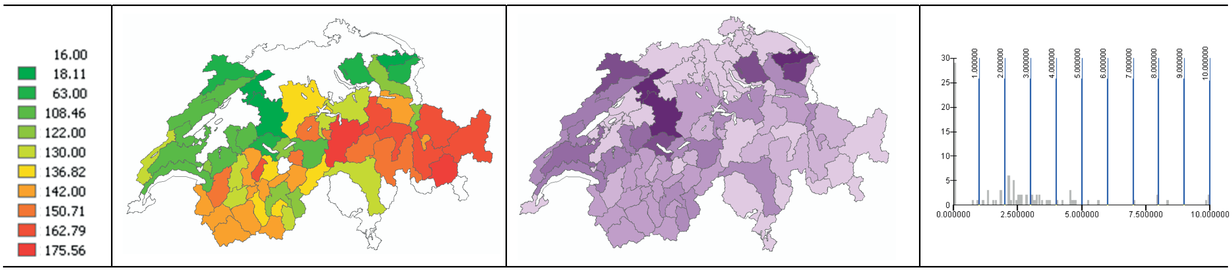
Secondary homes (cold beds) [number of rooms in homes temporarily inhabited/total number of rooms in homes]



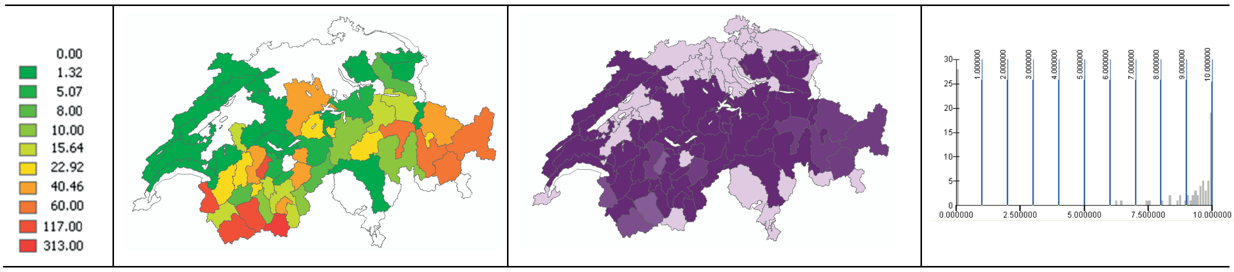
Proximity to substitute ski destinations [average number of ski resorts in a 25 km-radius]



Length of activity of ski resorts [average number of open days with at least 50 cm of snow on the upper part of the resort pondered on the capacity of the stations]

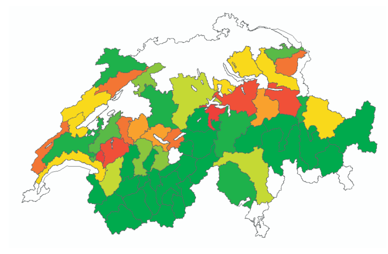


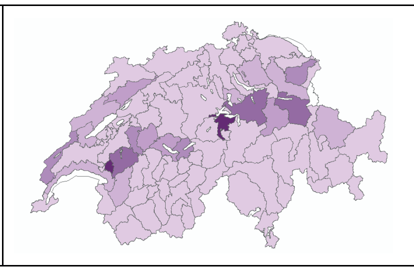
Artificial snow production [average km of slopes that can be potentially covered by artificially snow on a resort pondered on the capacity of the stations]

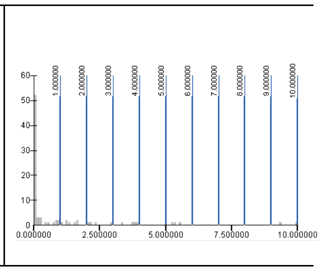


Total capacity of ski domains located under the future snow-reliability line [hourly flow rate/(altitude difference*hectares tourism region)*1000]

0.000
0.001
0.005
0.009
0.016
0.019
0.030
0.043
0.073
0.104
0.185

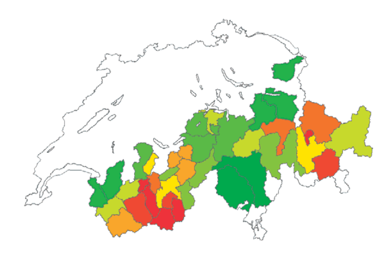


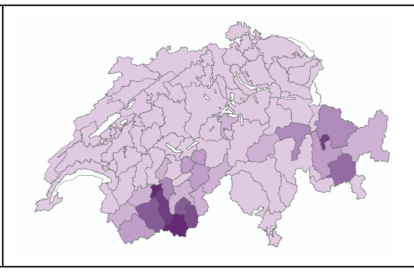


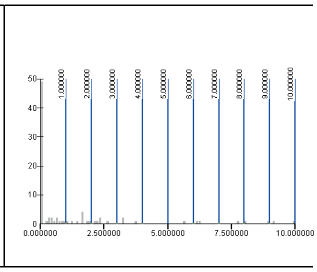


Length of infrastructure located on possible/probable permafrost melting [meters of length of infrastructure/hectares tourism region]

0.010
0.012
0.068
0.107
0.171
0.223
0.276
0.336
0.485
0.789
1.262

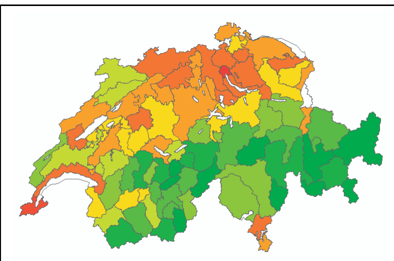


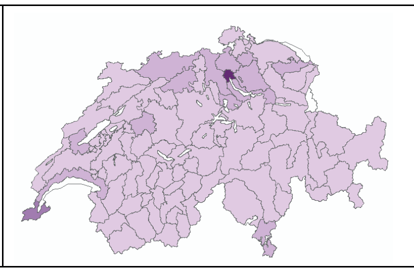


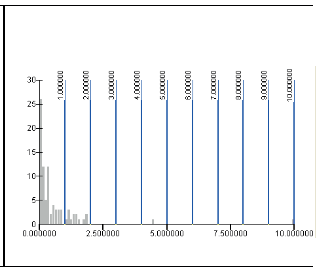


Density of resident population [resident population/hectares tourism region]

0.07
0.15
0.27
0.47
0.73
1.21
2.01
4.23
7.92
18.48
41.58

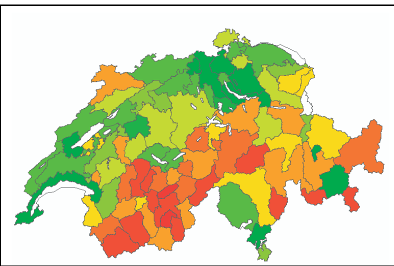


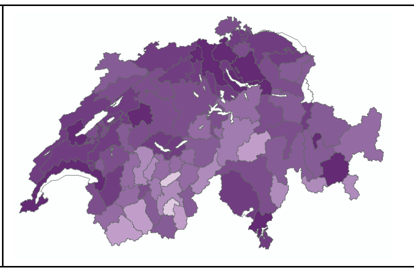


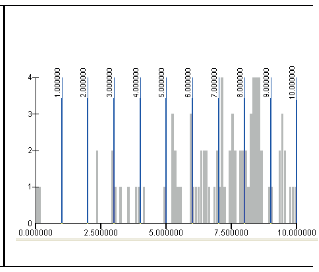


Share of the population born on place (collective knowledge on areas subject to natural hazards) [people born on the same municipality/total number of inhabitants]

0.20
0.23
0.26
0.29
0.31
0.34
0.37
0.42
0.47
0.61
0.73

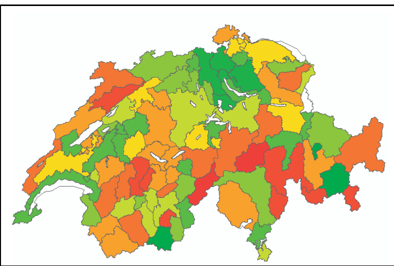


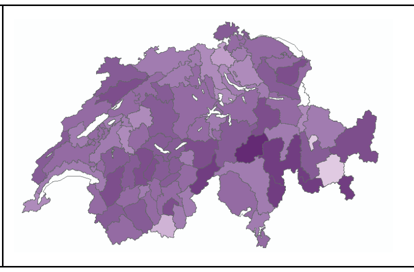


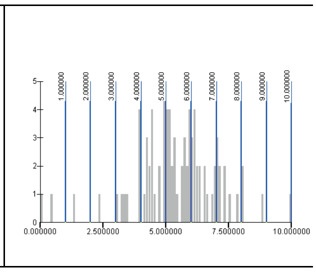


Age structure (age-dependency ratio) [(kids (<15 years) + elderly people (>64 years))/(people between 15 and 64 years old)*100]

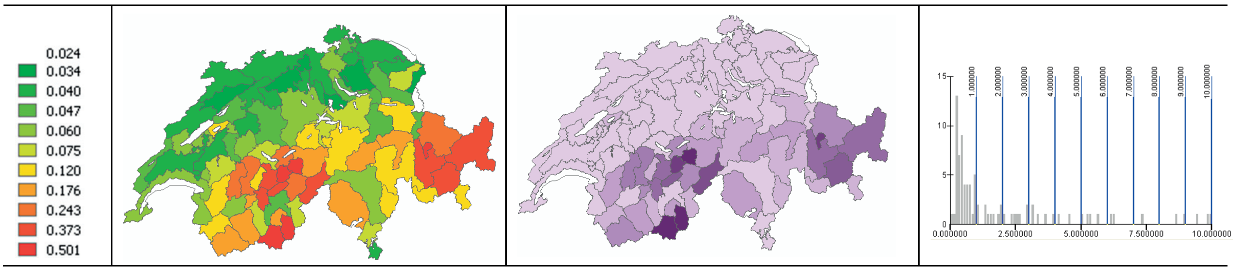
31.31
36.15
43.42
47.18
48.99
50.23
51.61
53.47
56.28
59.60
66.24



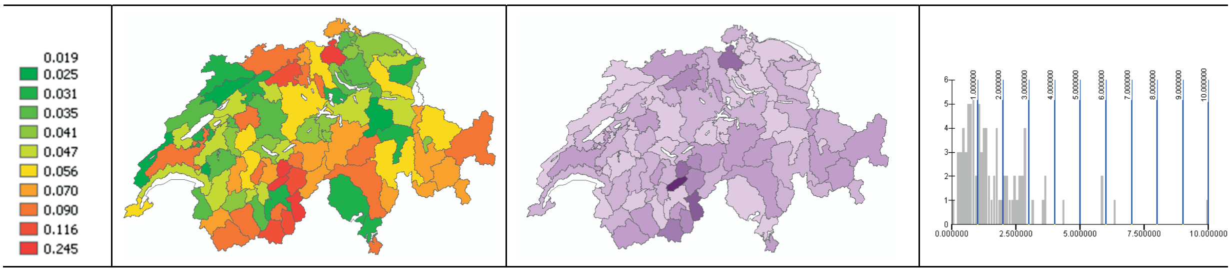




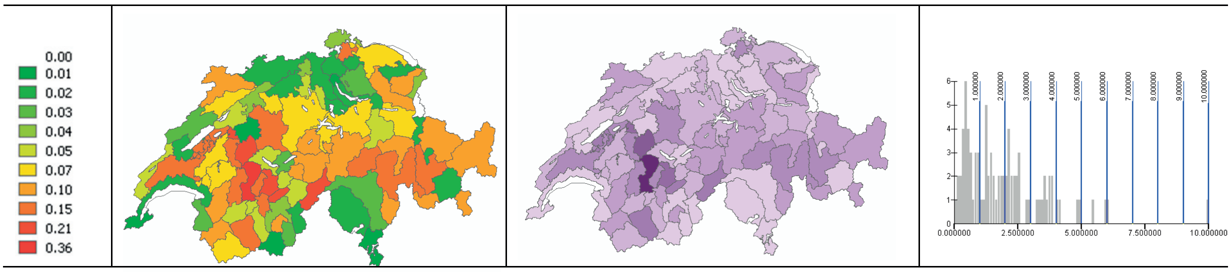
Share of jobs (full-time equivalents) in the hotel and catering sector [jobs in the hotel and catering sector/total number of jobs]



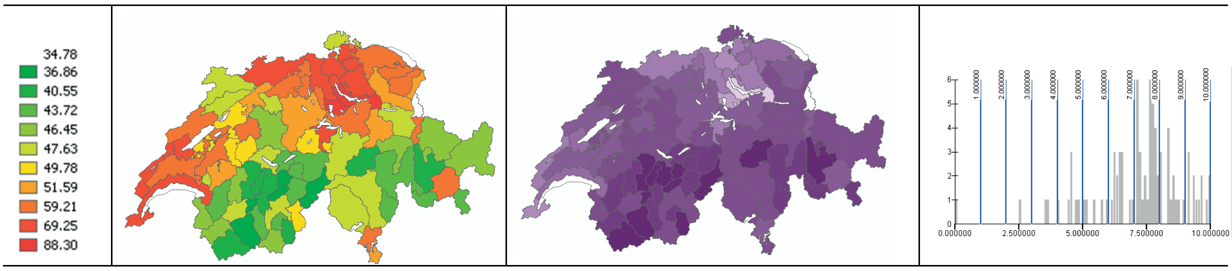
Share of jobs (full-time equivalents) in the transportation sector [jobs in the transportation sector/total number of jobs]



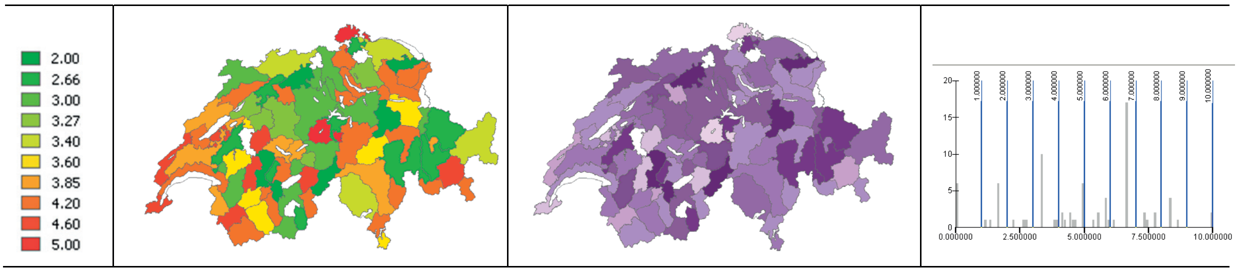
Share of jobs in the agriculture sector [jobs in the agriculture sector/total of jobs]



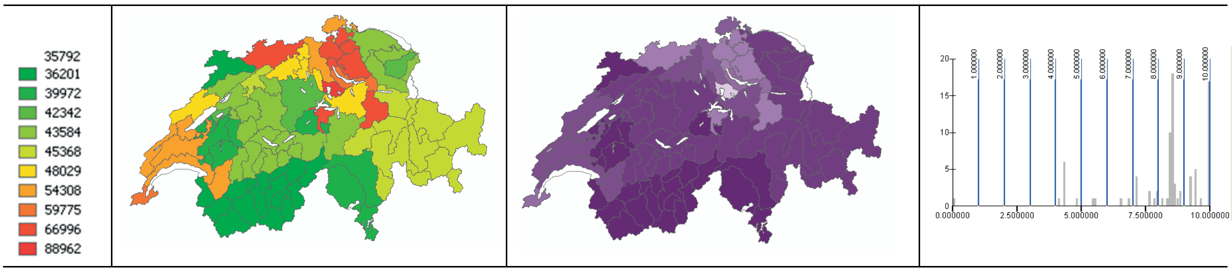
Average net income pro person in private dwellings [average annual income per person in 10^3 CHF]



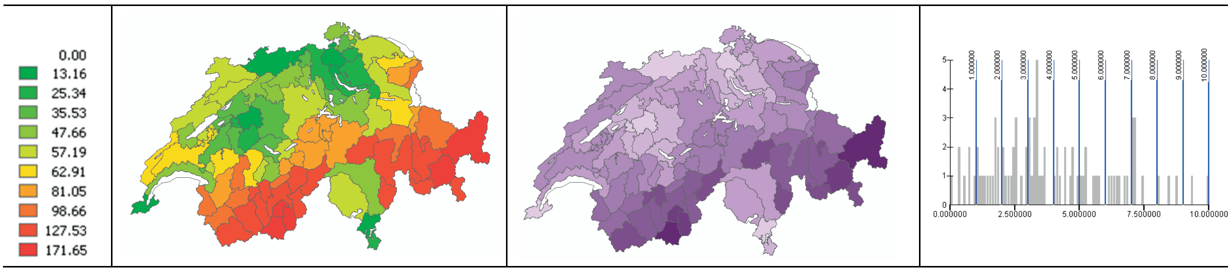
NOT INCLUDED - Average financial health of municipalities [from bad (1) to very good (5)]



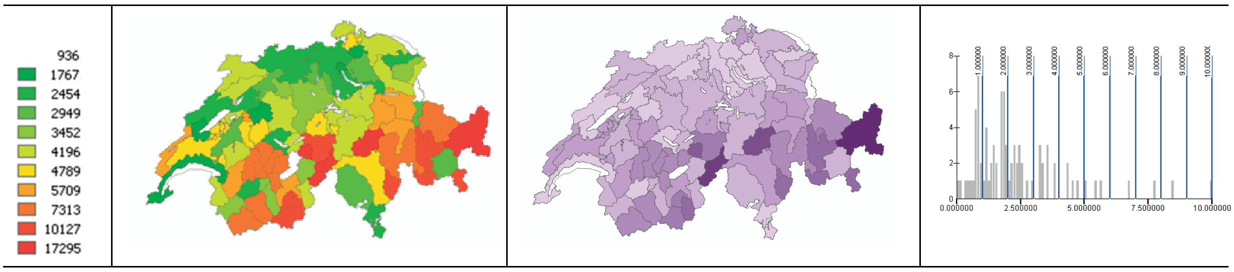
Average per capita cantonal income [average annual per capita cantonal income in CHF]



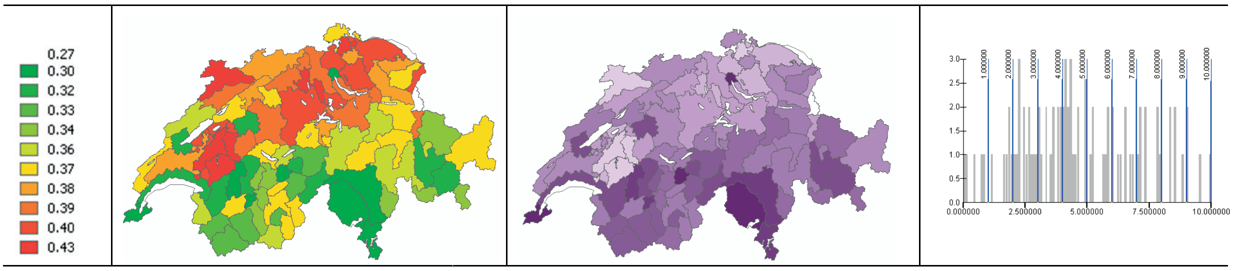
Accessibility [average minutes of travel from the nearest urban centre (public transports and personal mobility) pondered on the population]



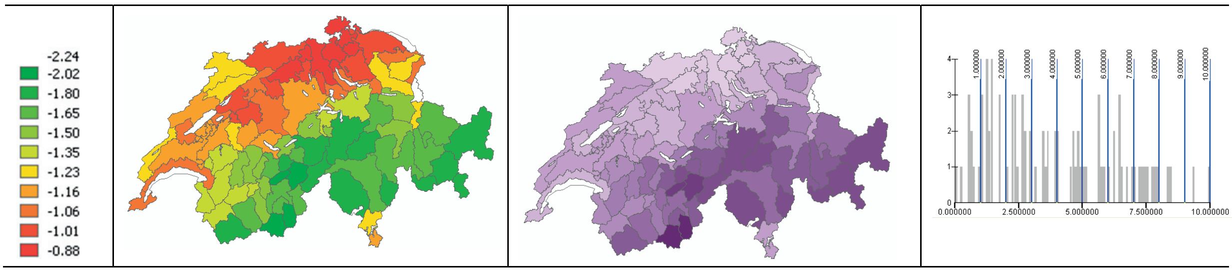
Accessibility to services [average meters of travel from nearest service pondered on the population]



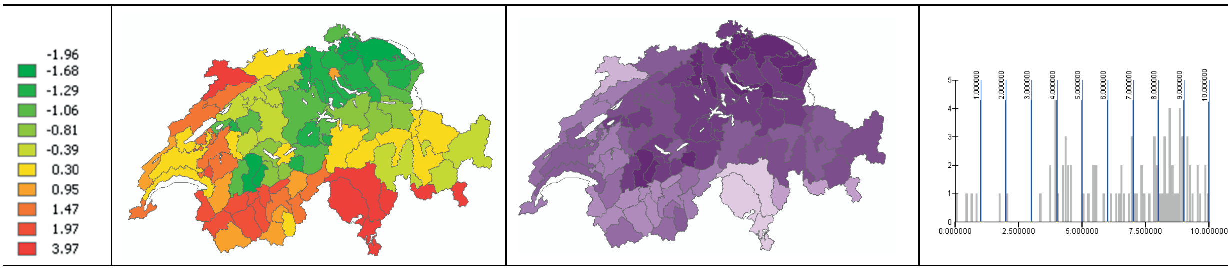
New or renovated buildings (after 1990) [number of new or renovated buildings/total of buildings]



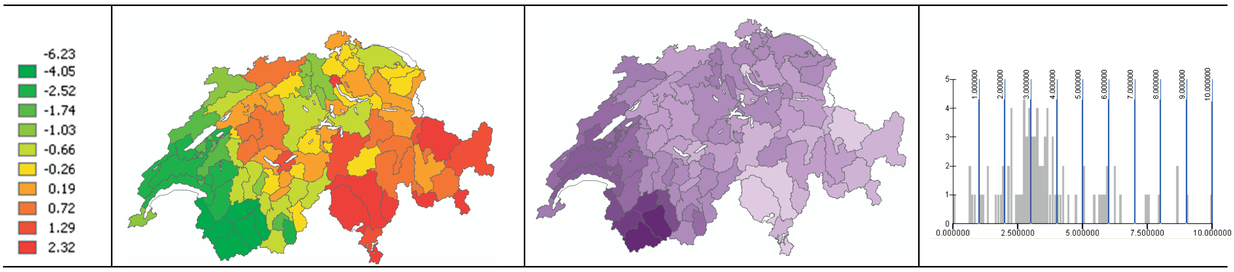
Density of transport network (existence of replacement routes) [log of kilometers of road and rail networks/hectares tourism region]



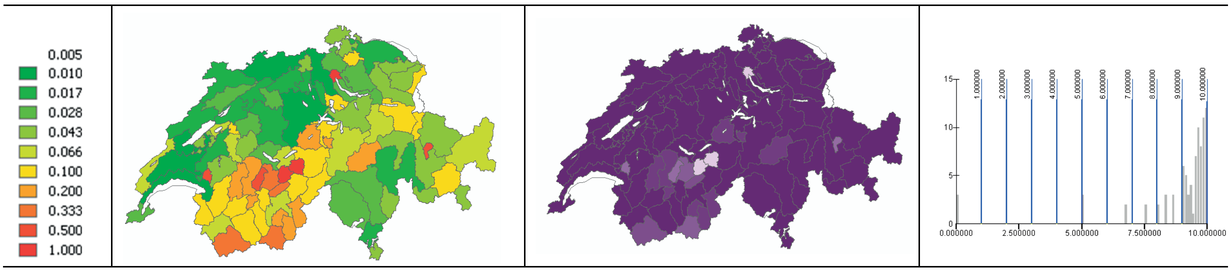
Left vs. right [average score of a Principal Component Analysis (PCA) for the opposition left vs. right in federal votes]



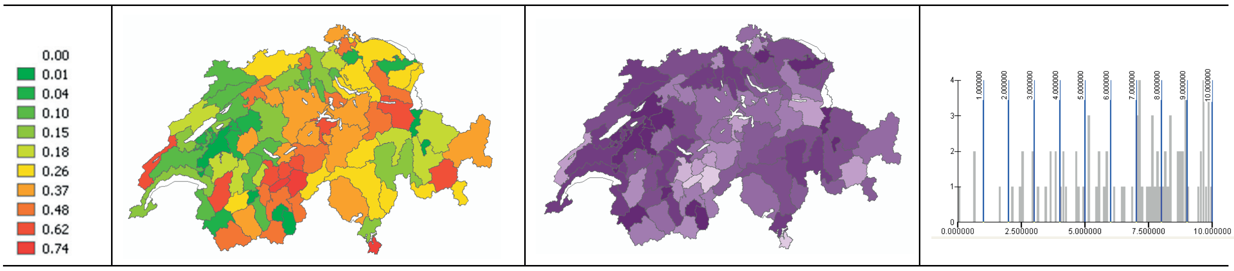
Ecologists vs. liberals [average score of a PCA for the opposition ecologists vs. liberals in federal votes]



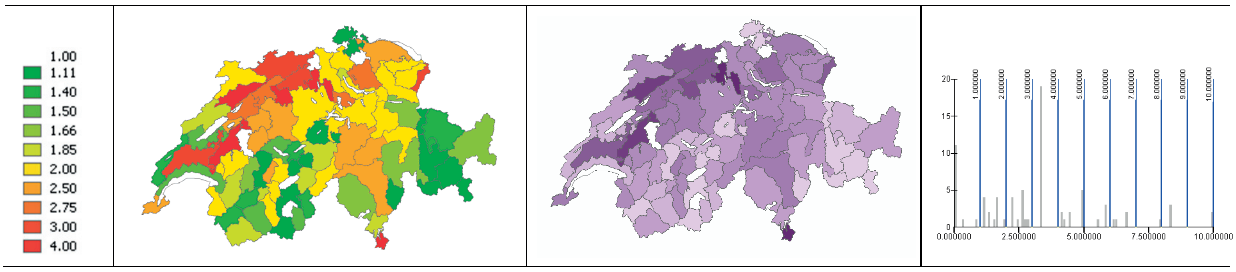
Size of the municipalities – municipalities aggregation [average number of inhabitants of the municipalities/total number of inhabitants of the region]



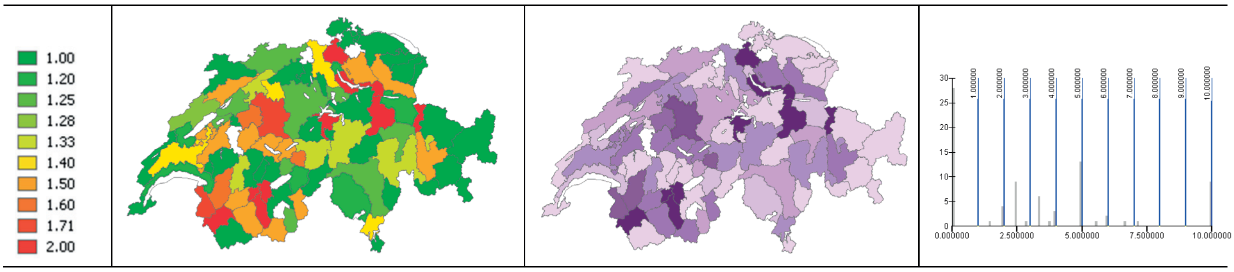
Land use protection [hectares of protected land/hectares tourism region]



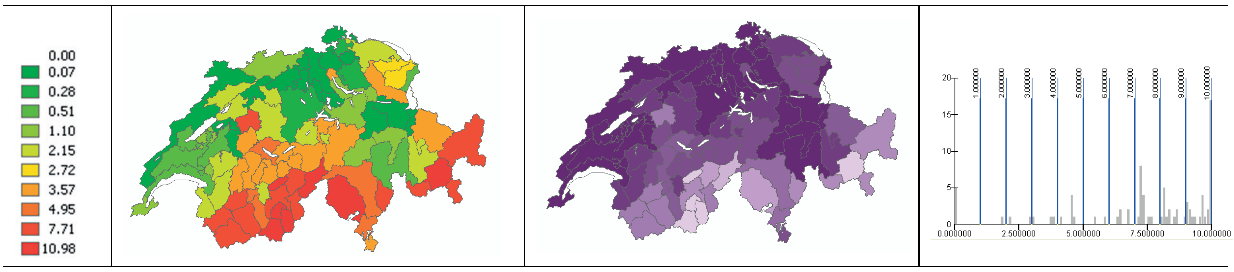
Landscape beauty [from very attractive (1) to very unattractive (5)]



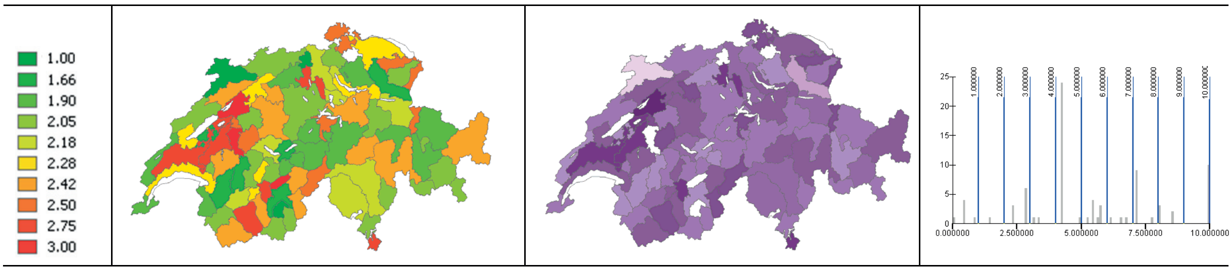
NOT INCLUDED - Water availability [from no problems (1) to very strong problems (3) in water availability]



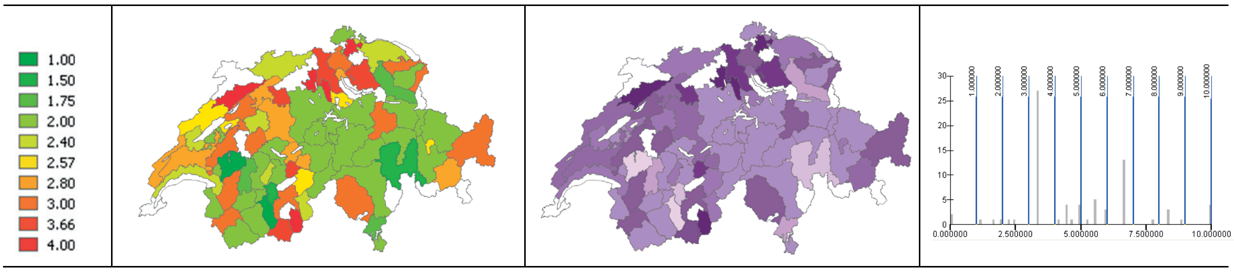
Existence of studies on climate change impacts for the region [number of studies carried out in the region]



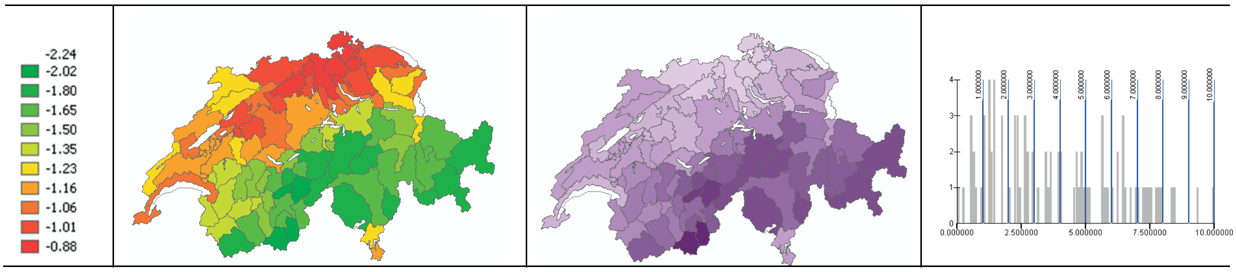
Public participation actions in the region [from frequent (1) to inexistent (3) public participation actions]



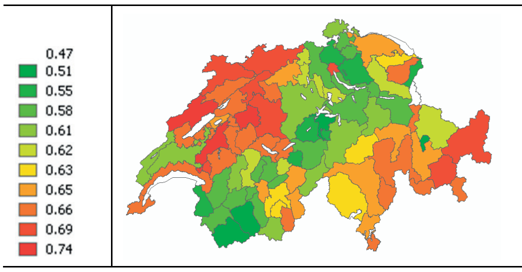
NOT INCLUDED - Subsidies [from very (1) to not helpful (4) communal, cantonal, or federal subsidies]

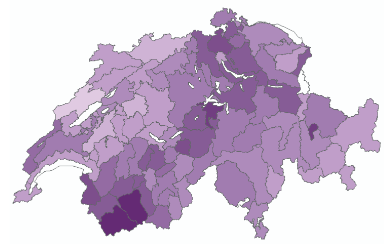


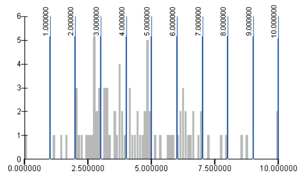
Density of transport network (existence of replacement routes) [log of km of rail and road networks/hectares tourism region]



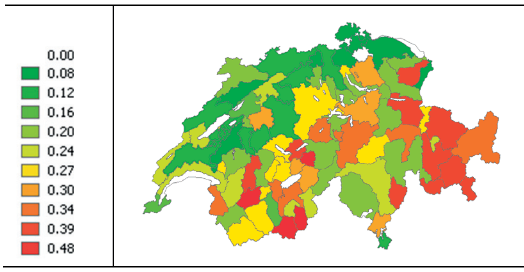
Political framework: results of a vote on right of appeal of organizations [negative votes/total of voting]

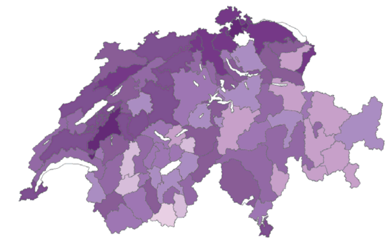


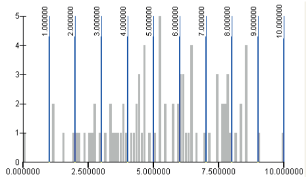




Past actions taken from the tourism sector in this direction [number of actions pondered on the number of answers]







A.6 Relevance of the indicators for the different impacts

Table A 8: Marked with an X the indicators that we considered for the different impacts.

Sensitivity	Changes in climate suitability	Snowpack reduction	Glaciers melting	Permafrost melting – rockfall	Natural hazards	Water scarcity – drought	Landscape – Scenic beauty changes
Tourism structure							
Tourism demand							
Tourism intensity	X	X	X	X	X	X	X
Guest nights/one-day tourists ratio	X	X	X	X	X	X	X
Length of stay	X	X	X	X	X	X	X
Skiers visits		X				X	
Winter seasonality	X	X	X	X	X	X	X
Summer seasonality	X	X	X	X	X	X	X
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry'	X	X	X	X	X	X	X
International attractiveness (share of foreign tourists)	X	X	X	X	X	X	X
Tourism supply							
Density of beds in hotels and health resorts and in the ‘parahotel industry’ (warm beds)	X	X	X	X	X	X	X
Tourism supply structure (big vs. small hotels and restaurants)	X	X	X	X	X	X	X
Secondary homes (cold beds)	X	X	X	X	X	X	X
Proximity to substitute ski destinations		X					
Length of activity of ski resorts		X					
Artificial snow production		X				X	
Total capacity of ski domains located under the future snow-reliability line		X					
Total capacity of ski domains located over the future snow-reliability line (-)		X					
Length of infrastructure located on possible/probable permafrost melting				X			
Media and communication on snow condition		X					
Local population							
Density of resident population	X	X	X	X	X	X	X
Share of the population born on place (collective knowledge on areas subject to natural hazards)	X	X	X	X	X	X	X
Age structure (age-dependency ratio)	X	X	X	X	X	X	X

	Changes in climate suitability	Snowpack reduction	Glaciers melting	Permafrost melting – rockfall	Natural hazards	Water scarcity – drought	Landscape – Scenic beauty changes
Local economy							
Share of jobs (full-time equivalents) in the hotel and catering sector	X	X	X	X	X	X	X
Share of jobs (full-time equivalents) in the transportation sector 2001	X	X	X	X	X	X	X
Job seasonality	X	X	X	X	X	X	X
Share of jobs in the agriculture sector	X	X	X	X	X	X	X
Average net income pro person in private dwellings	X	X	X	X	X	X	X
Average financial health of municipalities	X	X	X	X	X	X	X
Average per capita cantonal income	X	X	X	X	X	X	X
Local infrastructure							
Accessibility	X	X	X	X	X	X	X
Accessibility to services	X	X	X	X	X	X	X
New or renovated buildings (after 1990)				X	X		
Density of transport network (existence of replacement routes)				X	X		
Water storage capacity	X	X	X	X	X	X	X
Energy use in destination in the tourism sector	X	X	X	X	X	X	X
Local institutions							
Left vs. right	X	X	X	X	X	X	X
Ecologists vs. liberals	X	X	X	X	X	X	X
Size of the municipalities - municipalities aggregation	X	X	X	X	X	X	X
Local environment							
Land use protection	X	X	X	X	X	X	X
Landscape beauty	X	X	X	X	X	X	X
Water availability	X	X	X	X	X	X	X

Adaptive capacity	Changes in climate suitability	Snowpack reduction	Glaciers melting	Permafrost melting – rockfall	Natural hazards	Water scarcity – drought	Landscape – Scenic beauty changes
Feasibility							
Social							
Existence of studies on climate change impacts for the region	X	X	X	X	X	X	X
Public participation actions in the region	X	X	X	X	X	X	X
Economic							
Average net income pro person in private dwellings	X	X	X	X	X	X	X
Average financial health of municipalities	X	X	X	X	X	X	X
Average per capita cantonal income	X	X	X	X	X	X	X
Subsidies	X	X	X	X	X	X	X
Technological							
Density of transport network (existence of replacement routes)				X	X		
Possibility of self green energy development	X	X	X	X	X	X	X
Institutional							
Past actions taken from the tourism sector in this direction	X	X	X	X	X	X	X
Part of an official tourist region (Swiss tourism)	X	X	X	X	X	X	X
Destination communication	X	X	X	X	X	X	X
Left vs. right	X	X	X	X	X	X	X
Ecologists vs. liberals	X	X	X	X	X	X	X
Environmental							
Land use protection	X	X	X	X	X	X	X
Water availability	X	X	X	X	X	X	X
Acceptability							
Social							
Political framework: results of a vote on right of appeal of organizations	X	X	X	X	X	X	X
Past actions taken from the tourism sector in this direction	X	X	X	X	X	X	X

A.7 Theory on the Analytical Hierarchy Process (AHP) and on the Consistency Ratio (CR)

For each of the 5 levels and the different groups of indicators (Figure A 2) presented in Section 4.4.2 a pairwise comparison was carried out by stakeholders. Table A 9 represents the relative weights available for the comparison. A square reciprocal matrix was generated with the elements aij (i,j = 1..n), where aii = 1 and aji = 1/aij (reciprocal value). An example is given in Table A 10. The scores of the n indicators (w_1, w_2, … w_n) are calculated as follow: (A-nI) w = 0. Results for the example are presented in Table A 11.

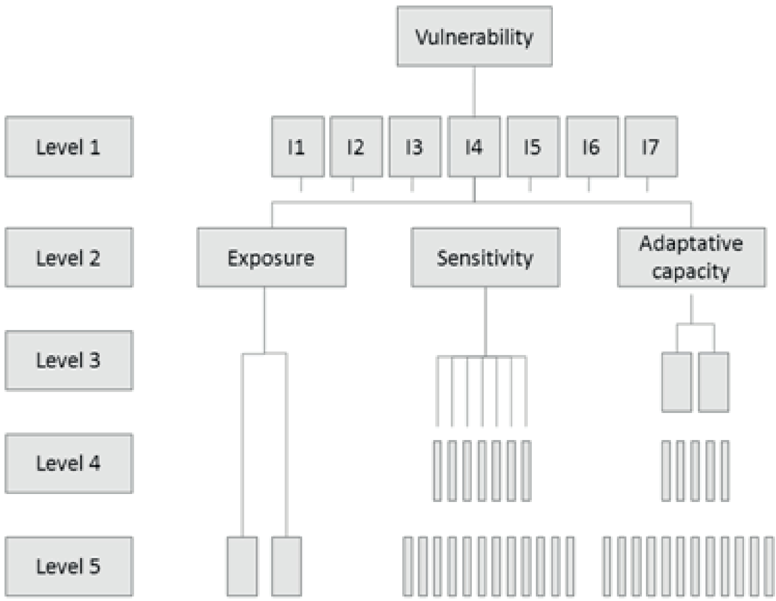


Figure A 2: The 70 indicators describing vulnerability are distributed among the three components exposure, sensitivity, and adaptive capacity and among further families. In total, five levels exist. The letter I stands for impact.

Table A 9: Representation of the relative weights available for the comparison.

Absolute importance of the second	Demonstrated importance of the second	Essential or strong importance of the second	Weak importance of the second	Equal importance	Weak importance of the first	Essential or strong importance of the first	Demonstrated importance of the first	Absolute importance of the first
1/9	1/7	1/5	1/3	1	3	5	7	9

Table A 10: Example of a pairwise comparison carried out by one of the experts for the assessment of the relative importance of the impacts. The (-) sign signifies a possible beneficial impact for the tourism sector and therefore a decreased vulnerability, whereas the (+) sign signifies a negative impact and therefore increased vulnerability. When no sign is given, the indicator implicitly increases vulnerability. It should be noted that the matrix is reciprocal and that experts filled only half of it, the second half being calculated subsequently.

Vulnerability of tourism to climate change	Changes in climate suitability (-) [1]	Snowpack reduction (+/-) [2]	Glaciers melting [3]	Permafrost melting – rock falls [4]	Natural hazards [5]	Water scarcity – drought [6]	Scenic beauty changes [7]
Changes in climate suitability (-)	1	1/5	1	1	1	3	3
Snowpack reduction (+/-)	5	1	5	5	5	5	5
Glaciers melting	1	1/5	1	1	1	3	3
Permafrost melting – rock falls	1	1/5	1	1	1	3	3
Natural hazards	1	1/5	1	1	1	3	3
Water scarcity – drought	1/3	1/5	1/3	1/3	1/3	1	1
Scenic beauty changes	1/3	1/5	1/3	1/3	1/3	1	1
Sum	9.67	2.20	9.67	9.67	9.67	19.00	19.00

Table A 11: Normalized matrix (the column average must sum up to 1 approximately).

Vulnerability of tourism to climate change	[1]	[2]	[3]	[4]	[5]	[6]	[7]	Sum	w
Changes in climate suitability (-)	0.10	0.09	0.10	0.10	0.10	0.16	0.16	0.82	0.12
Snowpack reduction (+/-)	0.52	0.45	0.52	0.52	0.52	0.26	0.26	3.05	0.44
Glaciers melting	0.10	0.09	0.10	0.10	0.10	0.16	0.16	0.82	0.12
Permafrost melting – rock falls	0.10	0.09	0.10	0.10	0.10	0.16	0.16	0.82	0.12
Natural hazards	0.10	0.09	0.10	0.10	0.10	0.16	0.16	0.82	0.12
Water scarcity – drought	0.03	0.09	0.03	0.03	0.03	0.05	0.05	0.33	0.05
Scenic beauty changes	0.03	0.09	0.03	0.03	0.03	0.05	0.05	0.33	0.05
Sum	1.00	1.00	1.00	1.00	1.00	1.00	1.00	7.00	1.00

The row average gives an approximation of the eigenvector of the matrix. The eigenvector is an estimate of the relative weights of the criteria that are being compared. Because personal judgment does seldom agree perfectly, the degree of consistency generated by the rating is measured by a Consistency Ratio (CR). This ratio indicates the probability that the matrix ratings were generated randomly. The rule of thumb is that a CR less than or equal to 0.1 designates an acceptable reciprocal matrix, a ratio over 0.1 indicates that the matrix should be modified. Adjusting the matrix needs finding inconsistent judgments regarding to the importance of criteria, adjusting these judgments by comparing again the pairs of criteria judged inconsistently (Yahaya et al. 2010). The following calculation was carried out in order to calculate the CR. Table A 12 presents the Random Consistency Index (RI).

CR: CI/RI

Where CI= λmax-n/n-1

CI: Consistency Index

N: Number of criteria.

λmax is priority vector multiplied by each column total.

Table A 12: Random Indices for matrices of various sizes.

n	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49	1.51	1.48	1.56	1.57	1.59

For example, in the case given above:

CI= ((0.12*9.67+0.44*2.20+0.12*9.67+0.12*9.67+0.12*9.67+0.05*19.00+0.05*19.00)-7/(7-1)= 0.05[122]

CR=0.05/1.32= 0.04 (1.32 being the RI for a matrix of 7). The results are therefore considered as consistent.

[122] Result obtained with the not-approximated values.

A.8 Form for the face-to-face Multicriteria Analysis carried out with experts

Hereafter we present the beginning of the form given to the experts during face-to-face interviews. It should be noted that each expert got only a part of the document (as can be seen in Annex A.10).

WEIGHTING OF CRITERIA – Analytical Hierarchy Process (AHP) (Saaty 1977)

'The Analytic Hierarchy Process (AHP) is a general theory of measurement. It is used to derive ratio scales from both discrete and continuous paired comparisons. These comparisons may be taken from current measurements or from a fundamental scale which reflects the relative strength of preferences and feelings. The AHP has a special concern with departure from consistency, its measurement and on dependence within and between the groups of elements of its structure.' (Saaty 1977).

Table A 13: The scale determining the relative weight attributed in quantitative values

Absolute importance of the second (y)	Demonstrated importance of the second (y)	Essential or strong importance of the second (y)	Weak importance of the second (y)	Equal importance	Weak importance of the first (x)	Essential or strong importance of the first (x)	Demonstrated importance of the first (x)	Absolute importance of the first (x)
1/9	1/7	1/5	1/3	1	3	5	7	9

Table A 14: An example - comparison of distances of cities from **Olten**

x \ y	Winterthur	Lausanne	Sydney	Berlin	Moscow
Winterthur	1	1	1/9	1/3	1/7
Lausanne	1	1	1/9	1/3	1/7
Sydney	9	9	1	5	3
Berlin	3	3	1/5	1	1/3
Moscow	7	7	1/3	3	1

Table A 15: The weight obtained in the pairwise comparison and the effective distance of the cities from Olten:

	Weight	Distance
Winterthur	0.04	86 km
Lausanne	0.04	165 km
Sydney	0.52	16 567 km
Berlin	0.12	900 km
Moscow	0.28	2 187 km

The consistency ratio is 0.04 < 0.1. The matrix is therefore consistent.

We look at the vulnerability of tourism in Switzerland to climate change. We retained seven impacts (Figure A.3) (I1: Changes in climate suitability, I2: Snowpack reduction, I3: Glaciers melting, I4: Permafrost melting, I5: Natural hazards, I6: Water scarcity – drought, I7: Landscape – scenic beauty changes. Vulnerability can be decomposed in three components (IPCC 2007a): exposure, sensitivity, and adaptive capacity. A definition is given in the attached documentation. For each impact, these three components can be further split in different indicators describing them. These indicators are organized in levels, as depicted in Figure A 3 and Figure A 4).

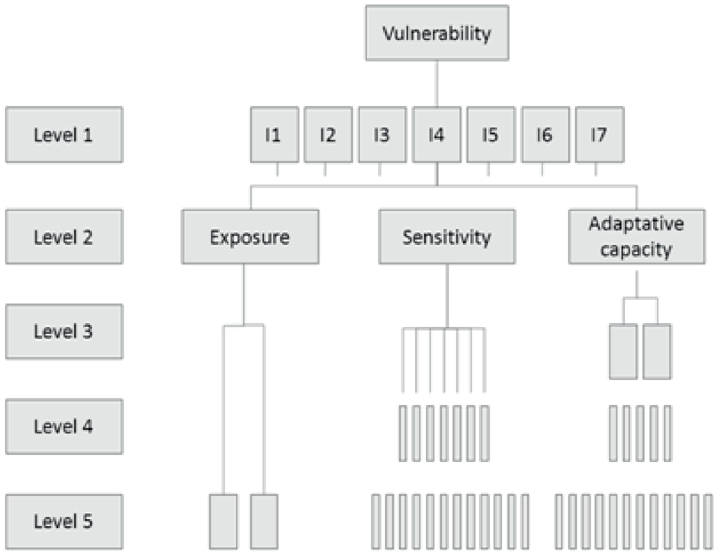


Figure A 3: The organization of the various indicators describing tourism vulnerability to climate change (levels 1-5). In total, five levels are given.

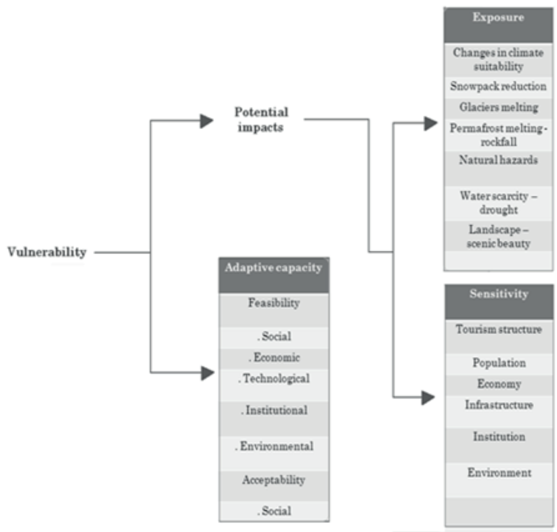


Figure A 4: Vulnerability is composed of three components: exposure, sensitivity, and adaptive capacity. These three categories can further be split into the families of indicators presented in the figure. Each of them contains various indicators.

The question to be answered was: “In your opinion, which indicator, in a pairwise comparison, is more relevant in defining the words underlined in the matrix? And to which extent?” Please give a weight referring to Table A.13.

Table A 16: MATRIX 1 - 21 choices

IMPACTS

LEVEL 1

Vulnerability of tourism to climate change in Switzerland and in 2050	Changes in climate suitability (-)	Snowpack reduction (+/-)	Glaciers melting	Permafrost melting- rock falls	Natural hazards	Water scarcity – drought	Scenic beauty changes	I feel VERY confident	I don't feel confident AT ALL
Changes in climate suitability (-)	1								
Snowpack reduction (+/-)		1							
Glaciers melting			1						
Permafrost melting- rock falls				1					
Natural hazards					1				
Water scarcity – drought						1			
Scenic beauty changes							1		

Table A 17: MATRIX 2 - 3 choices

LEVEL 2

Vulnerability of tourism to climate change	Exposure	Sensitivity	Adaptive capacity	I feel VERY confident	I don't feel confident AT ALL
Exposure	1				
Sensitivity		1			
Adaptive capacity			1		

Note that: a) adaptive capacity does not necessarily contribute to effective adaptation; b) the complete elimination of vulnerability through adaptive capacity is unlikely (Easterling III et al. 2004); c) responsibility for management of some risks may lie beyond the household or local government level; and d) the adaptive capacity of some systems (e.g., natural ecosystems) is quite limited.

A.9 Information on the face-to-face interviews for the Multicriteria Analysis

Table A 18: Persons interviewed, their function, and day of the face-to-face interview.

Expert	Function of the interviewed person	Day of the interview
Expert 1	Climatologist at the UNIGE Geneva	31.01.2011
Expert 2	Manager UNESCO World Heritage SAJA	20.01.2011
Expert 3	Lecturer, Project Manager ITF HTW Chur	21.01.2011
Expert 4	Head of Business Development MySwitzerland	18.01.2011
Expert 5	Vicedirector RMS	04.02.2011
Expert 6	Staff member - tourism policy RMS	04.02.2011
Expert 7	Professor on tourism IUKB Sion	08.02.2011
Expert 8	Scientific Advisor HES-SO Valais	08.02.2011
Expert 9	Staff member ILF HSR	08.02.2011
Expert 10	Assistant director on tourism HTW Chur	08.02.2011
Expert 11	Professor on tourism ILF HSR	08.02.2011
Expert 12	Scientific Assistant ITF HTW	08.02.2011
Expert 13	Director SAB	11.03.2011

A.10 Individual results of the Multicriteria Analysis

Table A 19: Individual results of the Multicriteria Analysis for the 13 experts interviewed.

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert 11	Expert 12	Expert 13	w score *	Standard deviation
Vulnerability of tourism to climate change															
Changes in climate suitability (-)	0.03		0.12		0.30	0.06	0.08							0.12	0.07
Snowpack reduction (+/-)	0.29		0.44		0.10	0.06	0.36							0.25	0.14
Glaciers melting	0.20		0.12		0.04	0.32	0.19							0.17	0.08
Permafrost melting - rock falls	0.08		0.12		0.03	0.08	0.04							0.07	0.03
Natural hazards	0.07		0.12		0.09	0.13	0.19							0.12	0.03
Water scarcity - drought	0.10		0.05		0.20	0.31	0.12							0.15	0.08
Scenic beauty changes	0.22		0.05		0.25	0.05	0.02							0.12	0.09
Sum	1.00		1.00		1.00	1.00	1.00							1.00	
Impacts															
Exposure	0.20		0.11		0.14						0.21			0.16	0.04
Sensitivity	0.20		0.26		0.14						0.55			0.29	0.13
Adaptive capacity	0.60		0.63		0.71						0.24			0.55	0.15
Sum	1.00		1.00		1.00						1.00			1.00	
Changes in climate suitability															
Changes in climate suitability for light outdoor activities (-) 2011-2040 vs control (1961-1990)	0.07	0.39	0.20						0.45					0.28	0.14
Share of mountainous area in the region (-)	0.75	0.51	0.60						0.45					0.58	0.10
Share of lakes in the region (-)	0.18	0.10	0.20						0.09					0.14	0.05
Sum	1.00	1.00	1.00						1.00					1.00	
Snowpack reduction															
Share of the region located between the current and the future snow reliability line	0.88	0.83	0.75	0.13	0.17							0.83	0.17	0.54	0.33
Share of the region located above the future snow reliability line (-)	0.13	0.17	0.25	0.88	0.83							0.17	0.83	0.46	0.33
Sum	1.00	1.00	1.00	1.00	1.00							1.00	1.00	1.00	
Natural hazards															
Number of past natural hazards (1972-2007)	0.07		0.12				0.06	0.44						0.17	0.13
Cost of past natural hazards (1972-2007)	0.26		0.59				0.56	0.08						0.37	0.20
Cost on infrastructure of past natural hazards (1972-2007)	0.59		0.23				0.26	0.04						0.28	0.15
Share of the region with 100-year flood probability	0.08		0.06				0.12	0.44						0.17	0.13
Sum	1.00		1.00				1.00	1.00						1.00	

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert 11	Expert 12	Expert 13	w score *	Standard deviation
Sensitivity															
Tourism demand	0.21		0.16							0.04	0.14			0.14	0.05
Tourism supply	0.21		0.16							0.03	0.15			0.14	0.05
Population	0.07		0.04							0.04	0.22			0.09	0.06
Economy	0.06		0.07							0.03	0.15			0.08	0.04
Infrastructure	0.07		0.06							0.30	0.09			0.13	0.09
Institutions	0.06		0.26							0.28	0.18			0.20	0.07
Environment	0.31		0.26							0.28	0.06			0.23	0.08
Sum	1.00		1.00							1.00	1.00			1.00	
Tourism demand															
Tourism intensity			0.08					0.12		0.05	0.10			0.09	0.02
Guest nights/one-day tourists ratio			0.12					0.08		0.08	0.12			0.10	0.02
Length of stay			0.03					0.05		0.08	0.20			0.09	0.05
Skiers visits			0.21					0.31		0.06	0.14			0.18	0.08
Winter seasonality			0.33					0.31		0.06	0.14			0.21	0.11
Summer seasonality			0.07					0.05		0.06	0.21			0.10	0.06
Gross occupancy rate (365 days) in hotels, health resorts, and in the 'parahotel industry'			0.04					0.02		0.55	0.05			0.16	0.19
International attractiveness (share of foreign tourists)			0.11					0.07		0.06	0.04			0.07	0.02
Sum			1.00					1.00		1.00	1.00			1.00	
Tourism supply															
Density of beds in hotels and health resorts and in the 'parahotel industry' (warm beds)		0.02				0.22		0.02						0.09	0.09
Tourism supply structure (big vs. small hotels and restaurants)		0.10				0.10		0.02						0.08	0.04
Secondary homes (cold beds)		0.02				0.11		0.02						0.05	0.04
Proximity to substitute ski destinations		0.05				0.04		0.08						0.06	0.02
Length of activity of ski resorts		0.10				0.09		0.08						0.09	0.01
Artificial snow production		0.07				0.02		0.21						0.10	0.07
Total capacity of ski domains located under the future snow-reliability line		0.13				0.03		0.30						0.15	0.10
Total capacity of ski domains located over the future snow-reliability line (-)		0.23				0.07		0.02						0.11	0.08
Length of infrastructure located on possible/probable permafrost melting		0.07				0.08		0.15						0.10	0.03
Media and communication on snow condition		0.21				0.24		0.09						0.18	0.06
Sum		1.00				1.00		1.00						1.00	
Population															
Resident population						0.27			0.38	0.14		0.57		0.34	0.13
Share of the population born on place (collective knowledge on areas subject to natural hazards)						0.67			0.50	0.71		0.14		0.51	0.19
Age structure (age-dependency ratio)						0.06			0.13	0.14		0.29		0.15	0.07
Sum						1.00			1.00	1.00		1.00		1.00	

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert 11	Expert 12	Expert 13	w score *	Standard deviation
Economy															
Share of jobs (full-time equivalents) in the hotel and catering sector							0.10		0.02			0.07		0.06	0.03
Share of jobs (full-time equivalents) in the transportation sector							0.06		0.07			0.03		0.05	0.01
Job seasonality							0.03		0.14			0.18		0.12	0.06
Share of jobs in the agriculture sector							0.02		0.12			0.07		0.07	0.03
Average net income pro person in private dwellings							0.16		0.19			0.22		0.19	0.02
Average financial health of munici-palities							0.31		0.24			0.33		0.29	0.04
Average per capita cantonal income							0.31		0.21			0.09		0.21	0.08
Sum							1.00		1.00			1.00		1.00	
Infrastructure															
Accessibility		0.28			0.03		0.07	0.16			0.05			0.12	0.08
Accessibility to services		0.28			0.09		0.05	0.07			0.13			0.12	0.06
New or renovated buildings (after 1990)		0.17			0.08		0.27	0.03			0.25			0.16	0.08
Density of transport network (existence of replacement routes)		0.15			0.08		0.29	0.07			0.35			0.19	0.11
Water storage capacity		0.06			0.37		0.27	0.18			0.06			0.19	0.10
Energy use in destination in the tourism sector		0.06			0.36		0.06	0.49			0.16			0.22	0.16
Sum		1.00			1.00		1.00	1.00			1.00			1.00	
Institutions															
Left vs. right		0.09							0.20	0.33		0.28		0.23	0.08
Ecologists vs. liberals		0.45							0.20	0.33		0.64		0.41	0.14
Size of the municipalities - munici-palities aggregation		0.45							0.60	0.33		0.07		0.37	0.16
Sum		1.00							1.00	1.00		1.00		1.00	
Environment															
Land use protection		0.33					0.11	0.07		0.33				0.21	0.12
Landscape beauty		0.33					0.26	0.75		0.33				0.42	0.16
Water availability		0.33					0.63	0.18		0.33				0.37	0.13
Sum		1.00					1.00	1.00		1.00				1.00	
Adaptive capacity															
Feasibility	0.25		0.25		0.17						0.17			0.21	0.04
Acceptability	0.75		0.75		0.83						0.83			0.79	0.04
Sum	1.00		1.00		1.00						1.00			1.00	
Feasibility															
Social	0.11		0.10								0.24			0.15	0.06
Economic	0.23		0.36								0.32			0.30	0.05
Technological	0.47		0.11								0.12			0.23	0.16
Institutional	0.15		0.11								0.23			0.16	0.05
Environmental	0.05		0.32								0.09			0.15	0.11
Sum	1.00		1.00								1.00			1.00	

	Expert 1	Expert 2	Expert 3	Expert 4	Expert 5	Expert 6	Expert 7	Expert 8	Expert 9	Expert 10	Expert 11	Expert 12	Expert 13	w score *	Standard deviation
Social feasibility															
Existence of studies on climate change impacts for the region			0.25			0.17						0.13	0.17	0.18	0.04
Public participation actions in the region			0.75			0.83						0.88	0.83	0.82	0.04
Sum			1.00			1.00						1.00	1.00	1.00	
Economic feasibility															
Average net income pro person in private dwellings			0.13				0.06	0.07		0.09				0.09	0.02
Average financial health of municipalities			0.38				0.50	0.07		0.71				0.41	0.19
Average per capita cantonal income			0.13				0.19	0.16		0.09				0.14	0.03
Subsidies			0.38				0.25	0.71		0.11				0.36	0.18
Sum			1.00				1.00	1.00		1.00				1.00	
Technological feasibility															
Density of transport network (existence of replacement routes)									0.50		0.75	0.83		0.69	0.13
Possibility of self-green energy development									0.50		0.25	0.17		0.31	0.13
Sum									1.00		1.00	1.00		1.00	
Institutional feasibility															
Past actions taken from the tourism sector in this direction							0.25	0.15	0.31	0.04			0.05	0.16	0.10
Part of an official tourist region (Swiss tourism)							0.07	0.04	0.25	0.04			0.37	0.15	0.12
Destination communication							0.13	0.41	0.31	0.08			0.17	0.22	0.11
Left vs. right							0.05	0.06	0.06	0.42			0.21	0.16	0.12
Ecologists vs. liberals							0.50	0.34	0.06	0.42			0.20	0.30	0.14
Sum							1.00	1.00	1.00	1.00			1.00	1.00	
Environmental feasibility															
Land use protection							0.13	0.25	0.50	0.10				0.24	0.13
Water availability							0.88	0.75	0.50	0.90				0.76	0.13
Sum							1.00	1.00	1.00	1.00				1.00	
Social acceptability															
Political framework: results of a vote on right of appeal of organizations						0.88			0.17		0.17	0.13		0.33	0.27
Past actions taken from the tourism sector in this direction						0.13			0.83		0.83	0.88		0.67	0.27
Sum						1.00			1.00		1.00	1.00		1.00	

* Without inconsistent results

A.11 Results of the cluster analysis

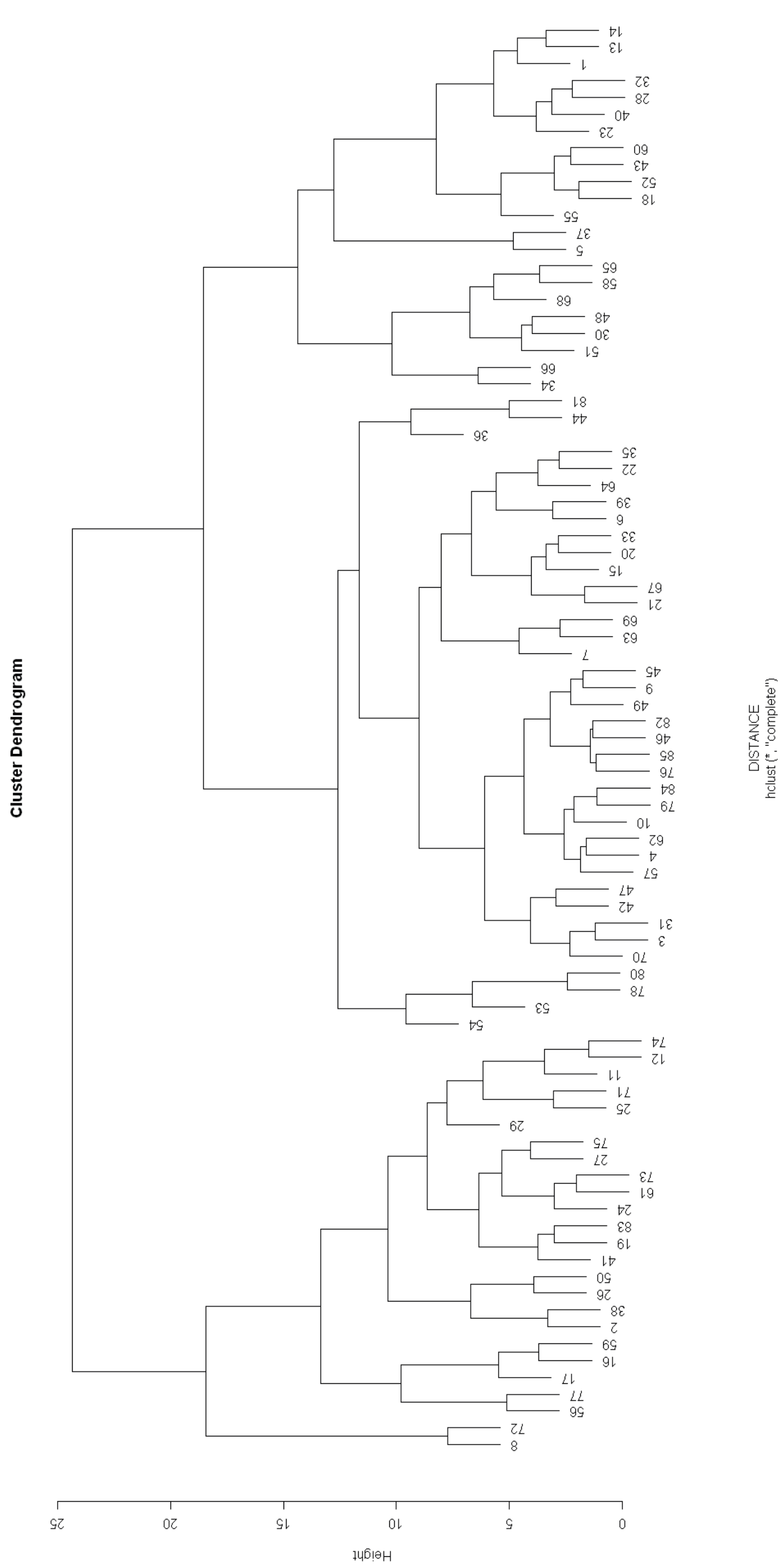


Figure A 5: Dendrogram showing complete linkage clustering of the 85 tourism regions for exposure. Numbers refer to the ones given in Figure 3.1.

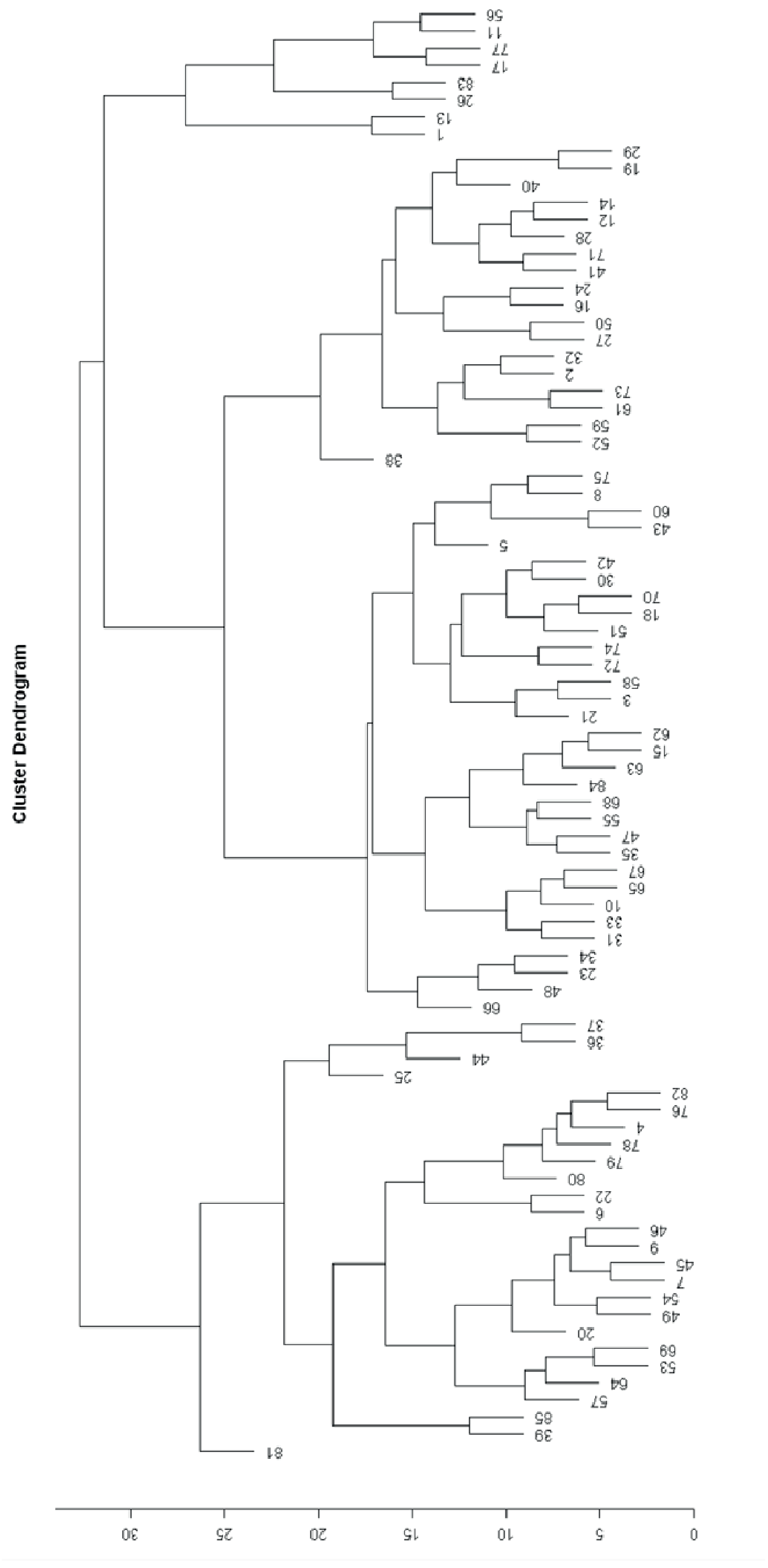


Figure A 6: Dendrogram showing complete linkage clustering of the 85 tourism regions for sensitivity. Numbers refer to the ones given in Figure 3.1.

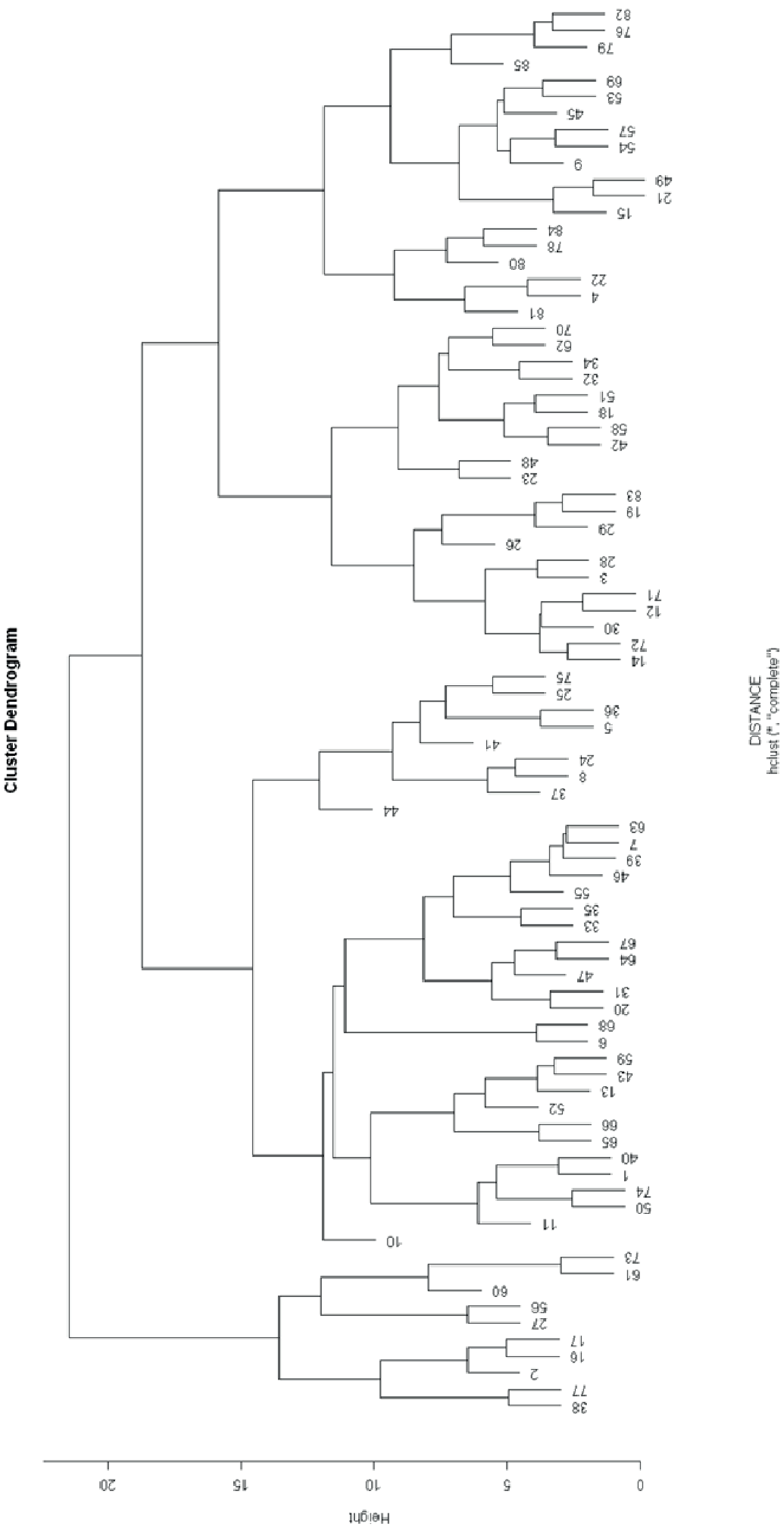


Figure A 7: Dendrogram showing complete linkage clustering of the 85 tourism regions for adaptive capacity. Numbers refer to the ones given in Figure 3.1.

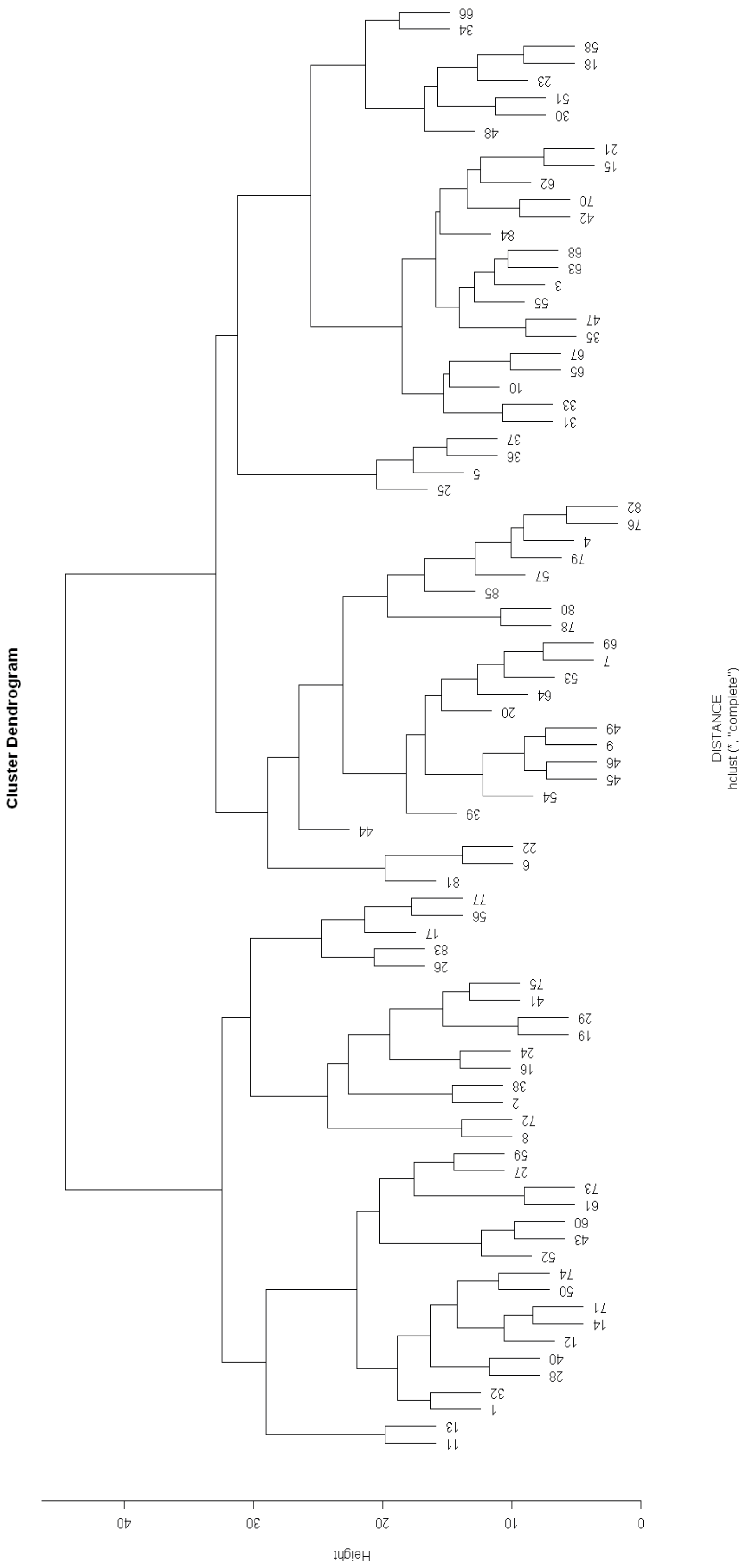


Figure A 8: Dendrogram showing complete linkage clustering of the 85 tourism regions for vulnerability. Numbers refer to the ones given in Figure 3.1.

A.12 Geographical definition of the different tourism regions

Table A 20: Geographical definition of the different tourism regions, with differenciations respectively for the Alps, the Jura, cities, lakes, and Plateau and Southern Ticino.

Tourism region	Geography
Adelboden	Alps
Aletsch	Alps
Appenzellerland	Alps
Basel Region	Jura
Bellinzona and Northern Ticino	Alps
Bern	Cities
Biel/Bienne Seeland	Lakes
Brig - Belalp	Alps
Brugg Region	Plateau and Southern Ticino
Canton of Jura	Jura
Central Graubünden - Arosa	Alps
Central Graubünden - Lenzerheide, Savognin, Bergün	Alps
Crans-Montana	Alps
Davos Kloster, Prättigau	Alps
Emmental	Prealps
Engadin Scuol	Alps
Engadin St. Moritz	Alps
Ferienregion Heidiland	Alps
Ferienregion Lötschberg	Alps
Fribourg and the Centre	Plateau and Southern Ticino
Gantrisch Region	Prealps
Geneva Region	Cities
Glarnerland	Alps
Goms	Alps
Grächen-St. Niklaus	Alps
Graubünden - Italian-speaking area	Alps
Grindelwald	Alps
Gstaad-Saanenland	Alps
Haslital	Alps
Interlaken	Lakes
Jura Bernois	Jura
Lake Geneva Region - Alps	Alps
Lake Geneva Region - Countryside	Plateau and Southern Ticino
Lake Geneva Region - Jura	Jura
Lake Geneva Region - Towns and Lakes	Lakes
Lake Lugano	Lakes
Lake Maggiore and Valleys	Alps
Lauchernalp - Lötschental	Alps
Laupen Region	Plateau and Southern Ticino
Lenk - Simmental	Alps
Leukerbad	Alps

Tourism region	Geography
Luzern Region	Prealps
Martigny Region	Alps
Mendrisiotto	Plateau and Southern Ticino
Mittelland I	Plateau and Southern Ticino
Mittelland II	Plateau and Southern Ticino
Neuchâtel	Jura
Nidwalden	Lakes
Oberaargau	Plateau and Southern Ticino
Obere Surselva	Alps
Obwalden	Alps
Portes du Soleil - Chablais	Alps
Region of Lake Murten	Lakes
Rheintal	Alps
Rhine Valley, Bündner Herrschaft, Chur	Alps
Saas-Fee/Saastal	Alps
SchaffauserLand	Plateau and Southern Ticino
Schwyz	Alps
Sierre - Anniviers	Alps
Sion Region - Anzère	Alps
Sion Region - Les 4 vallées et Evolène	Alps
Solothurn and Region	Plateau and Southern Ticino
St. Gallen - Bodensee	Prealps
The Lakes Region	Lakes
The Pre-Alps - Gruyères - Moléson	Prealps
The Pre-Alps - Les Paccots	Prealps
The Pre-Alps - Schwarzsee	Prealps
Thunersee	Lakes
Thurgau - Bodensee	Plateau and Southern Ticino
Toggenburg	Prealps
Untere Surselva	Alps
Uri	Alps
Verbier St-Bernard	Alps
Viamala	Alps
Visp Region	Alps
Wengen-Mürren-Lauterbrunnental	Alps
Winterthur and its region	Plateau and Southern Ticino
Zermatt Matterhorn	Alps
Zuerichsee	Lakes
Zueri-Unterland	Plateau and Southern Ticino
Zug Region	Lakes
Zürcher Oberland	Plateau and Southern Ticino
Zürcher Weinland	Plateau and Southern Ticino
Zurich	Cities
Zurich Mittelland	Plateau and Southern Ticino

A.13 English version of the online survey

Befragung zu Klimawandel, Tourismus und Anpassung in der Schweiz/Enquête sur les changements climatiques, le tourisme et l'adaptation en Suisse/Sondaggio sui cambiamenti climatici, il turismo e l'adattamento in Svizzera

** Version française en bas ** - Veuillez nous excuser pour les envois multiples
** Versione italiana in basso ** - Scusandomi in anticipo per eventuali invii multipli
** English version below** - Sorry for cross-posting

Deutsche Version – Doppelzusendungen bitten wir zu entschuldigen

Sehr geehrte Damen und Herren,

Im Rahmen des nationalen «Modellierung Sektor spezifischer Klimapolitik: Milderung, Anpassung und Akzeptanz» (NCCR MIADAC) Projekts und finanziell unterstützt vom Schweizerischen Nationalfonds, analysiert das Labor für Ökonomie und Ökologie Management der Eidgenössischen Technischen Hochschule (ETH) Lausanne die Verletzlichkeit des regionalen Tourismus in der Schweiz den Folgen des Klimawandels und welche Anpassungsmassnahmen auf lokaler und nationaler Ebene getroffen werden können. Der Online-Fragebogen enthält **5 Sektionen**. Das Ausfüllen dauert **ca. 10-15 Minuten** (28 Multiple-Choice Fragen).

http://go.epfl.ch/survey-tourism2

Mit Ihren Antworten helfen Sie die Kenntnisse über dieses Thema zu erweitern. Alle gesammelten Informationen werden streng vertraulich behandelt und nur im wissenschaftlichen Rahmen verwendet. Wir wären Ihnen sehr dankbar, wenn Sie den beantworteten Fragebogen vor dem **23. November** zurück schicken könnten. Bei Fragen kontaktieren Sie bitte Cecilia Matasci: cecilia.matasci@epfl.ch, +41 21 693 34 09. Falls Sie Interesse haben, können wir Ihnen gerne eine Zusammenfassung der Ergebnisse schicken.

Vielen Dank für Ihre Teilnahme und Unterstützung!

Freundliche Grüsse

Cecilia Matasci

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

NCCR CLIMATE
Swiss Climate Research

Version française

Madame, Monsieur,

Dans le cadre du projet national Modélisation Sectorielle des Politiques Climatiques: Mitigation, Adaptation et Acceptation (NCCR MIADAC) financé par le Fonds National Suisse, le Laboratoire de Recherches en Économie et Management de l'Environnement (REME) de l'École Polytechnique Fédérale de Lausanne (EPFL) travaille avec des personnes liées au secteur du tourisme comme vous à l'analyse de la vulnérabilité régionale aux changements climatiques du tourisme en Suisse et des possibles mesures qui peuvent être prises au niveau régional et national. Le sondage est composé de **5 sections**, le remplir vous prendra **environ 10-15 minutes** (28 questions à choix multiples).

http://go.epfl.ch/survey-tourism2

Avec votre participation, vous contribuez à enrichir la connaissance sur le sujet. Toutes les informations collectées pour les besoins de cette enquête, ainsi que l'identité de ses participants seront gardées strictement confidentiels et ne seront utilisées qu'à des fins scientifiques. Nous nous permettons de vous demander de répondre au questionnaire d'ici au mercredi **23 Novembre 2011**. Si vous avez des commentaires, des questions ou des remarques, vous pouvez nous contacter à l'adresse suivante: cecilia.matasci@epfl.ch ou en appelant le numéro suivant +41 21 693 34 09. Par ailleurs, si vous souhaitez être informés des conclusions de l'étude, nous vous ferons volontiers parvenir un résumé des résultats.

En vous remerciant par avance pour votre précieuse contribution!

Meilleures salutations,

Cecilia Matasci

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

NCCR CLIMATE
Swiss Climate Research

Versione italiana

In seno al progetto nazionale "Modellizzazione delle Politiche Settoriali dei Cambiamenti Climatici: Mitigazione, Adattamento e Accettazione" (NCCR MIADAC) finanziato dal Fondo Nazionale Svizzero per la ricerca scientifica, il Laboratorio della Gestione dell'Economia e dell'Ambiente del Politecnico Federale di Losanna (EPFL) sta analizzando, con la collaborazione di persone legate al settore del turismo come lei, la vulnerabilità regionale ai cambiamenti climatici del settore del turismo in Svizzera e le possibili misure d'adattamento che possono essere prese al livello locale e nazionale. Il sondaggio è composto da **5 sezioni** e dura **circa 10-15 minuti** (28 domande a scelta multipla).

http://go.epfl.ch/survey-tourism2

Con le sue risposte, contribuisce alla conoscenza sul tema. L'informazione raccolta in seno a questo sondaggio - come anche l'identità di tutti i participati - sarà trattata in maniera strettamente confidenziale e sarà utilizzata unicamente a scopi scientifici. Potremmo chiederle di rispondere al più tardi entro il **23 Novembre 2011**? Se ha delle domande o dei commenti, può contattarci scrivendo un mail all'indirizzo seguente: cecilia.matasci@epfl.ch o telefonando allo +41 21 693 34 09. Se lo desidera, possiamo anche spedirle i risultai della ricerca, una volta elaborati.

La ringraziamo in anticipo per la sua gentile collaborazione !

Cecilia Matasci

EPFL ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

NCCR CLIMATE Swiss Climate Research

English version

Dear Madam or Sir

As a part of the national project "Modeling Sectoral Climate Change Policies: Mitigation, Adaptation, and Acceptance", (NCCR MIADAC) funded by the Swiss National Science Foundation (SNF), the Economics and Environmental Management Group at the Swiss Federal Institute of Technology (EPF) in Lausanne is working together with stakeholders like yourself to assess the regional climate change vulnerability of tourism in Switzerland and the possible adaptation measures that could be taken at the local and the national level. The survey has **5 sections** and takes about **10-15 minutes** to complete (28 multiple-choice questions).

http://go.epfl.ch/survey-tourism2

Your answers will contribute to deepen our understanding of this crucial field. All information collected in this survey, along with the identity of all participants, will be held in strict confidence and will be used for scientific purposes only. We ask you to complete the survey by **Wednesday, November 23, 2011**. If you have any comments, questions or remarks, please do not hesitate to reach us by e-mail at cecilia.matasci@epfl.ch or by phone at +41 21 693 34 09. Moreover, if you are interested in the outcomes of the survey, we will provide you with a summary of the results.

Thank you very much for your help and valuable contribution!

Kind regards,

Cecilia Matasci

ÉCOLE POLYTECHNIQUE FÉDÉRALE DE LAUSANNE

NCCR CLIMATE
Swiss Climate Research

PhD Student

EPFL ENAC INTER REME
BP 2237 (Bâtiment BP)
Station 16
CH-1015 Lausanne
Tel: +41 21 693 34 09
E-mail: cecilia.matasci@epfl.ch
Webpage: http://personnes.epfl.ch/cecilia.matasci

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Section 1:

This section relates to your perception of climate change and of its impacts

During this survey, we often refer to the term 'your region', see the image below to see our definition of regions :

1. We are interested in your opinion. Please indicate to what extent you agree with the following statements :

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree	Not specified
The impacts of climate change are already causing global problems today	◉	○	○	○	○	○
The impacts of climate change will lead to global problems in 2030-50	◉	○	○	○	○	○
The impacts of climate change are already causing problems in the tourism sector in my region today	◉	○	○	○	○	○
The impacts of climate change will lead to problems in the tourism sector in my region in 2030-2050	◉	○	○	○	○	○

2. What changes from climate change do you expect in your region by **2030-50**? Please mark all changes that you expect for your region with a cross :

☐ Increase in mean annual temperature
☐ Changes of tourist seasons (e.g. shorter winter season)
☐ Increase in number of warm days in the summer (>25°C)
☑ Decrease in water availability in the summer
☐ Decrease in water availability in the winter
☑ Increase in frequency and magnitude of extreme events (e.g. storms, mass movements such as debris flows, heavy rainfall events, floods, heat waves)
☐ Decrease in snow-reliability in the lowlands
☑ Decrease in snow-reliability in higher altitudes

Figure A 9: The beginning of the survey.

Climate change, tourism and adaptation in Switzerland survey

In the frame of the national NCCR MIADAC project (Modeling Sectoral Climate Change Policies: Mitigation, Adaptation, and Acceptance) funded by the Swiss National Science Foundation (SNF), the Economics and Environmental Management Laboratory (REME) at the Swiss Federal Institute of Technology (EPF) in Lausanne is analyzing the regional climate change vulnerability of tourism in Switzerland and the possible adaptation measures that could be taken at the local and the national level. This survey should help to assess:

1/ the regional vulnerability to climate change, and

2/ the adaptive capacity of the tourism sector in Switzerland

With your answers, you contribute to the knowledge on this subject. All information collected in this survey, as also the identity of all participants, will be held in strict confidence and will be used for scientific purposes only. The survey has **5 sections** and takes about **10-15 minutes** to complete. If you have any comments, questions or remarks please e-mail us at: cecilia.matasci@epfl.ch or call the following number +41 21 693 34 09.

Thank you very much for your help and valuable contribution!

Section 1: This section relates to your perception of climate change and of its impacts

During this survey, we often refer to the term 'your region'; see the image below to see our definition of regions:

1. We are interested in your opinion. Please indicate to what extent you agree with the following statements

	Strongly disagree	Disagree	Neither disagree nor agree	Agree	Strongly agree	Not specified
The impacts of climate change are already causing global problems today						
The impacts of climate change will lead to global problems in 2030-50						
The impacts of climate change are already causing problems in the tourism sector in my region today						
The impacts of climate change will lead to problems in the tourism sector in my region in 2030-2050						

2. What changes from climate change do you expect in your region by **2030-50**? Please mark all changes that you expect for your region with a cross:

Increase in mean annual temperature
Changes of tourist seasons (e.g. shorter winter season)
Increase in number of warm days in the summer (>25°C)
Decrease in water availability in the summer
Decrease in water availability in the winter
Increase in frequency and magnitude of extreme events (e.g. storms, mass movements such as debris flows, heavy rainfall events, floods, heat waves)
Decrease in snow-reliability in the lowlands
Decrease in snow-reliability in higher altitudes
Shrinking glaciers
Melting permafrost
Positive or negative changes in scenic beauty (e.g. shifts of treeline to greater elevations)
None
Others

3. Have you already experienced some of these changes in your region? If yes, which ones?

4. In your opinion, how vulnerable is **the tourism sector in your region** regarding climate change? For vulnerable we intend a region that is susceptible to, or unable to cope with the adverse effects of climate change, including climate variability and extremes.

Not vulnerable at all
Partly vulnerable
Quite vulnerable
Very vulnerable
Not specified

5. Generally speaking, does the tourism sector in your region have a short/long term strategy? And if yes, does it consider adaptation to the impacts of climate change (e.g. moderate potential damages, take advantage of opportunities, or cope with the consequences) or possible actions to reduce greenhouse gases emissions (mitigation)? More answers are possible:

Yes, and it considers possible mitigation measures
Yes, and it considers adaptation to the impacts of climate change
Yes, but it doesn't consider neither adaptation nor mitigation
No
I don't know

6. How strong do you evaluate the impacts of climate change on tourism in your region in relation to other changes (e.g. globalization, changes in taste, population structure, mobility patterns, global economy, etc.)? (1 = far less important; 10 = much more important)

	1	2	3	4	5	6	7	8	9	10
Relative importance										

7. In your region, how strong do you consider to be the risk of water scarcity and/or drought in **2030-50** due to climate change (in summer or winter)?

Very strong
Moderately strong
Strong
Moderate
Low
Not existing

Section 2: This section relates to your perception on the determinants of vulnerability. The following questions will help us complete the vulnerability map we are working on

8. Do you already experience at the present problems in water availability/water scarcity for the tourism industry in your region in some periods of the year?

Yes, strongly
Yes, moderately
No
I don’t know

9. How do you rate the landscape beauty and attractiveness of your region for tourists, in comparison for example to the Jungfraujoch-Grindelwald region or the National Park?

Very attractive
Quite attractive
Neither unattractive nor attractive
Quite unattractive
Very unattractive
Not specified

10. How would you describe your region in relation to public participation actions (as for example for requesting actions from the municipality, for blocking some ongoing projects, etc.)?

The community has often undertaken public participation actions
It's possible that in my region public participation actions have taken place
I have never heart of public participation actions taking place in my region

11. How do you describe the financial health of the municipality you work in?

Very good
Fairly good
Neither good nor bad
Fairly bad
Bad
I don't know

12. Does the tourism sector in your region receive communal, cantonal, or federal subsides?
Yes, and they are extremely helpful
Yes, and they are helpful
Yes, but they are not helpful at all
No
I don't know

13. How important do you think are, **generally speaking**, the following aspects in determining the vulnerability of the tourism sector in regard to climate change? (1 = not important; 10 = very important)

	1 2 3 4 5 6 7 8 9 10
The exposure of the region (e.g. the snowpack reduction, glacier and permafrost melting, etc.)	
The sensitivity of the region (e.g. the tourism, the economic, social, institutional, etc. structure of the region)	
The adaptive capacity of the region (e.g. the willingness to adapt of stakeholders, the acceptability among inhabitants, economic, technological barriers, etc.)	
The exposure of the region (e.g. the snowpack reduction, glacier and permafrost melting, etc.)	

Section 3: This section relates to your perception on the adaptive capacity of the tourism sector to climate change, and the possible barriers existing hindering the process

14. How do you assess the ability of tourism to cope with climate change impacts in your region? E.g. its ability to moderate potential damages, take advantage of opportunities, or cope with the consequence of climate change?
Not existing at all
Low
Average
High

Very high
Not specified
15. Which do you think are the most important obstacles to the implementation of measures and strategies that help facing climate change in the tourism sector in your region? (1 = not important; 10 = very important)

	1 2 3 4 5 6 7 8 9 10
The resistance and blocking of the local population to the implementation of adaptation measures	
The lack of political willingness to act in the region	
The lack of political willingness to act at the cantonal or national level	
The lack of willingness to act of people working in the tourism sector in the region	
The lack of coordination and interaction in the tourism sector in the region	
The low economic means at disposal and the costs of the adaptation measures	
The non-availability of technological solutions	
The lack of information about the regional impacts of climate change and possible adaptation measures and strategies among stakeholders	
The lack of feasible solutions	

16. Others:

17. What do you think could help overcoming these barriers?

18. How would you react if you start to see the impacts of climate change on your business? Considering all the time and energy the different actions imply:

I would begin start searching for information but would stop if this becomes too difficult
I would collect and review information, and I would then start planning possible solutions and eventually contact people. But I would stop if a possible solution doesn't clearly appear
I would not be the organizer of a meeting. But if someone else would start gathering people in order to think about possible solutions, I would join for at least one meeting
I would try to organize other concerned people in my region to find possible solutions until something is found. Even if it were to take much time and energy and until a solution is found
I don’t see the need to act. I would continue my business as usual
Others (please specify)

19. Please explain your choice. What could make you change your ideas and your behavior?

Section 4: This section relates to adaptation to climate change in the tourism sector

20. A set of activities to adjust the tourism sector to the impact of climate change is being discussed. Please select from the following list those adaptation activities that have been implemented in the

past, are currently being implemented or will be implemented in the future in your region. Multiple responses are possible:

Promoting innovation and diversification of tourism offers
- Creation of new summer attractions
- Development of Spa programs and promotion of health specific aspects

Further developing and securing of snow sports activities
- Extension of existing ski areas to higher elevations
- Building new high-altitude ski areas
- Cooperation or merger of cableway companies
- Securing snow-reliability by using additional snowmaking equipment
- Construction of reservoirs for water supply of artificial snowmaking
- Promotion of glacier skiing

Promoting year-round tourism
- Withdrawal from ski tourism in ski areas at lower elevations
- Development of year-round tourism offers that are climate and weather independent
- Increasing the attractiveness of the region by emphasizing regional specialties
- Improving learning opportunities and cultural offers
- Informing tourists about climate change impacts

Use of insurance instruments
Improving natural hazards management
Monitoring the impacts of climate change on the tourism sector
Promoting research and development projects in order to actively participate in climate change adaptation of tourism
None
Others

21. Which of the measures that have been implemented in your region do you consider as most effective?

22. If no adaptation measures to climate change have been taken in your region, why?

We don't believe in climate change
There is too much uncertainty concerning the impacts of climate change
We have not thought about it
We don't know how do to it
Others

23. Which other adaptation activities or strategies do you think are feasible in the tourism sector of your region by 2020?

Section 5: Knowledge and information

24. How do you gather information about climate change and possible coping strategies and activities? Multiple responses are possible:

Newspaper
Radio
Television
Academic literature
Internal sources of information (e.g. company magazine, newsletters)
Invited scientists
External consultants
Others

25. Is the available information about the impacts of climate change on your region sufficient to plan and implement activities to adapt to climate change?

Not sufficient
Partly sufficient
Sufficient
Not specified

26. Which other information would you need to plan and implement activities to cope with climate change? Multiple responses are possible:

National climate change scenarios
Regional climate change scenarios
Regional climate impact studies
Vulnerability assessments
Database of regional historical climate records
Regional records of extreme events
Regional hazard and risk maps
Others

27. In your opinion, how could decision makers and communal/cantonal/national policies help adaptation processes?

Personal details

28. Sex

M / W

29. Age

<20 / 20-29 / 30-39 / 40-49 / 50-59 / >60

30. Please insert the name and the postal code of **your activity location**

Name of the municipality
Postal code

31. Do you work at a regional, cantonal, or national level?

Region
Canton
Nation
Other (please specify)

32. Sector

Food and beverage serving services
Passengers and transport services
- Cablecar
Accommodation
Travel agencies, mountain guides
Detail business
Cultural services
Public administration
Public interest association
Research
Others

33. Specific occupation

Directorate
Head of department/section
Administrator
Employee
Other

34. If you are interested in the results of the survey, you can insert here your email address:

35. Your feedback is also very welcome!

This is the end of our survey. Thank you very much for your participation!

A.14 Relation among potential impacts, adaptive capacity, and vulnerability according to stakeholders' opinion

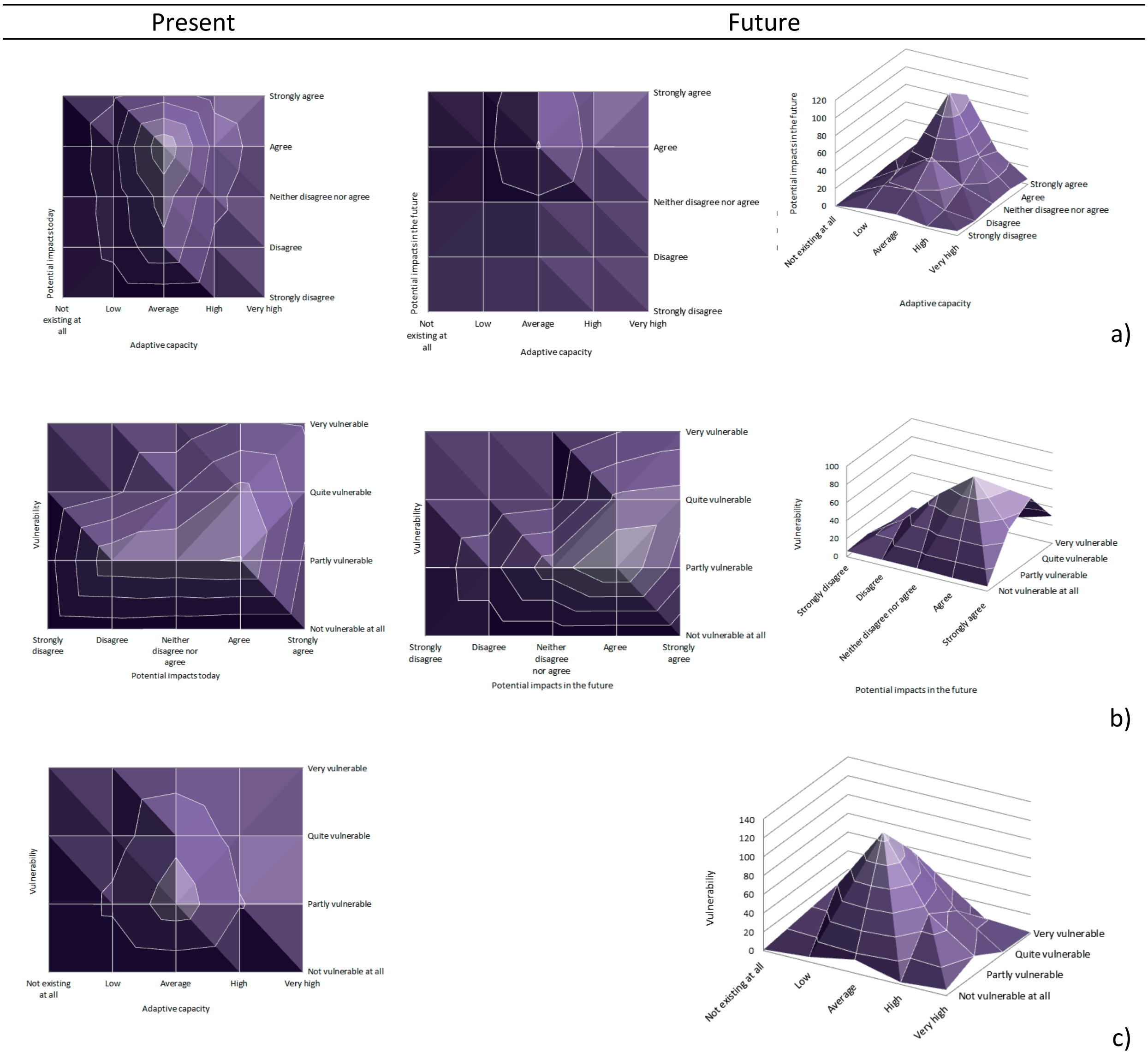

Figure A 10: The three dimensions of the relation among respectively the present (left) and future (right) potential impacts of climate change (exposure and sensitivity), adaptive capacity, and vulnerability according to stakeholders' opinion (N=499).

A.15 Information on the face-to-face interviews

Table A 21: Persons interviewed, type, day, and duration of the interviews.

Region	Municipality	Function of the interviewed person	Type of interview	Day of the interview	Interview duration
Grindelwald	Thun (for Grindelwald)	Cantonal office (office director of the construction, transport and energy department/Bau-, Verkehrs- und Energiedirektion Tiefbauamt des Kantons Bern)	Face-to-face	25.07.2011	48 min
Lenk - Simmental	Erlenbach im Simmental (Stockhorn)	Cableway company (CEO and manager marketing)	Face-to-face	25.07.2011	35 min
Engadin St. Moritz	St. Moritz	Tourism office (head of public relations and member of the management)	Phone interview	28.07.2011	39 min
Engadin St. Moritz	Pontresina	Municipality (mayor)	Phone interview	05.08.2011	?
Bellinzona and Northern Ticino	Campo (Blenio)	Cableway company (officer for the company/responsabile della stazione)	Face-to-face	09.08.2011	29 min
Lake Maggiore and Valleys	Locarno (Cardada)	Cableway company (president)	Face-to-face	09.08.2011	1h 39 min
Zermatt Matterhorn	Zermatt	Tourism office (director)	Face-to-face	11.08.2011	1h 01 min
Lake Maggiore and Valleys	Locarno (Cardada)	Impact assessment office (director)	Phone interview	16.08.2011	?
Verbier St-Bernard	Bagnes (Verbier)	Cableway company (director of technology and operations)	Face-to-face	18.08.2011	37 min
Uri	Andrematt	(project director)	Phone interview	23.08.2011	18 min
Lake Lugano	Rivera (Monte Tamaro)	Monte Tamaro society	Phone and email contacts	From 23.08.2012	
Engadin St. Moritz	St. Moritz	Cableway company (CEO)	Face-to-face	25.08.2011	1h 16 min
Adelboden	Adelboden	Tourism office (manager marketing/Geschäftsleiterin Marketing)	Face-to-face	19.09.2011	35 min
Adelboden	Adelboden	Tourism office (managing director/Geschäftsleiter Betrieb)	Face-to-face	19.09.2011	32 min
Saas-Fee/Saastal	Saas Fee	Tourism organization (president), accommodation (owner of an hotel), municipality (vice president)	Face-to-face	19.09.2011	53 min
Grindelwald	Grindelwald	Municipality (mayor)	Face-to-face	20.09.2011	50 min
Toggenburg	Wattwill (Obertoggenburg)	External association (president of Energietal Toggenburg)	Face-to-face	12.10.2011	47 min
Schwyz	Sattel	Municipality (district council clerk/Gemeindeschreiber) and part of the administrative board of the mountain cableway company/Verwaltungsrat)	Face-to-face	12.10.2011	42 min
Luzern Region	Schwarzenberg	Municipality (member of the municipal council)	Email	11.06.2012	

A.16 Translation and long transcription of the face-to-face interviews

"Not in this area. We are not so exposed, no"

Erlenbach im Simmental (Stockhorn) (part of the Lenk - Simmental region), 25.07.2011 – A member of the cableway company

"Ogni anno le stagioni si accorciavano un po'. Poi magari hai dentro comunque un anno come l'anno scorso dove abbiamo prodotto meno di quest'anno perché ne è arrivata più dal cielo […] Nei punti dove batte molto il sole, anche direttamente, lì avevamo sempre degli scompensi […] e dopo avevamo dentro quei due-tre pezzi vuoti dove anche ad andarla a raccattare di qua e di là con i gatti delle nevi non ci si riusciva più."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

"Seasons were becoming a bit shorter every year. Then perhaps you still have a year like the last one in which we produced less artificial snow because it snowed more […]. In the spots where the sun shines a lot, also directly, there we always had a lack of snow […] and then we had these two or three places in which even by gathering snow from here and there it was not possible anymore."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

"L'anno scorso se non avevamo l'impianto, questo lo puoi scrivere, a fine gennaio avremmo chiuso. Mentre grazie all'innevamento artificiale abbiamo potuto tirare fino al 20 di marzo. Però siamo veramente molto legati alla meteo. Nel senso che senza neve non fai niente. Però come ti ho detto prima a pieno regime sono più o meno 30 posti di lavoro più tutto quello che gira attorno sono tutte cose, vale anche la pena di investire e produre la neve. Lo so che i costi sono elevati. Però ... […] E lì (author's note: in 1996) è entrato un po' tutto. Lì si trattava di o lasciamo perdere o dobbiamo fare qualcosa. È un po' come una grossa ditta che ha bisogno di un grosso macchinario e che deve investire milioni per soprravivere. Per noi è la medesima cosa. Poi magari ... già siamo in cima ad una valle, già l'economia e quella che è … bene o male così qualche posto di lavoro lo riusciamo a mantenere […] Sai, si lega un po' tutto ... le case di vacanza vengono su, lavorano i ristoranti, sai è un po' tutto un giro che funziona anche grazie a una piccola stazione che è la nostra […]"

"È un misto un po' fra le due le cose. Bisogna andare avanti passo per passo. Pero anche il fatto di volerci indirizzare più verso l'estate, questo penso faccia parte di una strategia. C'è stata anche un po' consigliata […] È un po' quello il discorso che ti dicevo prima ... Perche bene o male è un pochino dell'economia è grazie ad un impianto come il nostro che gira. E vero che se non riceviamo dei sostegni difficilmente riusciamo a rimanere in piedi. Infatti il comune l'anno scorso ci ha dato anche un grosso contibuto per quello che abbiamo fatto […] Noi qualcosa abbiamo fatto per adattarci. Abbiamo speso anche molti soldi. Pero lotteremo fino all'ultimo per rimanare in piedi."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

"Last year, you can write it down, at the end of January we would have closed. But thanks to artificial snowmaking we could continue until the 20th of March. But we are really much linked to weather conditions. In the sense that without snow you don't do anything. But, as I told you before, when we work at top speed, there are more or less 30 working places plus all the things that rotate around. It is worth it to invest and to produce artificial snow. I know that the costs are high […] then (author's note: in 1996) everything started. There we had to decide either to stop or to do something. It's a bit like a big industry

that needs millions in order to survive. For us it was something very similar. Then perhaps … we are at the end of a valley, the economy is what it is. Somehow or other we manage to keep some working places […] you know, everything is somehow linked, people come to holiday houses, restaurants have work. You know, it's a circle that works also thanks to a small resort as ours."

"It's a mix of both. We must go on step by step. But also the fact that we want to focus on summer, I think, is part of a strategy. It was also suggested to us […] It's a bit what I was telling you before. Because somehow or another it's thanks to an economy like ours that a small part of the economy turns. It's true that if we do not receive help, we can hardly stand up. Actually, last year the municipality gave us a big contribution for what we did […] We did something to adapt. We also spent a big amount of money. But we will fight until the end to keep going."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

"Ma bene. Diciamo, per dirti, l'anno scorso il consiglio comunale il nostro sostegno è passato mi sembra all'unanimità. E la popolazione reagisce anche bene nel senso che capisce che se uno ha un'appartamento da affittare qualcosa l'affitta anche un po' più facilmente. Uno che lavora qua se c'è possibilità di lavorare può guadagnare un franco. Però poi dopo c'è sempre quello che spara dentro […] Ma lì finora non abbiamo avuto particolari problemi. Già nella prima fase nel '96 è vero che abbiamo dovuto superare tutto ... però la cosa l'han capita e ... è andato bene. Sai abbiamo anche la fortuna che qui non abbiamo zone protette. Fosse stato sul Lucomagno per esempio dove è zona di protezione a livello nazionale addirittura ecco che la cosa sarebbe stata impossibile."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – a member of the cableway company*

"Però ogni tanto sia i media sia certi documentari che fanno, secondo me, certe volte fanno vedere le cose peggio di quello che realmente sono."

Campo (Blenio) (part of the Bellinzona and Northern Ticino region), 09.08.2011 – A member of the cableway company*

"La problematica del cambiamento climatico è l'innalzamento del bosco. È un grossissimo nostro problema […] E poi, un altro problema è che questo innalzamento del bosco è favorito dal regresso dell'agricultura, praticamente dal non più uso degli alpeggi. Francamente per un posto come Cardada vedo questo quale maggiore problema a cui andiamo incontro [...] Boschi in quota e la felce acquilina che invade i prati sono due cose che non si collegano molto con il turismo […] Il turista non ama queste cose. Il turista ama prati liberi, curati e boschi in quota quando sa che vi può trovare sentieri e punti panoramici. Ecco, queste sono cose che il turista chiede."

Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 – The president of the cableway company*

“The problem with climate change is the upward shift of the forests. It is a huge problem for us […] And then, another problem is that this shift of the forest is favored by the retreat of agriculture, by the, so to say, abandonment of alpine pasture. Here, frankly, for a place like Cardada I see the worst problem that we are facing […] High lying forests with bracken,[123] *these are two things that do not match so well with tourism […] Tourists don’t like these things. Tourists like free and well-kept meadows or high lying forests when they know that there they can find paths and sightseeing spots. Well, these are the things that tourists want.”*

Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 – The president of the cableway company*

"Effettivamente il tema è anche molto sentito da Funivie Svizzere e ne parliamo regolarmente. E ci sono delle stazioni che chiaramente devono cambiare totalmente strategia. Dall'altra parte bisogna anche dire che sempre di più la necessita di avere almeno due stagioni è fondamentale perché i costi di questi impianti diventano sempre più elevati, le condizioni quadro ci impongono maggiori investimenti e maggiori spese. E quindi sempre di più noi dobbiamo cercare la doppia stagione. Quindi delle volte bisogna dire dove il cambiamento di strategia era causato proprio dall'impossibilità di continuare un progetto com'era precedentemente oppure anche dalla volontà di migliorare comunque la situazione e di trovare delle soluzioni per rinforzare la stagione più debole. E un po’ una zona grigia quella lì.”

“Abbiamo anche situazioni molto chiare, ma non sono tante, per esempio il Tamaro che è nato anche lui per quale centro di sport invernali perché c'era la neve ma è arrivato al punto di dover cambiare strada per diverse ragioni, ma sopratutto per la mancanza di neve […] Comunque il Tamaro è il luogo che veramente ha cambiato strategia. Nel caso di Cardada per la verità non è che abbiamo cambiato granché strategia. E vero che Cardada è nata anche per andare a sciare per i locarnesi. Però è altrettanto vero che da sempre la stagione forte di Cardada è la stagione estiva. Quindi noi fondamentalemente non abbiamo cambiato strategia invernale. L'unica cosa che abbiamo fatto, visto che l'inverno era sempre un costo che andava a caricare la stagione estiva, abbiamo deciso ad un certo momento, per delle ragioni di soppravivenza finanziaria, di cedere allo sci club tutto quello che aveva a che fare con lo sci. Ciò non toglie che oggi come oggi noi collaboriamo ancora con lo sci club. ”

“Dinanzi alle nuove realtà meteorologiche devi vedere cosa ti vale la pena fare, se andare in direzione dell'inverno o in direzione dell'estate. Io vedo che tendenzialmente negli ultimi anni gli impianti di risalita puramente invernali hanno fatto dei grossissimi investimenti per poter garantirsi l'inverno. Quindi l'innevamente artificiale è stato sicuramente la posta di spesa maggiore negli ultimi anni delle grandi società dell'arco alpino, dove lo sci era predominante. Oggi questi stessi stanno pensando a come migliorare ulteriormente la situazione. Visto che verosimilmente anche con gli investimenti che hanno fatto non riusciranno più a migliorare la situazione della loro stagione invernale, stanno pensando a come migliorare la loro seconda stagione, che poi a dipendenza del sito dove si trova può essere più o meno pagante. I grandi fortunati sono quelli dove la stagione più forte fa il 55% e la più debole il 45% [...] Ma quelli che hanno 90% in una stagione e 10% nell'altra, oggi sicuramente non investiranno più nel 90%, ma cercheranno di migliorare il 10 perché il 90 % invernale oggi vuole dire che hai raggiunto il top e non vai più oltre. Lì quelli devono solo stare attenti lo stesso di fare dei piccoli rinnovamenti, ma più che altro tecnici per non lasciare diventare troppi vecchi gli impianti [...] che pero alla fine sono investimenti molto contenuti in confronto a quello che è stato l'investimento iniziale od i susseguenti per l’innevamento artificiale."

Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 – The president of the cableway company*

"Mettere d'accordo tutti questi attori, le assicuro che è la cosa più difficile. Non è tanto realizzare un progetto, ma è mettere d'accordo prima tutti questi qui, poi trovare i soldi e poi realizzarlo. Per questo abbiamo cominciato con questo master plan. Lo abbiamo fatto vedere a tutti e se qualcuno aveva qual-

[123] *Pteridium aquilinum* (L.) Kuhn.

cosa da ridire, lo avrebbe dovuto dire subito. Allora in verità, opposizioni non le abbiamo avute più di tanto. Perché è chiaro, questo master plan non porta a vincoli pianificatori come tali e quindi semmai qualche opposizione potrebbe nascere al momento dell'esecuzione […] per intanto quindi abbiamo cercato di coinvolgere tutti anche se poi tutti non si sono lasciati coinvolgere. Fino ad adesso non abbiamo avuto molte resistenze, salvo [...] che in determinati ambienti, pero la cosa non va oltre questi personalisimi. Però queste sono anche delle situazioni che non si devono sottovalutare, perché a dipendenza di chi stai toccando, può provocare delle reazioni che ti impediscono di portare avanti questo lavoro. "

Locarno (Cardada) (part of the Lake Maggiore and Valleys region), 09.08.2011 – The president of the cableway company*

"Zermatt is in a very favorable position in the international attraction. It's still the countryside, the Matterhorn. This is still the high and can help us in different ways. Not only in the skiing. This you can do it everywhere. Here you can ski with a nice view. Here we have the Matterhorn. And the same thing goes also for excursion tourism. This is certainly a big help and therefore again the companies are healthy enough to invest also in the future. In other regions they think how they can survive and here we still have projects that go in the future."

Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

"In the past it was not really a topic […] because it was not as dramatic as it is nowadays. People were not so aware. Zermatt was one of the first places where people became aware since we have a lot of glaciers and the glaciers are actually involved in our tourism product, by having for example the summer ski [...] Here we are really affected from climate change but, like I said, 5-10 years ago nobody was speaking about it. Because if you would have come out in the market in terms of communication and marketing, it would have been really strange with the reaction of our clients. So it's just recent thing."

"Zermatt is nowadays the last ski area open 365 days a year. The general will is to have it open all the yearlong. We are still in the lucky situation to have a glacier that allows that but the efforts to maintain this ski area become every year more and more difficult […] And this costs a lot of money to maintain. You come to a point where you really have to make the calculations and say when are the costs too high in terms of the revenues you get […] You know, having skiing offer all year round means that in a bad winter season when the snow early in the season doesn't fall, people come automatically to the place where you have some summer skiing. So what you invest more for the maintenance of the product you earn then in communication. You don't have to do that much communication like places where you don't have summer ski [...] So this is a specific example."

"Then there is climbing. Zermatt is a climbing destination, and we note more accidents with rock falling [...] because often permafrost freezing is not there anymore [...] you can see an increase of accidents in this way […] And also, going back to the cablecar company, all these stations in the mountains with the posts holding the cables, they have to be examined more now because all the anckers are in the frozen rocks and they have to see if this is still OK."

"And a positive effect, when we talk about the product, maybe not this year but when you look back to a summer like 2003, when you have really a hot weather that people are more seeking cooler places where you have 25 degrees. Here in Switzerland we used to have milder summers, summers are becoming hotter and hotter and people use to escape it [...] it's not yet a big trend but you see that there is an increase and that people come more and more in summer [...] And it is also a short decision, for people to come up not only for a day, but for a weekend or so."

"For me, personally, climate change is a chance more than a threat […] especially in the summer time in which in the last decades we had problems in attracting people on the mountain because it was not in fashion, because it was an active holiday and passive holidays were much more attractive […] Of course, in the same time our main business, the winter business, has a question mark. So far we can handle it because we invest a lot in artificial snowing, in slope preparation."

"And there is also another point. Even if here in Zermatt, we can offer ski for another 10 or 20 years, and certainly more than almost anybody else because we are higher, we are in a good zone for a lot of snow, and we have invested a lot for snow security and snow machines; even then for us it's a big problem because the skiing usually doesn't start in Zermatt. In our generation, our friends from the flatlands learned to ski there. In Lausanne you had some snow [...] nowadays the kids cannot, they know ski maybe from the TV."

Zermatt (part of the Zermatt region), 11.08.2011 – A member of the tourism office

"Pour le moment on ne mesure pas encore ça.[124] *Ce qu'on constate c'est les pluies qui sont plus intenses en été, mais ça reste une perception totalement subjective. On n'a pas de mesures à ce niveau-là. Mais l'hiver franchement, non. J'en suis convaincu, qu'il y a un changement qui est en train de se passer. Vous connaissez le professeur Beniston. J'ai eu encore une conférence avec lui il y a pas très longtemps [...] Le thème de la journée était le climat et les glaciers. Donc des choses qui nous concernent directement parce que si on n'a plus de neige on ne va pas être bien. Alors, les démonstrations qu'il nous fait, elles sont claires. Mais à notre stade et à notre niveau on ne les a pas encore perçues. Aujourd'hui, je ne pense pas qu'on puisse dire qu'il y a un impact, franchement. Nous, on a un avantage aussi, c'est qu'on est très haut en altitude […] Donc on est moins impacté que par exemple une station des Préalpes fribourgeoises."*

Bagnes (Verbier) (part of the Verbier St-Bernard region), 18.08.2011 – A member of the cableway company*

"At the moment, we still don't measure it. What we notice are more intense rainfalls during summer, but this remains a totally subjective perception. We don't have measures for that. But for winter, definitely, not. I am persuaded that there is a change which is taking place. You know professor Beniston. I had a conference with him not so long ago […] The subject of the day was the climate and the glaciers. Well, things which concern us directly because if we don't have snow anymore then we have a problem. The demonstration that he made was clear. But at our stage and at our level, we haven't felt them yet. Today, I cannot say that there is an impact, honestly. We, we have also an advantage, it's that we are very high in altitude […] So, we are less affected than, for example, a resort in the Fribourg Prealps."

Bagnes (Verbier) (part of the Verbier St-Bernard region), 18.08.2011 – A member of the cableway company*

"Yes of course we have a lot of permafrost in Engadin. We have also one the most famous men, Dr Felix Keller about permafrost who lives in Samaden. For us is not a problem building on permafrost, if we have a pylon or a chairlift or something on permafrost ... it's not a problem because we know it and we can handle it. In the region where we are, we think that permafrost is not so that it comes from one second to the other second or from one day to the other. We know it. We have water tubes in permafrost, we have cables in permafrost … So it's moving of course, but slowly. At Pontresina they made a big dam ten or eight years ago but it is also political. Experts say 'It's dangerous' and you have to do something and then if it's true or not, who knows. As mountain railway think we don't have a problem. We know permafrost, we handle it."

St. Moritz (part of the Engadin St. Moritz region), 25.08.2011 – A member of the cableway company

"Ce qu'on voit est que les glaciers sont plus petits de ce qu'ils étaient il y a des années, ça se voit […] Et puis, ce qu'on voit aussi, c'est que les changements sont énormes, par exemple vendredi dernier il faisait très chaud et aujourd'hui c'est presque une vingtaine de degrés de moins. C'est vraiment des grands changements et je pense qu'on n'avait pas ça il y a des années […] les extrêmes. Et puis pour l'hiver […] l'année passée on avait assez de neige et il faisait toujours beau temps, mais ce qu'on remarque aussi est que si on peut se promener en janvier à Berne en T-shirt, il n'y a plus personne qui est intéressé à aller skier […] Il y a vraiment le printemps qui arrive déjà en janvier et puis on remarque qu'il faut beaucoup plus d'effort pour vraiment motiver les gens à aller en montagne pour aller skier parce que pour eux c'est déjà le printemps."

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

[124] Author's note: impacts of climate change on snowpack.

“What we see, it’s that glaciers are smaller than years ago, this we can see […] And then, what we also see, it’s that variations are huge. For example, last Friday it was very hot and today it’s almost 20 degrees less. These are really big variations and I think that we didn’t have that some years ago […] these extremes. And then for the winter season […] last year we had enough snow and the weather was always nice. But what we also notice is that, if we can already walk around in T-shirts in Bern in January, then there is nobody who is interested in going skiing anymore […] There is really spring coming already in January. And then, we notice that we have to make much bigger efforts to really motivate people to come to the mountains for skiing because for them it’s already spring.”

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

"Normalement on fait au peu près si la saison est 100%, nous avons plus que la moitié en hiver et moins que la moitié en été. Et comme ça on s’était dit qu’il faut plus d'effort pour l'été parce que bien sûr les lits, ça reste le même nombre. Et comme ça là, il y plus de capacité et bien sûr aussi l'autre effet est qu'on devient un peu plus indépendants de l'hiver et des sports d'hiver. Je sais qu'il y a des études qui disent que dans 100 ans il n'y aura que 2 régions en Europe pour aller skier, des choses comme ça. Peut-être c'est un peu noir mais en fait oui, le développement n'est pas vraiment pour nous, parce que nous sommes à une altitude de 1450 m, c'est tout. Et puis bien sûr, les montagnes, ça va jusqu'à 2400 quelque chose, mais quand même on n'a pas vraiment des montagnes à 4000 m ici. Et aussi pour le wellness bien sûr, il nous faut aussi un thème pour l'été. Comme ça on a voté pour un environnement sain, de pouvoir se promener, bien sûr l'eau est aussi très importante chez nous […] l’eau est très présente [...] et pour ça ce n'est pas trop loin de chercher pour développer le wellness ici."

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

“Pas pour le moment, mais je crois que ça vient bientôt. Donc si on ne fait rien maintenant, dans 5 ans ils vont demander mais comment vous faites.”

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

“C’était un processus. Déjà avant on avait dit qu’il faut faire plus d’alpine wellness. Je ne sais pas si vous êtes au courant; on avait aussi le projet d’un grand ressort et puis pour le moment on cherche de l’argent, quelqu’un pour faire vraiment les gros investissements. Et puis, bien sûr, ils étaient tous aussi en contexte avec ça […] Le problème est qu’on avait une famille de Koweït qui voulait le financer et puis l’année passée ils ont annulé à cause de l’économie et comme ça il faudra commencer de nouveau avec la recherche et pour le moment on n’a pas encore un nom à dire.”

Adelboden (part of the Adelboden region), 19.09.2011 – A member of the tourism office*

“On a deux stratégies principales, c’est premièrement le ski en hiver et puis le wellness en été Wellness qui veut dire que nous ne comprenons pas seulement comment on comprend peut-être wellness qui est la solution wellness pour les hôtels mais en plus c’est donc la nature qu’on introduit, la possibilité de se rencontrer entre les hôtes et les gens d’ici et puis troisièmement les produits des paysans des alpes. […] L’idée est née parce qu’on a vu qu’on avait trop de produits dans la corbeille pour dire ‘voilà, là on est forts et puis là c’est des produits qu’on a comme tous les autres’. Pour se différencier un peu des autres il fallait quand même se concentrer sur les deux.”

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

«Il y avait des études qui étaient fait par le canton de Berne [author’s note: Müller and Weber 2007] donc les réactions dans les prochains 30 ans. C’est ce qu’on a fait aussi, parce que on a dit, ça nous dit rien comment le monde va changer en 50 ans il faut agir maintenant et puis voir ce qui se passe dans les

25 ans qui vont venir. Et donc nous à Adelboden on a fait ça, on a dit qu'il faut réagir, qu'il faut faire quelque chose. Ce n'est pas seulement les gens qu'on va tenir ici, mais il faut dire aux gens commet on va agir du point de vue du climat […] On s'est encore demandés ce qui va se passer à Adelboden, quels étaient les pas qu'on a déjà fait, qu'est-ce qui se passe avec notre climat, les analyses qu'on a fait avec le tourisme et avec la commune aussi politiquement, qu'est-ce que qu'on peut faite avec l'école de ski, peut être les téléphériques, qu'est ce que l'hôtellerie peut faite et tout ça."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

"La chance est plus grande si on prend le départ avec la station d'Adelboden et puis d'inviter les autres à travailler avec nous que de dire que 'Ah il faut faire ça' et puis il y a les barrières qui apparaissent. Comme ça on peut prendre les barrières en parlant avec chacun. Parce que pour nous après c'est clair que qui met la stratégie c'est nous, autrement ça ne marche pas du tout. On a vu donc le canton qui a dit 'Il faut faire ça, ça, ça' ... ça n'a jamais fonctionné."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

"Pour ce qui concerne le ski, il ne faut dire trop, on est fort, le produit marche très bien. En ce qui concerne le produit wellness, il faudrait l'Alpenbad. Ce n'est pas bloqué mais ça ne nous aide pas beaucoup la crise mondiale maintenant et l'euro ça n'aide pas beaucoup pour les investisseurs d'investir. C'est clair, parce que pour les investissements qui sont fait depuis l'étranger ça veut dire que le produit Alpenbad en ce qui concerne le bâtiment et tout ça c'est monté de quelques 25% […] L'Alpenbad c'était le focus, ou c'est encore le focus, qu'il faut absolument pour dire cette idée de wellness en été. Mais les autres pôles, il les faut aussi, parce que sinon on a un produit comme tous les autres."

Adelboden (part of the Adelboden region), 19.09.2011 – The resort manager*

"Ce qui est clair et ce qu'on voit ce sont trois points. Premièrement les glaciers qui reculent [...] Deuxièmement, les forêts qui remontent. Ça, tous les clients le voient. Le troisième phénomène, c'est le temps qui change plus rapidement. Avant, ici chez nous, c'était plus stable. On ne dit pas meilleur ou pire, mais maintenant il y a plus d'extrêmes [...] ça, ce sont des choses qui ont changé. Et aussi les pluies, qui sont plus intenses. Ça, on le voit […] Chaque matin quand je viens au travail je vois que la terre se change. Je ne peux pas dire si c'est bien ou mauvais, je peux seulement dire que qu'on voit le changement. Celui à Zürich ne voit pas comme moi ici le glacier. Mais nous, ici, on voit le glacier, les forêts, ..."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 – A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"What's sure and what we see are three points. First, glaciers that retreat […] Secondly, forests that shift upwards. This, all clients see it. The third phenomena, it's the weather that changes more rapidly. Before, here by us, it was more stable. I am not saying better or worse, but today we have more extremes […] These are the things that changed. And also rainfall, which is more intense. This, we can see […] Every morning, when I come to work, I see that the Earth is changing. I cannot say if it's good or bad, I can only say that here we see the changes. The one in Zurich doesn't see, as I do here, the glacier. But us, here, we see the glacier, the forests, ..."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 – A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"L'étude a montré qu'on est vulnérable. Mais les choses qui sont vulnérable, sont, pour la façon de tourisme que nous, on fait, plus avantageuses. Ça va enter, mais sur l'ensemble c'est plutôt positif pour nous."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 – A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"Ça a commence en 1991, j'avais un seminaire et puis là ça m'a pris. Deuxième chose, comme je vous ai dit, j'ai des enfants. Troisième chose, je suis cretien […] Dans mon cœur, je crois qu'il faut tenir soin, comme on peut. On ne peut pas tout changer. Et puis je vois tous les jours comment ça change."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 – A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"Il y a des différents: le positif est que tout le monde nous dit 'Vous allez être la ''Sommerfrische' du futur dans les montagnes' parce que si dans les villes à Milan, à Genève, partout ça va devenir plus chaud ils vont de nouveau comme il y a 100 ans dans les montagnes. Deuxième phénomène: ils disent que les chutes de neige dans notre région vont être plus intenses. Moins mais plus intenses. Alors on va être sauvés parce qu'on est à 1800 m. Et le troisième phénomène, c'est le glacier qui recoule. Ça peut être un inconvénient pour le ski d'été par exemple mais il y a d'autres phénomènes. Il y a des lacs qui sortent. Il y a des nouveaux domaines qui s'ouvrent pour le free ski. Alors là où le glacer recoule, en dessous on peut avoir des nouvelles pistes [...] Avant ce n'était pas important la neige. Il y a 50 ans, ce n'était pas important parce qu'on n'avait pas grand tourisme. Maintenant, tout dépend quand la neige tombe, en quelle quantité, s'il y a du vent ou pas. On a un nouveau phénomène dans notre vallée, c'est qu'on a moins de vents. Alors moins de 'Verflachungen'. Alors, c'est très difficile à dire encore. Il faut plus de temps pour dire la vérité quels sont les impacts. Il peut y avoir peu de neige, mais s'il n'y a pas de vent, pour le ski, pour le balisage c'est bien [...] Pour le permafrost, on a une ou deux stations qu'on doit contrôler plus fort comment et où ça va aller."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 – A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"There are different aspects: the positive one is that everybody tells us that we are going to be the summer resort of the future because if in cities like Milan, Geneva, etc., it is getting hotter, people will go again, like 100 years ago, in the mountains. Second phenomenon: they say that snowfalls in our region are going to be more intense. Less but more intense. Then we will be saved because we lie at 1800 m. And third phenomenon: the glacier that is retreating. This could be a drawback for summer skiing for example, but there are other phenomena. There are lakes which are born. There are new areas that will be created for free skiers. Then, below where glaciers retreat, we can have new slopes […]"

"Before snow was not important. 50 years ago, it was not so important because we didn't have so much tourism. Now, everything depends on when snow falls, and in which amount, if there is wind or not. We have a new phenomenon in the valley, it's that we have less wind. This means less flattening. Well, it's still very difficult to say for the moment. We need more time to define which truly the impacts are. There could be less snow, but if there is no wind, for the ski and the preparation of the slopes, that's OK […]. For permafrost, we have two stations that we have to check more often to check the evolution."

Saas Fee (part of the Saas-Fee/Saastal region); 19.09.2011 – A member of the regional tourism organization and of the municipality also active in the accommodation sector*

"We see the glaciers going backwards and then we have these rock falls from mountains sides. It's getting instable. There is this process. And we had these lakes on the glaciers, with the water coming out and we had to build this tunnel."

Grindelwald (part of the Grindelwald region), 20.09.2011 – A member of the municipality

"We know that there is a change and we have to be aware of this. We have to be careful with our investment in ski resorts, that's true. But here in Grindelwald we have a summer and a winter season. For us the summer is very important, even more important than the winter season. So it is a tradition here not to invest all the money in winter tourism. So we have nice hiking trails in summer and we don't want to spoil this with huge winter installations. On the other side almost 1/3 of our clients are non-skiers in winter. So we have already alternative things to do in winter."

"I think that's because you can see it here. If you live in a town, then you may have heard about climate change, but then every day you wake up in the morning, you take your car, you go to work and you feel nothing about climate change. But here, here you can see it, you can see how the glaciers go backwards, you can hear how the rocks fall, you hear the rivers transporting stones, there is the sound also ... You see the amount of stones you take out of these rivers. And that is, I think, the special thing we live here and we have to combine it with our tourism. To the newspapers and all media I must always tell that the hotels and houses are safe and our guests do not have to fear something, e.g. the drop of rocks from the mountains, but we are close to it and we live together with it […] We are not more vulnerable than others but you can see the changes here, that's the thing."

Grindelwald (part of the Grindelwald region), 20.09.2011 – A member of the municipality

"I think that Toggenburg will notice this more than other regions. It's not the only one but it might be more or less easier to run winter tourism business in Graubünden or Wallis than in Toggenburg as we are a little bit lower and we are not the first choice. Therefore we do not have the possibilities for investments like Davos or Zermatt and all these areas and therefore I think that we have to be very careful with what happens and what we do in the future. It's really important to run a good strategy. But we have a lot of chances as we are nearer to the The Swiss Plateau than Graubünden or Wallis. You can go to Toggenburg for one day easily from Zurich or from the very eastern part of Switzerland or from Konstanz, and so on. So we have big chances in daily tourism, which is not the case in St. Moritz […] I would give a score of 7 on 10. Toggenburg is more vulnerable than higher areas, but there are other regions that have the same problems. We are not the only ones with higher vulnerability."

Wattwill (Obertoggenburg) (part of the Toggenburg region), 12.10.2011 – A member of Energietal Toggenburg

"Yes, everywhere. And in Toggenburg we feel that climate is changing ... the temperature, the snow, the quick changes all the time. So, last Sunday we had snow in very low areas and yesterday it was quite gone again […] In winter sometimes is very cold and few days latter is very warm again […] Sometimes you have flowers in January and the other time you have snow in May."

Wattwill (Obertoggenburg) (part of the Toggenburg region), 12.10.2011 – A member of Energietal Toggenburg

"Ein bisschen schwierig zu sagen. Es gibt natürlich diese Wetter Phänomene durch stark niederschlage, lange trocken Perioden, und was offensichtlich ist, man sieht von hier an den Uri Rotstock, da gibt's eine Gletscher und man seht, dass das Gletscher zurück geht, das ist offensichtlich […] aber für uns ins Voralpine Raum ist es jetzt nicht wichtig. Es ist mehr eine Beobachtung, nicht eine Auswirkung."

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

“It’s a bit difficult to say. There are for sure these weather phenomena as strong rainfall, long dry periods. And what is apparent is … we see from here the Uri Rotstock. There, there is a glacier and we can see that it’s retreating. This is obvious […] but for us in the Prealpine region it’s not important yet. It’s more an observation, not a repercussion.“

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

”Die Gemeinde macht ein Leitbild fürs Gemeindesarbeit. Und das hielt dann auch Finanzen, soziale, Schule, und so weiter. Und da macht die Gemeinde ein Ausbilde. Danach es gibt ein Tourismus Leitbild, das basiert über dem […] Das gibt eine Arbeitsgruppe. Die Gemeinde, Seilbahn, Landwirte, Restaurants sind da dabei …oder, ein partizipativer Prozess ... da waren 10 oder 12 Leute dabei […] Es gibt nicht so große Hürden. Es gibt sicher Leute die sagen ‘Ah Klimaerwärmung stimmt nicht‘. Das ist auch politisch motiviert oder, eher konservative Menschen sagen Klimaerwärmung hat schon immer gegeben. Aber keine Opposition, in Gegenteil, diese Windkraftanläge, sind sie Leute darüber sogar stolz […] Man muss ein bisschen innovativ sein, dass muss positiv erscheinen. Es ist auch eine Strategie, dass man sagt man will ein bisschen auch Pionier sein, ein bisschen eine schritten vorhanden. Als Gemeinde aber auch als Tourismus Unternehmer.”

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

“Und es wäre auch eine Überlegung, wenn wir jetzt für die Bergbahn reden muss, man sich überlegen macht man Winter Sport ja oder nein auf der Hohe von 800-1600 Meters. Wenn man … ich bin auch ein Verwaltungsrad der Bahn und bin Gemeindeschreiber. Wir haben uns überlegt bei der Bahngesellschaft und entschiedet das wir machen nach wie vor Wintersport. Bieten wir an, die folge davor ist dass man endlich beschneien muss […] 1991 war die Gesellschaft kurz vor der Konkurs. Dann hat man 1992 eine Kapitalerhöhung gemach, hat man einem Sommerrodelbahn gebaut. Das heisst, man hat gemerkt, dass eigentlich das Potential in Sommer ist wichtig zu entwickeln, das hatte man vorher nicht. Also hat man sich 1990 gesagt wir wollen den Sommer stärken und das Ziel ist das auch in Sommer auch Geld verdienen kann und nicht nur in Winter […] Das was nicht wegen Klimawandel, das war eine Ökonomische Entscheidung. Man hatte eines ganzen Jahres Betrieb. In Winter hat man Geld verdient, wenn es guter Schnee hat. In Sommer hat man wahrscheinlich nie viel Geld verdient in Gegenteil, eher Nichts […] Erst als die Gefahr gestand, dass die Gesellschaft in Konkurs ging, musste man sich überlegen wo hatten wir noch Potenzial […] Das war aber nicht eine Entscheidung wegen der Klimaerwärmung, sondern eine wegen der Ökonomische Situation der Gesellschaft. Jetzt zeigt sich aber natürlich diese Überlegung um den Sommer zu stärken auch im Bekauf des Klimaveränderung natürlich auch eine richtige Entscheidung war.”

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

”Schon zum Thema Klimaerwärmung. Man kann entweder nichts machen, und man kann sagen man muss sich anpassen weil die Klimaerwärmung kommt. Aber auch an die andere Seite sollte man auch etwas tun, oder probieren. Vielleicht hilft ja, wer weisst. Aber niemand etwas machen, dass hilft sicher nicht.“

Sattel (part of the Schwyz region), 12.10.2011 – A member of the municipality and of the cableway company*

“Nein. Die Region Luzern ist keine ausgesprochene Winter-Destination. Die Touristen werden Luzern, den Pilatus usw. auch mit weniger Schnee besuchen. Für den Titlis/Engelberg könnte die Situation sich ändern, da auf dem Titilis der Gletscher als Highlight verkauft wird.”

Schwarzenberg (part of the Luzern Region, 11.06.2012 – A member of the municipal council*

“No, the Luzern region is not a prominent winter destination. Tourist will visit e.g. Luzern and the Pilatus also with less snow. For the Titlis/Engelberg the situation could be different, because on the Titlis the glacier is sold as a highlight.”

Schwarzenberg (part of the Luzern Region, 11.06.2012 – A member of the municipal council*

“Wir bemerken nichts bei Flora und Fauna. Auch haben wir nicht weniger Besucher. Jedoch haben wir den Skilift in Schwarzenberg (800 m.ü.M) letzten Herbst geschlossen in Folge Schneemangel.”

“Das Angebot von Schwarzenberg ändert sich. Im Winter kann der Skilift wegen den wärmeren Temperaturen nicht mehr betrieben werden.”

Schwarzenberg (part of the Luzern Region, 11.06.2012 – A member of the municipal council*

“We do not perceive any changes in the flora and fauna. And we do not have fewer visits. However, we closed the ski-lift in Schwarzenberg (800 m AMSL) last fall because of lack of snow.”

“The offer of Schwarzenberg changes. In winter the ski-lift cannot operate anymore because of the higher temperatures.”

Schwarzenberg (part of the Luzern Region, 11.06.2012 – A member of the municipal council*

A.17 Results of the Generalized Linear Model

Table A 22: Results of the Fitting Generalized Linear Model.

Call: glm(formula = Willingness ~ SexFemelle * Age * RegionalLevel * Geography * Job * Language * Direction, family = poisson)

Deviance Residuals:

Min	1Q	Median	3Q	Max
-1.86465	-0.32383	0.01487	0.38177	1.32154

Coefficients: (16 not defined because of singularities)

	Estimate	Std. Error	z value	Pr(>|z|)
(Intercept)	2.06E+00	7.14E+00	0.289	0.773
SexFemelle	-2.21E+02	4.74E+02	-0.466	0.641
Age	3.77E-02	1.74E-01	0.217	0.829
RegionalLevel	-3.52E+00	5.84E+00	-0.603	0.546
Geography	2.10E+00	3.44E+00	0.61	0.542
Job	-3.81E-01	1.35E+00	-0.282	0.778
Language	-1.48E+00	6.67E+00	-0.222	0.824
Direction	-1.66E-01	7.00E+00	-0.024	0.981
SexFemelle:Age	4.83E+00	1.03E+01	0.467	0.64
SexFemelle:RegionalLevel	2.19E+02	4.74E+02	0.462	0.644
Age:RegionalLevel	7.60E-02	1.41E-01	0.538	0.591
SexFemelle:Geography	5.94E+01	1.30E+02	0.459	0.647
Age:Geography	-3.89E-02	7.81E-02	-0.497	0.619
RegionalLevel:Geography	-8.19E-01	2.94E+00	-0.279	0.781
SexFemelle:Job	4.23E+00	1.10E+01	0.385	0.7
Age:Job	-6.04E-03	3.18E-02	-0.19	0.849
RegionalLevel:Job	8.54E-01	9.07E-01	0.941	0.347
Geography:Job	-3.16E-01	6.32E-01	-0.5	0.617
SexFemelle:Language	9.03E+01	1.85E+02	0.489	0.625
Age:Language	-1.88E-02	1.50E-01	-0.125	0.9
RegionalLevel:Language	2.71E+00	3.46E+00	0.784	0.433
Geography:Language	-7.06E-01	1.93E+00	-0.366	0.714
Job:Language	4.04E-01	1.32E+00	0.306	0.759
SexFemelle:Direction	1.34E+02	2.89E+02	0.463	0.644
Age:Direction	-5.31E-02	1.73E-01	-0.308	0.758
RegionalLevel:Direction	3.54E+00	5.63E+00	0.629	0.529
Geography:Direction	-2.46E+00	3.35E+00	-0.734	0.463
Job:Direction	2.14E-01	1.29E+00	0.166	0.868
Language:Direction	2.99E-01	6.38E+00	0.047	0.963
SexFemelle:Age:RegionalLevel	-4.81E+00	1.03E+01	-0.465	0.642
SexFemelle:Age:Geography	-1.40E+00	3.08E+00	-0.455	0.649
SexFemelle:RegionalLevel:Geography	-5.97E+01	1.30E+02	-0.46	0.645
Age:RegionalLevel:Geography	-5.68E-03	6.86E-02	-0.083	0.934
SexFemelle:Age:Job	-5.23E-02	1.71E-01	-0.306	0.76
SexFemelle:RegionalLevel:Job	-4.20E+00	1.09E+01	-0.387	0.699
Age:RegionalLevel:Job	-1.15E-02	2.08E-02	-0.553	0.581
SexFemelle:Geography:Job	4.58E-01	4.91E-01	0.933	0.351
Age:Geography:Job	7.33E-03	1.34E-02	0.549	0.583
RegionalLevel:Geography:Job	7.04E-02	5.36E-01	0.131	0.896
SexFemelle:Age:Language	-2.28E+00	4.61E+00	-0.493	0.622
SexFemelle:RegionalLevel:Language	-8.78E+01	1.85E+02	-0.475	0.635
Age:RegionalLevel:Language	-3.87E-02	6.80E-02	-0.569	0.569
SexFemelle:Geography:Language	-2.17E+01	4.46E+01	-0.485	0.628
Age:Geography:Language	2.18E-02	4.83E-02	0.45	0.652
RegionalLevel:Geography:Language	-2.12E-01	1.40E+00	-0.152	0.879
SexFemelle:Job:Language	-3.33E+00	6.47E+00	-0.515	0.607
Age:Job:Language	2.07E-03	2.96E-02	0.07	0.944
RegionalLevel:Job:Language	-5.46E-01	4.90E-01	-1.114	0.265
Geography:Job:Language	1.00E-01	3.78E-01	0.265	0.791
SexFemelle:Age:Direction	-2.65E+00	5.70E+00	-0.465	0.642
SexFemelle:RegionalLevel:Direction	-1.33E+02	2.89E+02	-0.46	0.646
Age:RegionalLevel:Direction	-6.35E-02	1.38E-01	-0.46	0.646
SexFemelle:Geography:Direction	-3.90E+01	8.43E+01	-0.462	0.644
Age:Geography:Direction	4.66E-02	7.71E-02	0.605	0.545
RegionalLevel:Geography:Direction	6.23E-01	2.57E+00	0.243	0.808
SexFemelle:Job:Direction	-1.92E+00	4.40E+00	-0.436	0.663
Age:Job:Direction	1.00E-02	3.09E-02	0.325	0.745
RegionalLevel:Job:Direction	-6.41E-01	8.03E-01	-0.799	0.425
Geography:Job:Direction	3.86E-01	6.06E-01	0.637	0.524
SexFemelle:Language:Direction	-8.74E-01	5.48E+00	-0.159	0.873
Age:Language:Direction	4.21E-02	1.45E-01	0.29	0.772
RegionalLevel:Language:Direction	-1.94E+00	2.82E+00	-0.688	0.492
Geography:Language:Direction	1.10E+00	1.84E+00	0.598	0.55
Job:Language:Direction	-1.45E-01	1.26E+00	-0.115	0.908
SexFemelle:Age:RegionalLevel:Geography	1.40E+00	3.08E+00	0.453	0.651
SexFemelle:Age:RegionalLevel:Job	5.51E-02	1.69E-01	0.326	0.745

SexFemelle:Age:Geography:Job	-1.13E-02	1.28E-02	-0.882	0.378
SexFemelle:RegionalLevel:Geography:Job	-3.42E-01	4.56E-01	-0.749	0.454
Age:RegionalLevel:Geography:Job	-1.94E-04	1.05E-02	-0.018	0.985
SexFemelle:Age:RegionalLevel:Language	2.23E+00	4.62E+00	0.482	0.63
SexFemelle:Age:Geography:Language	5.42E-01	1.12E+00	0.485	0.628
SexFemelle:RegionalLevel:Geography:Language	2.17E+01	4.47E+01	0.486	0.627
Age:RegionalLevel:Geography:Language	1.11E-02	3.30E-02	0.335	0.737
SexFemelle:Age:Job:Language	7.91E-02	1.60E-01	0.494	0.621
SexFemelle:RegionalLevel:Job:Language	3.05E+00	6.37E+00	0.478	0.632
Age:RegionalLevel:Job:Language	5.14E-03	8.56E-03	0.601	0.548
SexFemelle:Geography:Job:Language	-1.70E-02	1.65E-01	-0.103	0.918
Age:Geography:Job:Language	-3.92E-03	9.46E-03	-0.414	0.679
RegionalLevel:Geography:Job:Language	4.00E-02	1.59E-01	0.252	0.801
SexFemelle:Age:RegionalLevel:Direction	2.65E+00	5.70E+00	0.466	0.641
SexFemelle:Age:Geography:Direction	8.93E-01	1.95E+00	0.458	0.647
SexFemelle:RegionalLevel:Geography:Direction	3.92E+01	8.44E+01	0.464	0.642
Age:RegionalLevel:Geography:Direction	8.51E-03	6.28E-02	0.136	0.892
SexFemelle:Age:Job:Direction	-4.97E-03	2.57E-02	-0.193	0.847
SexFemelle:RegionalLevel:Job:Direction	1.85E+00	4.16E+00	0.445	0.657
Age:RegionalLevel:Job:Direction	5.59E-03	1.90E-02	0.294	0.769
SexFemelle:Geography:Job:Direction	-1.08E-01	1.47E-01	-0.732	0.464
Age:Geography:Job:Direction	-8.77E-03	1.29E-02	-0.678	0.498
RegionalLevel:Geography:Job:Direction	-7.73E-02	4.67E-01	-0.165	0.869
SexFemelle:Age:Language:Direction	3.95E-02	1.30E-01	0.303	0.762
SexFemelle:RegionalLevel:Language:Direction	-1.49E+00	2.30E+00	-0.649	0.516
Age:RegionalLevel:Language:Direction	2.10E-02	5.26E-02	0.399	0.69
SexFemelle:Geography:Language:Direction	3.04E-01	1.06E+00	0.288	0.774
Age:Geography:Language:Direction	-2.92E-02	4.70E-02	-0.621	0.535
RegionalLevel:Geography:Language:Direction	1.61E-01	1.10E+00	0.147	0.883
SexFemelle:Job:Language:Direction	3.04E-01	8.46E-01	0.359	0.719
Age:Job:Language:Direction	-7.32E-03	2.86E-02	-0.256	0.798
RegionalLevel:Job:Language:Direction	3.00E-01	2.54E-01	1.179	0.238
Geography:Job:Language:Direction	-1.83E-01	3.59E-01	-0.51	0.61
SexFemelle:Age:RegionalLevel:Geography:Job	9.67E-03	1.19E-02	0.815	0.415
SexFemelle:Age:RegionalLevel:Geography:Language	-5.41E-01	1.12E+00	-0.483	0.629
SexFemelle:Age:RegionalLevel:Job:Language	-7.44E-02	1.59E-01	-0.467	0.641
SexFemelle:Age:Geography:Job:Language	6.18E-04	3.94E-03	0.157	0.875
SexFemelle:RegionalLevel:Geography:Job:Language	-2.24E-02	5.79E-02	-0.387	0.699
Age:RegionalLevel:Geography:Job:Language	-5.98E-04	3.38E-03	-0.177	0.86
SexFemelle:Age:RegionalLevel:Geography:Direction	-8.86E-01	1.95E+00	-0.455	0.649
SexFemelle:Age:RegionalLevel:Job:Direction	NA	NA	NA	NA
SexFemelle:Age:Geography:Job:Direction	2.01E-03	3.79E-03	0.53	0.596
SexFemelle:RegionalLevel:Geography:Job:Direction	NA	NA	NA	NA
Age:RegionalLevel:Geography:Job:Direction	4.25E-04	9.17E-03	0.046	0.963
SexFemelle:Age:RegionalLevel:Language:Direction	NA	NA	NA	NA
SexFemelle:Age:Geography:Language:Direction	-8.98E-03	2.35E-02	-0.382	0.702
SexFemelle:RegionalLevel:Geography:Language:Direction	NA	NA	NA	NA
Age:RegionalLevel:Geography:Language:Direction	-1.17E-02	2.69E-02	-0.435	0.664
SexFemelle:Age:Job:Language:Direction	-3.59E-03	2.00E-02	-0.179	0.858
SexFemelle:RegionalLevel:Job:Language:Direction	NA	NA	NA	NA
Age:RegionalLevel:Job:Language:Direction	NA	NA	NA	NA
SexFemelle:Geography:Job:Language:Direction	NA	NA	NA	NA
Age:Geography:Job:Language:Direction	5.54E-03	9.14E-03	0.606	0.544
RegionalLevel:Geography:Job:Language:Direction	NA	NA	NA	NA
SexFemelle:Age:RegionalLevel:Geography:Job:Language	NA	NA	NA	NA
SexFemelle:Age:RegionalLevel:Geography:Job:Direction	NA	NA	NA	NA
SexFemelle:Age:RegionalLevel:Geography:Language:Direction	NA	NA	NA	NA
SexFemelle:Age:RegionalLevel:Job:Language:Direction	NA	NA	NA	NA
SexFemelle:Age:Geography:Job:Language:Direction	NA	NA	NA	NA
SexFemelle:RegionalLevel:Geography:Job:Language:Direction	NA	NA	NA	NA
Age:RegionalLevel:Geography:Job:Language:Direction	NA	NA	NA	NA
SexFemelle:Age:RegionalLevel:Geography:Job:Language:Direction	NA	NA	NA	NA

(Dispersion parameter for poisson family taken to be 1)
Null deviance: 222.95 on 434 degrees of freedom
Residual deviance: 163.01 on 323 degrees of freedom
(103 observations deleted due to missingness)
AIC: 1740.2
Number of Fisher Scoring iterations: 4

A.18 The wiki

We created a wiki with the aim to develop a tool to enhance adaptation in the tourism sector by delivering the most recent information available, by raising climate change awareness among stakeholders and decision-makers, and generally by stimulating discussion and soliciting feedback. The website is accessible at the following address: http://wiki.epfl.ch/tccch. Additional background information about this thesis is available at the following link: http://wiki.epfl.ch/tccch/documents/additionalinformation.pdf.

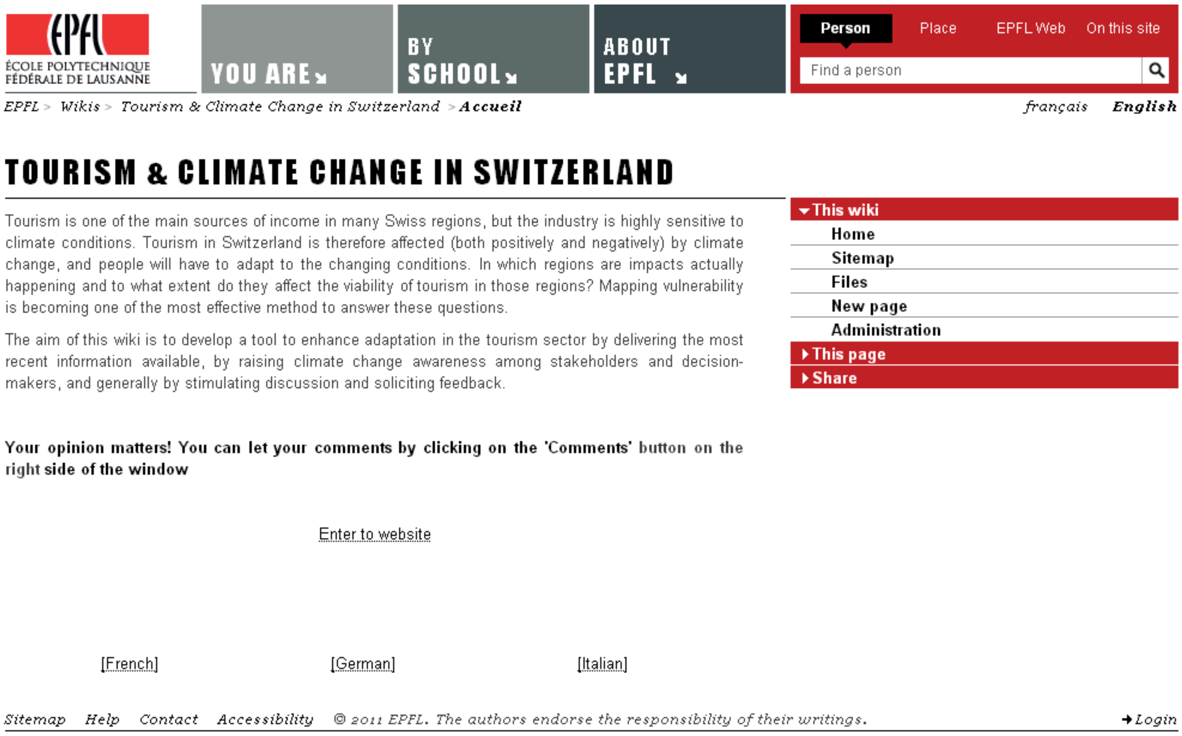

Figure A 11: The main page of the wiki: http://wiki.epfl.ch/tccch.

A.19 The SWIDCHI website

This website hosts a project surveying and gathering the knowledge available in Switzerland on the current and future impacts of climate change in the country. This inventory is a specific mandate given by NCCR Climate to the REME, financed by SNSF, and maintained with the support of the FOEN. The website is accessible at the following address: http://swidchi.epfl.ch/.

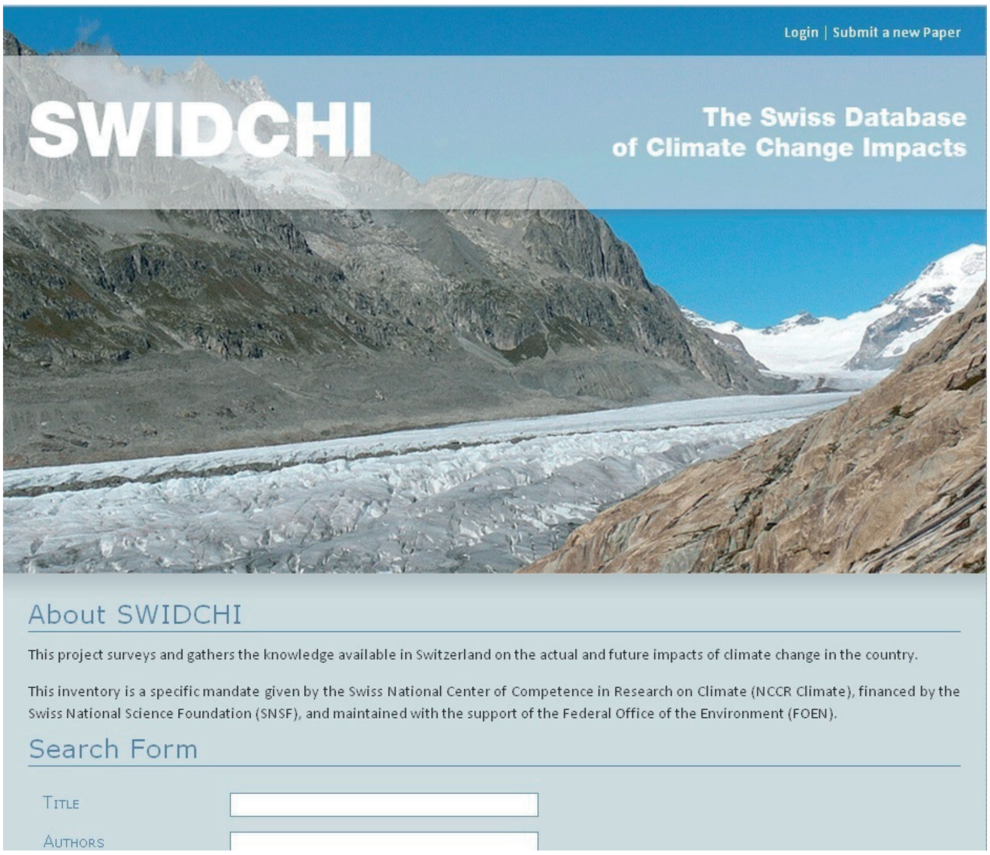

Figure A 12: The main page of the SWIDCHI website: http://swidchi.epfl.ch/.

Curriculum vitae

Cecilia Matasci	03.02.1981
Casa Solare	Citizenship: Swiss
CH - 6595 Riazzino	Place of Birth: Locarno

Handy: +41 (0)79 283 95 48

Fax: +41 (0)91 745 29 00

Email: cecilia.matasci@gmail.com

Education

2012	3-month exchange at the **Potsdam Institute for Climate Impact Research** (PIK), Germany in the frame of my doctoral thesis
2008 - 2012	Doctoral thesis at the Swiss Federal Institute of Technology Lausanne (EPFL), Switzerland
2005 - 2006	Master thesis at the Swiss Federal Institute of Technology Zürich (ETHZ), Switzerland
2004 - 2006	Master in Natural Sciences of the Environment at the **University of Geneva**, Switzerland
2000 - 2003	Equivalent of a Bachelor in Biology at the **University of Lausanne**, Switzerland
1996 - 2000	Scientific Matura in Locarno, Switzerland

Professional experience

2008 - 2009	**Infovel - Centre of Excellence for Sustainable Mobility**, Switzerland
2008	Research Lab on the Economics and Management of the Environment at the **EPFL**, Switzerland

Internships

2007	**WWF China** - Kunming Office, China
2007	**City of Neuchatel** - Urbanism Department, Switzerland
2006 - 2007	**KORA** - coordinated research projects for the conservation and management of carnivores in Switzerland - in Bern, Switzerland
2000 - 2004	Various apprenticeship experiences abroad (in Indonesia, New Zealand, Australia, England, Serbia, and the Netherlands)

Publications

Journal publications

- C. Clivaz, M. Doctor, S. Gessner, T. Luthe, C. Matasci, M. Schuckert, D. Siegrist, R. Wyss. *Facilitating adaptation to climate change - results from a participatory research project in Switzerland.* Submitted to Mountain Research and Development.

Conference articles

- C. Gonseth and C. Matasci. *Analysis of the sensitivity of ski tourism demand to climate change in Switzerland*. Managing Alpine Future II - International Conference, Innsbruck, Austria, 2011.
- C. Matasci. *The vulnerability of Swiss Alpine tourism to climate change. An analysis of its causes, its magnitude, and its spatial heterogeneity*. Managing Alpine Future II - International Conference, Innsbruck, Austria, 2011.
- C. Matasci and J-C Altamirano-Cabrera. *The vulnerability of Switzerland towards climate change: the case of tourism.* ISEE Conference 2010 - Advancing Sustainability in a Time of Crisis, Oldenburg and Bremen, Germany, 2010.
- C. Matasci and J-C Altamirano-Cabrera. *Climate Change and Tourism in Switzerland: Impacts, Vulnerability and Possible Adaptation Measures*. Facing Climate Change and the Global Economic Crisis - Challenges for the Future of Tourism, Bolzano, Italy, 2009.
- R. Domeniconi and C. Matasci. Assessing the ecological footprint of personal mobility - a case study on the benefits generated by the promotion of electric vehicles in Canton Ticino - Switzerland. 24th International Battery, Hybrid and Fuel Cell Electric Vehicle Symposium and Exhibition EVS24, Stavanger, Norway, 2009.
- C. Matasci, C. Seyler, H. J. Althaus, S. Kytzia. Analyse du Cycle de Vie de 20 bâtiments: analyse des différentes phases de vie et mise en évidence des causes principales de leur impact sur l'environnement. 14. Statusseminar Energie und Umweltforschung im Bauwesen, 8. September, Eidgenössischen Technischen Hochschule Zürich, Switzerland, 2006.
- M. A. Allamandola, S. Balbi, T. Bausch, A. Benati and L. Bonzanigo et al. *FINAL REPORT - European Territorial Cooperation Objective, Operational Programme Alpine Space ClimAlpTour - Climate Change and its Impact on Tourism in the Alpine Space*, 2011.
- C. Matasci and J-C Altamirano-Cabrera (2010). Climate Change and Tourism in Switzerland: a Survey on Impacts, Vulnerability and Possible Adaptation Measures. NCCR Working Paper, Bern.
- C. Matasci and R. Domeniconi (2009). *Analisi dell'impatto della mobilità individuale in Ticino*. Press Conference (Mendrisio, Switzerland). Mai 2009. Infovel - Centro di Competenze per la Mobilità Sostenibile.
- C. Matasci (2006). Life Cycle Assessment of 21 Buildings: Analysis of the Different Life Phases and Highlighting of the Main Causes of Their Impact on the Environment. Mémoire No 128 - Master en Sciences Naturelles de l'Environnement.

Linguistic knowledge

Italian	Mother tongue
French	Fluency written and spoken (C2)
English	Fluency written and spoken (C2)
German	Good knowledge (C1)
Spanish	Fairly good knowledge (B2)
Chinese	Fairly good knowledge (A2)

Informatics knowledge

Microsoft Office (Word, Excel, PowerPoint, Project 2000), GIS tools (ArcGis 9.3.1), Latex, FeedbackServer, Stella, R, Indesign (basis), Illustrator (basis)

Activities

- President 2010-2011, vice-president 2009-2010, and project coordinator (2008-2012) of **Unipoly** (University and Federal Institute of Technology Lausanne's student association for sustainable development)
- Nature educator for **Pro Natura Ticino** (2004-2009)
- Since 2012: member of the environment commission of the **Swiss Alpine Club** section Les Diablèrets

Hobbies

Orienteering (competitions), mountain hiking, running, ski touring, swimming, biking, languages