The vulnerability of Switzerland towards climate change : the case of tourism

Cecilia Matasci

EPFL Swiss Federal Institute of Technology Lausanne, Switzerland

Abstract

Once there was agriculture. Then it didn't ensure people's subsistence anymore and it got slowly replaced by tourism as the main source of income in many Swiss Alpine regions. Would climate change have similar consequences on this sector? Without being so radical, tourism in the Alpine region is effectively affected (both positively and negatively) by climate change and has to act in order to adapt to the changing conditions. In which regions is this more true? For which reasons? To which extents? Mapping vulnerability appears to be a good method to answer these questions. In this paper the fundaments are set in order to apply the tool. After a presentation of the technique, a description is made of the impacts of climate change affecting tourism in Switzerland. Moreover, the indicators that will help depicting vulnerability are portrayed. The subject of this work is of particular relevance due to the vulnerability of the sector in regard to climate change, to the importance of tourism for the Swiss economy, to the lack of studies on the subject on a national and regional level, and generally speaking due to the urgent need for more detailed assessments of adaptation costs.

Keywords: climate change, adaptation, vulnerability, vulnerability mapping, tourism, Switzerland

Introduction

Climate change has an impact on Switzerland, its environment, its society, and its economy. Because this impact will become more important in the future, it is important to understand it, and to assess its extent both temporarily, and spatially. One of the first comprehensive assessments for Switzerland was carried out at the end of the 1990s with the National Research Program of the Swiss National Science Foundation (NRP 31) – 'Climate Change and Natural Hazards'. This program covered a wide range of possible direct and indirect physical impacts – see, for a summary, Bader et al. (2000) and Kunz (1999). Followed other studies, with an increase in frequency over the past years. Many of them were and are carried out under the National Climate Change National Centre of Competence in Research (NCCR) Climate. The 'Swiss database of climate change impacts' (SWIDCHI) [1] collects this available knowledge on the actual and

[1] See http://www.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

future impacts of climate change in the country. Basing on the available information, two studies tried to understand which sectors will be most touched, and to which extent (Meier and Nationales Forschungsprogramm 1998; Ecoplan/Sigmaplan 2007)[2]. One of the outcomes of both these studies, looking from the economic point of view, is that tourism will be one of the most affected 'sectors' of the Swiss society.

1.1 The importance of tourism in the Swiss economy

Tourism exerts an important influence on the Swiss economy, accounting for 5.6% of the GDP. Direct income is principally generated by accommodation (25%), the catering industry (17%), and passenger transport (16%) (SECO 2006) (Figure 1). From the 30.4 billions CHF_{2005} totally generated by the Swiss economy in the tourism year 2005, 18.4 billions (61%) were directly generated by inner tourism. Foreign tourists spent, on the other hand, 12 billions (39%), accounting for approximately 5.3% of the income generated by export in Switzerland (BfS, 2008). This places tourism as the 4th place concerning exportations. Tourism is also an important employer: 4.4 % of jobs were directly generated by tourism in 2005 (SECO, 2009). According to Dayer (1998), approximately 1 person every 11 is directly or indirectly occupied by tourism. In mountain areas, this part is considerably higher. In Valais, for example, 1 person over 3 is directly or indirectly employed by this industry. A more complete summary of the tourism structure and of its economic importance can be found in the annual report publish by the Swiss Tourism Federation (STV-FST 2008).

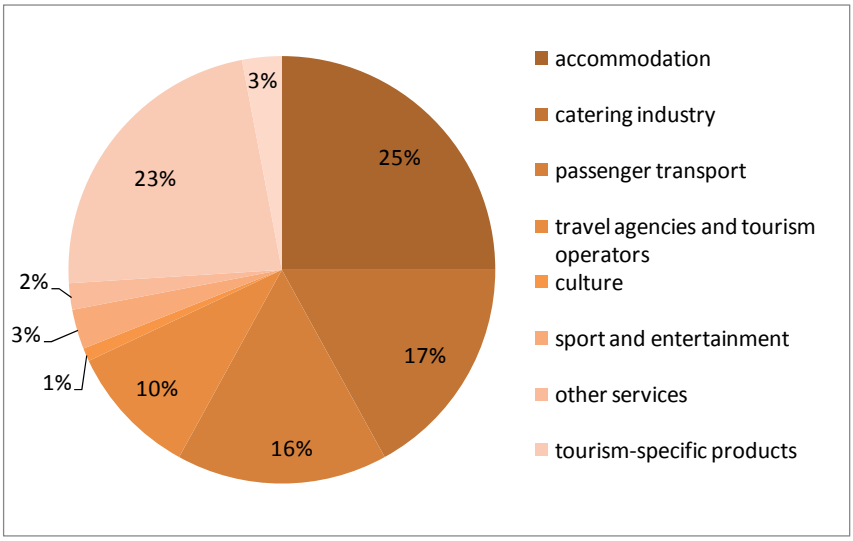

Figure 1: Direct income generated by tourism after type of product in 2005 (SECO 2006).

1.2 Assessing the vulnerability of tourism – a literature overview

Only few studies deal specifically with vulnerability to climate change and tourism, often focusing on coastal or alpine regions. Perch-Nielsen (2008) presented an index approach to assess the global

given by the Swiss National Center of Competence in Research (NCCR) Climate to the Research group on the Economics and Management of the Environment (REME), financed by the Swiss National Science Foundation (SNSF), and maintained with the support of the Federal Office of the Environment (FOEN).

[2] The REME is looking at the interrelations in a general equilibrium model.

vulnerability of beach tourism. Aggregate results on an annual level showed that the large developing countries and small islands might be among the most vulnerable. Moreno and Becken (2009) also looked at the coastal tourism and defined a methodology to assess climate change vulnerability. The paper concludes that this kind of methodology will facilitate vulnerability assessments, allow comparison to be made of vulnerabilities across different situations, provide a basis for more research into specific adaptation measures and assist destinations to develop a more sustainable tourism industry. On the other hand, literature also analyses the effects on winter and/or alpine tourism. Prettenthaler et al. (2006) analyzed the regional economic impacts of climate change on winter tourism in Austria in order to help implementing adaptation policies. The output of the research is an economic and climatological cluster analysis. Luthe and Berlow (2009) looked at the vulnerability of Alpine tourism to global change thanks to a structural network analysis in 20 ski areas of the Swiss Alps. The results led to a deeper and extended perspective on vulnerability, and revealed new ways of sustainable adaptation. Finally, Nyaupane and Chhetri (2009) analyzed the vulnerability to climate change of nature-based tourism in the Nepalese Himalayas. They proposed a conceptual framework, which include inaccessibility, fragility, marginality, diversity and niche. The study provides a regional perspective on assessing the impacts of climate change on tourism in protected areas of Nepal.

1.2 Research questions and aim of the paper

This paper aims at assessing the reasons that make Swiss tourism being vulnerable to climate change, and to create the basis for a vulnerability analysis. This as a first step in order to enhance adaptation measures in the 'sector', as illustrated in Figure 2.

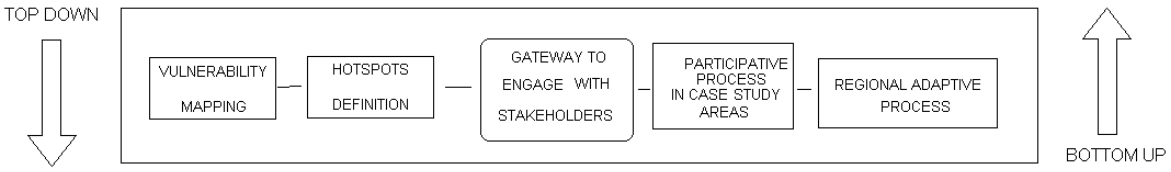

Figure 2 : The process started in the frame of this study.

Vulnerability is not homogeneously distributed. Some regions are more exposed than others; others could be more or less sensitive or have a high or low adaptive capacity. The information gathered will allow carrying out a vulnerability map. This is a top down approach which helps determining vulnerability hotspots, areas where - according to the climate scenarios - the effects of climate change can have a major impact. Once hotspots are known, a gateway to engage with stakeholders is created. Curiosity and interest between them can raise as pointed out by Preston et al. (2008) and participative processes in case studies areas can be more accepted. These will finally lead to regional adaptive processes, which are more bottom up processes.

The main questions rising are:

1. *How can vulnerability be assessed?*
2. *Which are the impacts of climate change that have the main influence on the 'sector'? In which way will they affect it?*
3. *Which are the indicators that help depicting vulnerability for the given region and for the given 'sector'?*

In order to answer these questions, the method used (vulnerability mapping) is presented in Chapter 2. In Chapter 3, the impacts and the indicators necessary to assess vulnerability are described. In Chapter 4, a discussion is carried out on the results of this work. The final section concludes.

2. Method

Vulnerability mapping

Vulnerability was defined by the IPCC (2007) 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, the concept of vulnerability describes the degree to which a system is likely to experience harm due to exposure to climate change (Turner, Kasperson et al. 2003), the extent to which it is susceptible to sustaining damage (Javed 2005) and to adapt to it. Damage from climate change could affect segments of the natural environment, elements of the national economy, of welfare and of human health (Benioff 1996). It could be pointed out that the term vulnerability has a negative connotation. Climate change (at least in a given period) could also bring positive aspects. We consider here vulnerability both with a positive and negative connotation. The experienced (positive or negative) harm for the tourism system will be perceived both on demand and offer (Figure 3). From one side, the effects of climate change will have an impact on demand. This impact can be perceived as a change in tourism flow and a consequent change in monetary flow. On the other hand, they will have an impact on offer. This can be perceived as a change in monetary flow because of costs on infrastructure and investments and in changes in employment flows. Adaptation measures can address both demand and supply and their outcome can be perceived on all of the three cited flows.

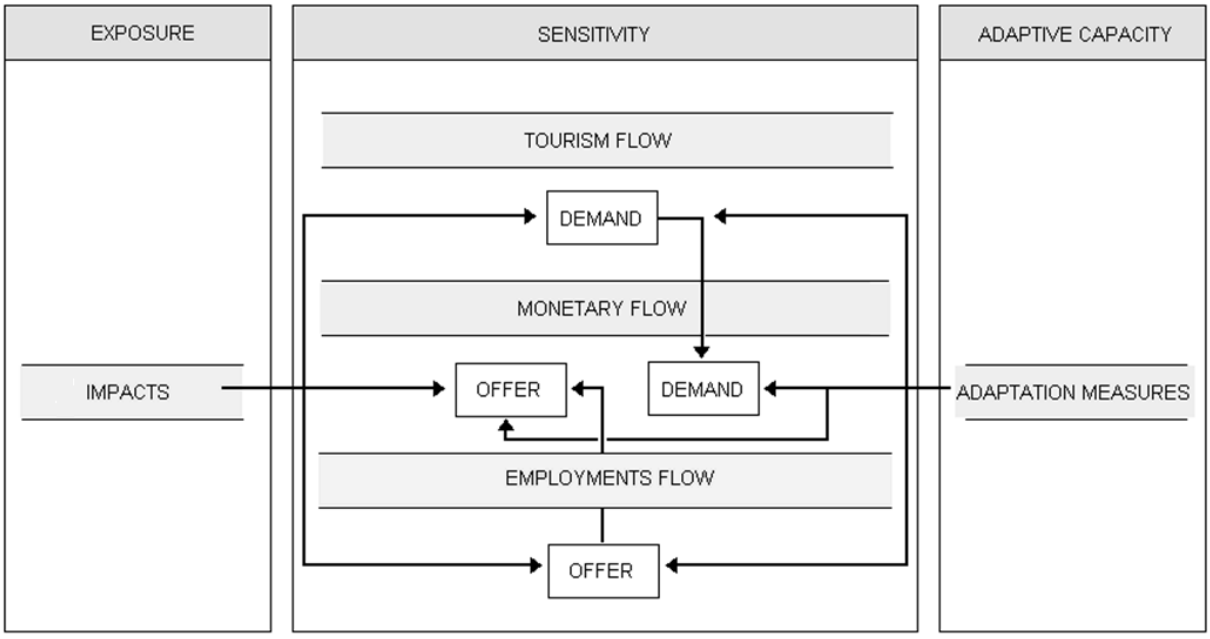

Figure 3: The flows in the system: impacts have an effect to the tourism flow, the monetary flow and the employment flow. On the same way, adaptation measures have a positive effect on them. These modifications of flows can all be translated in monetary terms.

4. Data

The choice of indicators

Worldwide, a broad array of attempts has been made to standardize the methodological framework (Benioff 1996; Kelly and Adger 2000; Fussel 2007; IPCC 2007) or the choice of indicators for the three components of vulnerability (exposure, sensitivity and adaptive capacity) (see e.g. Brooks et al. (2005)). Nonetheless, vulnerability is a complex and variable characteristic, depending on the spatial amplitude of the region studied (a set of nations vs. a single country) and from the choice of the selected sector (e.g. tourism, agriculture, biodiversity). Therefore, it is difficult to create ex-ante a standardized method, set of indicators or of indices that could be prescribed for conducting vulnerability research (Vulnerability Network and Observatory[3]). Vulnerability can be seen as a painting. We could try to describe it by cutting it into pieces, and to use these pieces as a jigsaw. The cutting could be made in thousand of different way, creating big or small pieces. The same is true for vulnerability mapping. Indicators can be selected in order to depict vulnerability. Few can be picked, or many. Care must be taken however, neither to create a too

[3] http://www.vulnerabilitynet.org/

simplistic image (too few indicators), nor to create a black box (too many of them). It is important, moreover, to try to select pieces that cover the biggest part of the picture, that do not overlap, or come from a different jigsaw. The selected list of indicators - divided in sub-components – is presented hereafter (Figure 4, Tables 1 and 2). Their choice undergoes a continuing process; the participation at the ClimAlpTour project[4] gave many positive inputs.

Exposure	Sensitivity	Adaptive capacity
Changes in climate suitability	Tourism structure	Feasibility
Snowpack reduction	Population	. Social
Glaciers melting	Economy	. Economic
Permafrost melting - rockfall	Infrastructure	. Technological
Natural hazards	Institution	. Institutional
Water scarcity – drough	Environment	. Environmental
Landscape – scenic beauty		Acceptability
		. Social

Figure 4 : Vulnerability is divided in three categories : exposure, sensitivity and adaptive capacity. These three categories can be further split into sub-components. Each of them is then composed by indicators.

Exposure

In the different studies carried out on the subject, various climate impacts affecting tourism are depicted. After considering the published literature on climate change impacts (using the SWIDCHI database), on vulnerability assessment (Brooks, Adger et al. 2005; Perch-Nielsen 2008; Preston, Smith et al. 2008), and from the discussion with experts, and after collecting feedbacks from stakeholders; the main climate

[4] The ClimAlpTour project looks at the impact of climate change on tourism in the Alps. More information can be found under http://www.climalptour.eu/content/.

change impacts considered to be of particular relevance were selected. These are seven: (i) changes in climate suitability; (ii) snow pack reduction; (iii) glaciers melting; (iv) permafrost melting and rockfalls; (v) natural hazards; (vi) water scarcity and drought; and (vii) landscape changes and scenic beauty.

i. Changes in climate suitability

Climate change will affect several elements such as average, maximum and minimum temperature, precipitation, wind speed, humidity, sunshine hours[5]. 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, defining the suitability of climate for sightseeing activities[6]. It is a composite measure of the climate well-being of tourists. Although climate is one of the variables that motivate tourists in their choice; it could play an important role in the final destination choice. It could be foreseen for Switzerland, that domestic tourist destinations, mainly at lakes and in the Alps, may become more attractive with increasingly hot summers.

ii. Snowpack reduction

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 2007), the lower snow line would raise of 270 m by 2050. More precise and reliable regional prediction could hardly be made at the moment; seeing the low predictability of rain- and snowfall in climate models[7]. With the increase in temperatures, the length of snow cover and the number of days with snowfall will decrease at low altitude (Agrawala and Oecd 2007; Beniston 2009). It could be therefore foreseen that, many low-altitude ski domains will be particularly affected, seeing that by 2050, these resorts won't have enough snow to allow a ski activity. On the other hand, high altitude locations, because of the higher level of precipitations, will enjoy more snowfall and will still benefit from the situation. As pointed out in the OECD report (Agrawala and OECD 2007) - which analyzed the Alpine area of France, Switzerland, Italy, and Austria up to 2050 - Switzerland will be less affected than neighbor countries (Figure 5). Changes in snow

[5] For example, mean annual temperature in Switzerland is supposed to increase of 2.1°C until 2050 in relation to 1990 Frei, C. (2004). "Die Klimazukunft der Schweiz – Eine probalistische Projektion.", OcCC (2007). Klimaänderung und die Schweiz 2050. Erwartete Auswirkungen auf Umwelt, Gesellschaft und Wirtschaft. O. ProClim. Bern.. Seasonally, the average temperature will increase of about 1.8°C in winter (+0.7/+3.4) and fall (+0.8/+3.3), of 2.1°C in spring (+1.1/+3.5), and of 2.7°C in summer (+1.4/+4.7).

[6] A description of the method can be found in Mieczkowski (1985) and in Perch-Nielsen (2008).

[7] People from the Swiss Federal Institute for Forest, Snow and Landscape Research/the Institute for Snow and Avalanche Research (WSL/SLV), the University of Geneva (UNIGE) and the EPFL are working on this aspect.

quantity and snow cover periods will not only affect tourism because of the changed availability of snow for skiing. They will also affect it indirectly, by modifying the ecosystems characteristics (changes in water flow modifying e.g. the vegetation) and the availability of water for other domains (Beniston 1994). We will however not consider those two latter aspects.

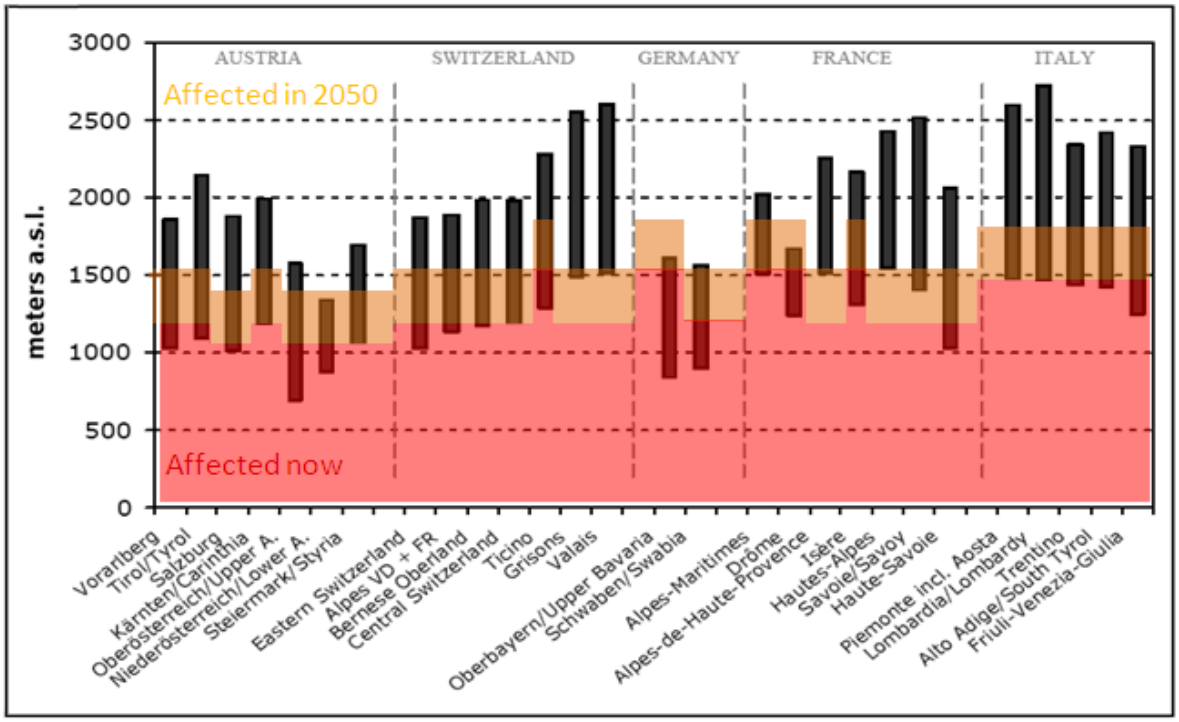

Figure 5 : Mean altitude range of Alpine ski areas at a regional level. In red the already affected regions, in orange, the regions affected in 2050. As seen, Switzerland will gain competitiveness in the future. Source: (Agrawala and OECD 2007).

iii. Glaciers melting

Many studies (e.g. (Maisch 1992; Paul, Maisch et al. 2007)) suggest an upward shift of the steady-state equilibrium line altitude (ELA_0[8]) for glaciers of 120 to 170 m for a 1°C temperature increase. By 2050, glaciers surface in Switzerland will probably have decreased by 54-80% in relation to 1973, and its volume by 50-78% (Paul, Maisch et al. 2007). The retreat of the glaciers in the near future will tend to accelerate rather than continuing in a linear fashion (Bader, Kunz et al. 2000). Glacier melting will impact tourism in different ways. On one side, glaciers retreat will change alpine landscape and therefore it will modify scenic

[8] 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. ELA_0 is the ELA for which the steady state of the glacier equals zero (Paul, Maisch et al. 2007).

beauty. A study by Scott et al. (2007) demonstrated that if glaciers and alpine tundra had disappeared and occurrences of forest fires increased, more than 50% of visitors would visit the national park less or stop visiting all together (Perch-Nielsen 2008). It should nonetheless be kept in mind that new generations would not have necessarily a memory of the previous state of the landscape. Glaciers retreat will moreover affect soil instability (Haeberli and Beniston 1998) and create glaciers lakes[9]. Furthermore, as for snowpack reduction, it will modify water flow and availability. Finally, resorts offering ski, hiking, ice cave sightseeing, and tubing on glaciers will also be negatively affected. We consider here only the impact on scenic beauty.

iv. Permafrost melting – rockfall

Permafrost[10] also undergoes the impacts of climate change. It is foreseen that, with an increase of 1-2°C, the lower limit of permafrost will increase of 200-700 m (Bader, Kunz et al. 2000). Melting of permafrost destabilizes soil. Engadine, Valais, Bernese Alps and the Tödi region are particularly concerned. There is a high chance of having problems related to infrastructures such as ski lifts and protection against avalanches because these are fixed in the permafrost. Costs for sanation are elevated, sometimes implying the abandon of the site. Moreover, hikers will be particularly affected by the higher danger in rock falls.

v. Natural hazards

Natural hazards, as floods, debris flow, landslides and rockfalls will very probably change in frequency, intensity, and distribution in the future due to climate change (Bader, Kunz et al. 2000; Hilker, Badoux 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 occurrence of natural hazards will have consequences both on supply and demand: it will – from one side - affect infrastructure and human settlements that serve at the base for such activities (streets, cable-ways, ski lifts, alpine huts, etc). On the other hand, it could affect human lives and therefore decrease the attractiveness of a location.

[9] A study on the subject is being carried out in the frame of the National Research Programme NRP 61 'Sustainable Water Management'.

[10] Permafrost is defined as surface material whose temperature is constantly under 0°C. In the Alps, it is generally found over 2300 m. It is estimated that 5 à 6% of the Swiss territory is covered by permafrost (http://www.unil.ch/gse/page2743_fr.html).

vi. Water scarcity – drought

It was previously seen that, because of the increase in intense rainfall events and in rain, flood events are supposed to increase both in summer and in winter[11]. Additionally, in summer, the combination of less abundant precipitations and of more intense evapotranspiration could bring regionally to a decreased water contains in soils, to water scarcity and to drought. Moreover, because of snowpack reduction in the Alps, rivers will dry more frequently. This will imply a consequent seasonal water accumulation decrease. Furthermore, because of glaciers disappearing; drought could become more frequent during the post-summer periods in these areas. Taking as reason only the over-mentioned decrease of mean rainfall and of the number of rainy days, drought events (similar to the 2003 one) could last longer and be more frequent, in particular during summer (Frei 2004; Ecoplan/Sigmaplan 2007). Mainly affected will be the midlands and Jura (OcCC/ProClim 2007)[12]. 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 (Agrawala and OECD 2007). If water available becomes scarce, this could create conflicts with others sectors, as for example agriculture or energy production (OcCC/ProClim 2007; Freiburghaus 2009).

vii. Scenic beauty

Higher temperatures will mark in particular High-Alps' landscape. Many aspects of landscape, as glaciers (already seen above), vegetation or soil, will be particularly affected in the future. Flora and fauna will adapt to new conditions, but some natural processes, as forests growth, only take place slowly. Therefore, many effects will appear with a certain delay. Vegetation belts will move upwards. Treeline could theoretically rise of 400 m for the 2°C raise foreseen for 2050[13]. Because of shift to higher altitudes, low competitiveness, or impossibility to migrate, many species (in particular alpine flora) are deemed to disappear (Kienast 1998; Guisan and Theurillat 2000). In addition, there will be an acceleration of immigration of foreign species into Switzerland (OcCC/ProClim 2007; Pauchard, Kueffer et al. 2009) and changes in fauna's behaviour. For example, bird species that were once migratory already now overwinter in Switzerland (OcCC/ProClim 2007). With a strong temperature increase, desertification could be

[11] In summer, there will be less rain, but falling with higher intensity (Beniston 2004).

[12] It should also be pointed out that not only water quantity, but also water quality will diminish because of climate change.

[13] It has to be kept on 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 anthropogenic influences (mostly due to the reduction of 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 will disappear as well.

forecasted in the inner alpine dry valleys, if no water resistant plants immigrate (Zimmermann, Bolliger et al. 2006). Wallis, for example, could tend to desertification for a time horizon of 2100. All these aspects will modify landscape and consequently scenic beauty. Changes in scenic beauty could have an effect on tourism flow, both as a risk and as a chance (Scott and McBoyle 2007). Some regions could gain in attractiveness, other loose part of it.

Sensitivity

As seen in Chapter 3, 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 2007). It depends here on tourism structure, population, economy, infrastructure, institutions, and the environment (Table 1).

Table 1: The selected indicators describing sensitivity.

Sensitivity	
Tourism structure	
Tourism balance - income from tourism	[CHF directly and indirectly generated from the tourism sector/CHF generated from the whole economy]
Tourism demand	
Tourism intensity (TI)	[guest nights in hotels, treatment at a health resorts, and in the parahotel industry/inhabitants*100]
Guest nights/one day tourists ratio	[guest nights in hotels, treatment at a health resorts, and in the parahotel industry/one-day tourists]
Secondary homes temporarily inhabited	[secondary homes temporarily inhabited/ha]
Seasonality	[guest nights in hotels, treatment at a health resorts in winter/total guest nights in hotels, treatment at a health resorts]
Gross occupancy rate (365 days) in hotels, treatment at a health resorts	[guest nights/(number of bed-places * 365)]
International radiance	[guest nights from Swiss tourists/total guest nights]
Artificial snow production	[slopes artificially snowed/total of ski slopes]
Tourism offer	
Density of beds in hotels, treatment at a health resorts and in the parahotel industry[1]	[beds available/ha]
Tourism supply structure	[small scale establishments/total of establishments]
Proximity to substitute destinations	[ski resorts in a 20 km radius]
Length of activity of ski resorts	[days with enough good snow conditions]
Population	
Resident population	[population/ha]
Percentage of the population born on place in year 2000	[people born on place/total number of inhabitants]
Age structure	[kids (<15 Years) /100 elderly people (>64 Years)]
Economy	

Percentage of jobs (full-time equivalents) in the hotel and catering sector 2001	[jobs in the hotel and catering sector/total of jobs]
Percentage of jobs (full-time equivalents) in the transportation sector 2001	[jobs in the transportation sector/total of jobs]
Seasonality	[seasonal jobs in the hotel sector (winter + summer)/total of jobs]
Percentage of jobs in the agriculture sector	[jobs in the agriculture sector/total of jobs]
Average net income pro person in private dwellings 1997-1998	[average income in CHF]
Infrastructure	
Accessibility	[average minutes of travel from the nearest urban centre (public transports and personal mobility)]
Accessibility to services	[average minutes of travel from the nearest urban centre]
New or renovated buildings (after 1990)	[number of new or renovated buildings /total of buildings]
Water availability	[m^3 of water used by agriculture, industry, dwellings, for public use, for cooling of nuclear power plants and because of losses/ m^3 of water available from lakes, rivers, sources, and ground water]
Current water storage capacity	[m^3 of water that can be stored]
Energy use in destination in the tourism sector	[kWh/ha]
Institutions	
Left vs. right	[average score of a Principal Component Analysis (PCA) for the opposition left vs. right]
Ecologists vs. liberals	[average score of a PCA for the opposition ecologists vs. liberals]
Liberals vs. conservatives	[average score of a PCA for the opposition liberals vs. conservatives]
Environment	
Land use protection	[ha of protected land/ha]
Land use complexity	n.a.

[1] guest houses, bed-and-breakfast establishments, youth hostels and camping sites

Some of the indicators presented in Table 1 are not available at the moment. This is the case of the tourism balance (values exist only at the Swiss level or for some regions), the job seasonality, water availability and current water storage capacity, energy use. The first indicator, one of the most (if not the main) important one, was then replaced by proxies (data on tourism demand and supply structure). Concerning energy and water (also two very important aspects), the required data do unfortunately not exist at the moment. This eludes a very important 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 be too approximate.

Adaptive capacity

Adaptive capacity reflects 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 2.

Table 2: The selected indicators describing adaptive capacity.

Adaptive capacity	
Feasibility	
Social	
Public participation actions in the region	[number of actions]
Existence of studies on climate change impacts for the region	[number of studies]
Economic	
Average net income pro person in private dwellings 1997-1998	[average income in CHF]
Technological	
Density of transport network (existence of replacement routes)	[km of rail and road networks/ha]
Possibility of self green energy development	[number of existing renewable energy installations/ha]
Institutional	
Past actions taken from the tourism sector in this direction	[number of actions]
Part of an official tourist region (Swiss tourism)- corporate vs. community model	[boolean]
Left vs. right	[average score of a Principal Component Analysis (PCA) for the opposition left vs. right]
Ecologists vs. liberals	[average score of a PCA for the opposition ecologists vs. liberals]
Liberals vs. conservatives	[average score of a PCA for the opposition liberals vs. conservatives]
Environmental	
Land use protection	[ha of protected land/ha]
Acceptability	
Social	
Past actions taken from the tourism sector in this direction	[number of actions]
Results of the vote on "«Droit de recours des organisations: Assez d'obstructionnisme - Plus de croissance pour la Suisse!» (30.11.2008)	[positive votes/total of voting]

As before, some information is not yet available or is missing. Information often exists, but is still too fragmentary and difficult to collect rigorously. This is the case of public participation, possibility of self green energy development actions in the region (e.g. Repowermap[14]) and the affiliation to an official tourism region or to a corporation.

4. Discussion

As seen previously, vulnerability mapping is a complex and often time consuming method. Data are often not available or difficult to collect. The method possesses, on the other hand, more than one asset. In particular, it allows:

[14] This site inventorizes 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. http://www.repowermap.org/index_fr.php.

- raising stakeholders' awareness and interest on climate change impacts. Preston et al. (2008) indicate it as one of the principal motivations for attending workshops;
- establishing which impacts are relevant for a given region and to which extents;
- esta blishing if similarities exist between regions and therefore exchanging best practices and creating a platform of exchange;
- determining knowledge gaps, where more research should be carried out;
- creating debate (criticize map) and, allow stakeholders comparing analysis results with their own subjective perceptions of vulnerability in their region;
- better directing energies and investments (e.g. establishing where the confederation should grant money).

On the other hand:

- it contains an high incertitude because of the choice of the indicators, of the scenarios, of the weights, of the functional unit, etc.;
- it do not consider interrelations, side effects and feedback loops between impacts;
- it needs relevant time for collecting data and for elaborating it;
- it is subject to data gaps. In particular all the information on social, environmental, and ecologic scenarios are missing. If for climate change we have (robust) scenarios for 2050, and eventually also for population development (e.g. DEMOCHANGE[15]), no information on how e.g. the tourism structure could evolve in the future exists at the moment;
- it does not take into consideration what lies outside the system (Switzerland). For example, it does not indicate scenarios for future foreign tourism flow under climate change.

5. Conclusions

The map created in the frame of this study will eventually allow assessing where it is more important to start implementing adaptation measures. In addition, it will permit to assess if there are similarities between different areas and therefore where the implementation of collaboration and information sharing could be enhanced. Finally, results will indicate who could benefit from climate change and where adaptation measures should be implemented with priority. In this article we set the basis for the creation of this map. The selection of the methodology, of the impacts and of the indicators is the first step in this direction.

[15] http://www.demochange.org/

Reference

Agrawala, S. and OECD (2007). Climate change in the European Alps, OECD Organisation for Economic Co-operation and Development.

Bader, S., P. Kunz, et al. (2000). Climate risks - the challenge for alpine regions, Vdf Hochschulverlag AG an der ETH Zürich.

Benioff, R. (1996). Vulnerability and adaptation assessments, Kluwer.

Beniston, M. (1994). Mountain environments in changing climates, Routledge.

Beniston, M. (2004). Climatic change and its impacts, Kluwer Academic Publishers.

*Brooks, N., W. N. Adger, et al. (2005). "The determinants of vulnerability and adaptive capacity at the national level and the implications for adaptation." Global Environmental Change-Human and Policy Dimensions **15**(2): 151-163.*

Ecoplan/Sigmaplan (2007). Auswirkungen der Klimaänderung auf die Schweizer Volkswirtschaft (nationale Einflüsse). Bern.

Frei, C. (2004). "Die Klimazukunft der Schweiz – Eine probalistische Projektion."

*Freiburghaus, M. (2009). "Wasserbedarf der Schweizer Wirtschaft." gwa **12**.*

*Fussel, H. M. (2007). "Vulnerability: A generally applicable conceptual framework for climate change research." Global Environmental Change-Human and Policy Dimensions **17**(2): 155-167.*

*Guisan, A. and J. P. Theurillat (2000). "Assessing alpine plant vulnerability to climate change: a modeling perspective." Integrated Assessment **1**: 307-320.*

*Haeberli, W. and M. Beniston (1998). "Climate change and its impacts on glaciers and permafrost in the Alps." Ambio **27**(4): 258-265.*

*Hilker, N., A. Badoux, et al. (2009). "The Swiss flood and landslide damage database 1972–2007." Nat. Hazards Earth Syst. Sci. **9**: 913–925.*

IPCC (2007). Climate Change 2007 – Impacts, Adaptation and Vulnerability. .

Javed, A. (2005). "Vulnerability mapping: A GIS based approach to identity vulnerable regions to Climate change." The Geospatial Resource Portal.

*Kelly, P. M. and W. N. Adger (2000). "Theory and practice in assessing vulnerability to climate change and facilitating adaptation." Climatic Change **47**(4): 325-352.*

Kienast, F. (1998). Klimaänderung und mögliche langfristige Auswirkungen auf die Vegetation der Schweiz, vdf, Hochsch.-Verlag an der ETH.

*Kunz, P. (1999). Conclusions du Programme National de Recherche PNR 31 'Changements Climatiques et Catastrophes naturelles': Impacts sur la Société en Suisse, pistes pour le futur. **NFP31_conclusions** 172-179.*

Luthe, T. and E. L. Berlow (2009). Structural network analysis and dynamic outlooks for assessing vulnerability of tourism to global change. Applications of Social Network Analysis ASNA 2009 Panel "Environmental Networks". University of Zürich & ETH Zürich.

Maisch, M. (1992). Die Gletscher Graubündens, Geographisches Institut der Universität Zürich.

Meier, R. and K. u. N. i. d. S. Nationales Forschungsprogramm (1998). Sozioökonomische Aspekte von Klimaänderungen und Naturkatastrophen in der Schweiz, vdf.

*Moreno, A. and S. Becken (2009). "A climate change vulnerability assessment methodology for coastal tourism." Journal of Sustainable Tourism **17**(4): 473-488.*

*Nyaupane, G. P. and N. Chhetri (2009). "Vulnerability to Climate Change of Nature-Based Tourism in the Nepalese Himalayas." Tourism Geographies **11**(1): 95-119.*

OcCC (2007). Klimaänderung und die Schweiz 2050. Erwartete Auswirkungen auf Umwelt, Gesellschaft und Wirtschaft. O. ProClim. Bern.

OcCC/ProClim (2007). Climate Change and Switzerland 2050 - Expected Impacts on Environment, Society and Economy. Bern.

*Pauchard, A., C. Kueffer, et al. (2009). "Ain't no mountain high enough: plant invasions reaching new elevations." Frontiers in Ecology and the Environment **7**(9): 479-486.*

*Paul, F., M. Maisch, et al. (2007). "Calculation and visualisation of future glacier extent in the Swiss Alps by means of hypsographic modelling." Global and Planetary Change **55**(4): 343-357.*

Perch-Nielsen, S. L. (2008). Climate change and tourism intertwined, ETH.

Preston, B. L., T. F. Smith, et al. (2008). Mapping Climate Change Vulnerability in the Sydney Coastal Councils Group. P. f. t. S. C. C. Group.

*Scott, D. and G. McBoyle (2007). "Climate change adaptation in the ski industry." Mitigation and Adaptation Strategies for Global Change **12**(8): 1411-1431.*

SECO (2006). Schweizer Tourismus in Zahlen - Ausgabe 2006. Bern.

STV-FST (2008). Le tourisme suisse en chiffres 2008. S. d. É. à. l. É. SECO. Bern, Secrétariat d'État à l'Économie SECO: 52.

Turner, B. L., R. E. Kasperson, et al. (2003). A framework for vulnerability analysis in sustainability science. Washington, DC, US, National Academy of Sciences of the United States of America.

Zimmermann, N. E., J. Bolliger, et al. (2006). "Wo wachsen die Bäume in 100 Jahren?" Forum für Wissen: 63–71.