Climate Change and Tourism in Switzerland : a Survey on Impacts, Vulnerability and Possible Adaptation Measures

Cecilia Matasci, Juan-Carlos Altamirano-Cabrera

[1] *Research group on the Economics and Management of the Environment -*

Swiss Federal Institute of Technology Lausanne, CH-1015 Lausanne, Switzerland, cecilia.matasci@epfl.ch

The tourism industry is particularly affected by climate change, being very climate- and weather-dependent. Moreover, particularly in the Alpine region, it is specially exposed to natural hazards. Nonetheless, this industry is an important pillar of the Swiss economy, providing employment and generating income. Then, it becomes essential to reduce its vulnerability and starting implementing adaptation measures. In order to do so, it is important to define which areas face which problems and to recognize vulnerability hot spots. This motivation comes from the prospect that the largest environmental, social and economic damages are likely to be concentrated in vulnerable areas. This article presents an overview of the current state of the knowledge on the impacts, the vulnerability and the possible adaptation measures of the tourism industry in relation to climate change. Moreover, it presents different methods that could help assessing this vulnerability, referring in particular to the Swiss situation. This is the first step toward the establishment of the vulnerability analysis and the consequent examination of possible adaptation measures.

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

Introduction

Climate change is a global phenomenon, but its effects occur on a local scale. Moreover, these effects have a clear impact on economic activities. An example of an activity heavily affected is tourism. Tourism is closely interlinked with climate change both as culprit and as victim. On the one hand, it is responsible for a large portion of GHG emissions from leisure-related transport and high energy consumption in the accommodation and activity sectors. In Switzerland, for example, tourism generated approximately 6.1% of its overall GHG emissions (BAFU, 2007). From these emissions, 84% comes from air transport, 6% from other types of transport, and 8% from accommodation (Perch-Nielsen, 2008). On the other hand, the tourism industry is particularly affected by climate change, being very climate- and weather- dependent. Sea level rise, snow pack reduction, glaciers melting, increase of frequency of natural hazards, among other negative impacts, both modify tourism flow and damage infrastructures. This will lead to many regions and nations to become more vulnerable and fragile. One of the concerned regions is the Alpine chain and its villages (Agrawala, 2007).

Whereas the direct and indirect physical impacts of climate change have been widely studied worldwide (IPCC, 2009), the study of the socio-economic impacts and the possible adaptation measures is still in its infancy (Tol, 1995; UNEP/GRID, 2009). However, socio-economic impacts at different spatial levels could be important, if no adaptation measures are taken. It is nowadays widely accepted that mitigation measures should be coupled with adaptation strategies (IPCC, 2009). In this paper, we present an overview of the current state of the knowledge on the impacts, the vulnerability and the possible adaptation measures of the tourism industry in relation to climate change. Moreover, we present different methods that could help assessing this vulnerability, referring in particular to the Swiss situation. Our study is a first step toward the assessment of the vulnerability for the tourism sector, the determination of the most vulnerable zones and the starting of an adaptation process.

The structure of this article is the following: first, section 1 gives a brief overview of the tourism industry and of its importance in Switzerland. It then focuses on studies analysing impacts, vulnerability and adaptation measures. Because specific literature on Switzerland and tourism is still rare, a more general overview on worldwide studies looking also at other sectors is given. Section 2 presents a review of studies dealing specifically with the consequences of climate change on tourism. Section 3 discusses vulnerability. In addition, it gives an explanation of its components, as also of possible methods to assess it. A fourth chapter describes papers dealing with adaptation measures, and focuses in particular on Swiss policy and on tourism. Finally, the last chapter concludes.

1. The structure and importance of tourism in Switzerland

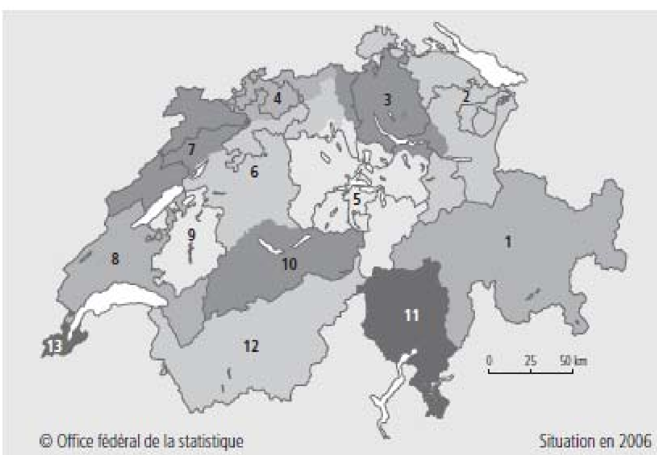

Figure 1. The 13 Swiss tourism regions: 1. Grisons, 2. Eastern Switzerland, 3. Zurich region, 4. Basel region, 5. Central Switzerland, 6. Mittelland, 7. Neuchatel, Jura and Bernese Jura, 8. Lake Geneva region, 9. Fribourg region, 10. Bernese Oberland, 11. Tessin, 12. Valais, 13. Geneva (SECO, 2009).

Switzerland is divided in 13 tourism regions, each one distinguishable for its specific characteristics; see Figure 1 (BfS, 2009a). Concerning supply and accommodation, there are 241,345 beds available in the country, shared between 4,924 establishments (Bfs, 2009b, see Table 1). The highest number of establishments could be found in the Grisons (13.7%), in Valais (12%), and in Eastern Switzerland (11.5%). Occupation rate varies between 71.6% (Geneva in summer) and 29.9% (Neuchatel, Jura and Bernese Jura in winter). Grisons also possess, by far, the highest tourism intensity, with 9 lodging nights over inhabitant, followed by the Bernese Oberland (5.5), and Valais (4.2). Small and average establishments account for the majority of the offer: almost 75% of the hotels do not possess more than 50 beds (SECO, 2009). With 54.4% of the stays, Swiss people generate the main tourist demand in the country (Figure 2). They are then followed by Europeans, with Germans representing 15.4%, British people 3.3%, Italians 3.1%, and French 2.9%. North-Americans stand for 3.0% of the stays, Japanese 1.8%, Chinese 1.1%, and Australians together with New-Zealanders 0.8% (BfS, 2009a). Reasons of foreign tourists to come to Switzerland are many and varied. In summer, tourists principally come to Switzerland for resting and for recreation, for walking and hiking, as also for leisure (e.g. summer festivals). In winter, sports represent the first reason of their arrival, followed by resting and recreation and finally leisure (Dayer, 1998).

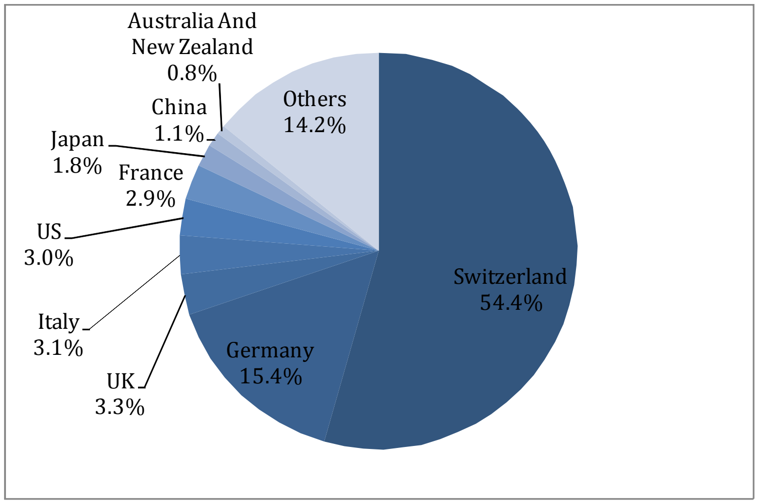

Figure 2. Overnights in hotels and health resorts in Switzerland, by guests' origin (BfS, 2009a).

Tourism exerts an important influence on the Swiss economy, accounting for 5.6% of the GDP. Direct income is principally generated by accommodation (18%), the catering industry (14%), and passenger transport (18%). The following tourism sub-sectors[1] account for the remaining of the direct income: travel agencies and tourism operators (7%), culture (1%), sport and entertainment (3%), tourism-specific products (14%), non tourism-specific products (24%). 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 exportation. 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.

[1] Tourism is not properly considered as an economic sector. It is more an intersection of other existing sectors (e.g. accommodation and catering, passenger transport, retailing). In this article, nonetheless, the term is used to characterize it.

Table 1. Number of establishments, beds, nights and occupation rates for the different tourism regions in 2008 (BfS, 2009b).

	Name	Establishments	Beds	Nights	Tourism intensity[1]	Occupation rate - winter	Occupation rate - summer	Total occupation rate
1	Grisons	677	38 124	6 239 848	9	61.7 %	52.9 %	57.6 %
2	Eastern Switzerland	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 Switzerland	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 measuring the relative importance of tourism to local economy.

2. Worldwide and national impacts of climate change on tourism

2.1. Direct and indirect physical impacts

Climate change and greenhouse effects are known since a long time. They were already described in the works of the French physicist Joseph Fourier in 1824 (Fourier, 1824). These early studies were then followed by a broad range of global and country-specific researches (Arrhenius, 1896;

Callendar, 1938; Keeling 1960, between others) leading - between 1980 and 1988 - to the world-wide recognition of these phenomena and to a better understanding of its direct (as for example changes in average temperature and rainfall) and indirect (e.g. the melting of glaciers and of permafrost induced by changes in temperature) physical impacts. The most recent kernel of the results on impacts can be found in the 4th IPCC report (IPCC, 2007b). In regards to Switzerland, the more comprehensive assessment 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, also focusing on tourism. A summary of these impacts is given in Badler & Kunz (2000) and in Kunz (1999). Other studies on the topic were carried out in the following years. A list and description of these studies can be found in the 'Swiss database of climate change impacts' (SWIDCHI)[2].

2.2. Socio-economic impacts

More recently, the socio-economic impacts of climate change on tourism were specifically addressed worldwide. Studies on the subject can be categorized as **qualitative** and **quantitative** (Hamilton & Tol, 2004). Qualitative studies provide information on vulnerabilities and the likely direction of change. Nevertheless, they do not provide estimates of changes in demand nor monetary values. The focus of these studies ranges from worldwide tourism destinations (Viner & Agnew, 1999) to specific areas or sectors such as the Caribbean coastal areas (Gable, 1997), the German North Sea coasts (Krupp, 1997), the Mediterranean region (Perry, 2000), and the international ski industry (Scott & McBoyle, 2007). Quantitative studies, where estimates of changes in demand are given, can be categorized into three groups: first, papers dealing with predicted changes to the **supply** of tourism services, often focusing on the winter sports industry (Abegg, 1996; Breiling & Charamza, 1999; Elsasser & Messerli, 2001; Elasser & Bürki, 2002; OECD/Abegg, 2007). Second, studies that predict the change in tourism **demand**, both assessing climatic attractiveness (Loomis & Crespi in Mendelsohn & Neumann (1999); Mendelsohn & Markowski in Mendelsohn & Neumann (1999); Lise & Tol, 2002; Hamilton, 2003; Hamilton et al., 2003) and simulation models of tourism flows (Hamilton et al., 2005a,b; Hamilton et al., 2007; Amelung et al., 2007; Bigano et al., 2006; and Perch-Nielsen, 2008). Third, studies considering **both supply and demand** and assessing a monetary value to these changes (Meier, 1998; Maddison, 2001; Berritella et al., 2004; Ecoplan/Sigmaplan, 2007; FIF, 2007; Bosello et al., 2007a; Bigano et al.; 2008). Quantitative studies can be also classified according to their geographical area. Lise & Tol (2002), Hamilton et al. *(*2003), Berritella et al. *(*2004), Hamilton et al. *(*2005b),

[2] See 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 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).

Bigano et al. *(*2006), Bigano et al. (2007), Bigano et al. *(*2008) consider worldwide impacts on tourism demand. Abegg (1996), König & Abegg (1997), Breiling & Charamza (1999), Elsasser & Messerli (2001), Elasser & Bürki (2002), OECD/Abegg (2007), Bigano & Bosello (2007) focus specifically on Switzerland or on the Alpine region. Other articles cited refer to other regions or countries (such as Loomis & Crespi in Mendelsohn & Neumann (1999), Mendelsohn & Markowski in Mendelsohn & Neumann (1999), Hamilton, 2003, and Maddison, 2001). These quantitative impact studies do only rarely consider seasonality problems[3], adaptation strategies and adaptation costs.

Hereafter, we focus on quantitative studies dealing with monetary valuation. We classify these in two types: i) worldwide and country-specific studies and ii) studies dealing with both the Alpine region and Switzerland. Few of the quantitative studies listed above extend into the assigning monetary values to the impacts (Berritella et al., 2004; Bosello et al., 2007a; OECD/Abegg, 2007). Berritella et al. (2004) studied the economic impacts of climate change induced variations in world-wide tourism demand. They used a world computable General Equilibrium Model (CGE), considering two shocks (predicted variations in tourist flows into changes of consumption preferences for domestically produced goods and reallocation of the income across world regions, simulating the effect of higher or lower tourists' expenditure). They found that at a global scale, climate change will ultimately lead to a welfare loss, unevenly spread across regions. Bosello et al. (2007a) analysed the environmental an economic vulnerability of Italian Alps by using the change in internal and foreign tourism flow in Italy, extrapolated to each province. The economic loss for the tourism industry was estimated as the product of the decrease in number of tourists for each sector times the average expenditure of the region. Results show an average contraction of the income for tourism for the Italian Alps of 10.2% in 2030 and of 10, 8% in 2090. Results differ nonetheless between provinces and types of tourism. The OECD/Abegg report (OECD/Abegg, 2007), on the other hand, analysed 666 ski areas from the European Alps (Austria, Switzerland, France, Germany and Italy) in order to assess the number of naturally snow-reliable ski areas present today and in the next decades and to suggest possible adaptation measures. It calculated the loss of skiers due to climate change, but it does not give monetary values. In case of an increase in temperature of 2°C, only 61% of today's ski areas would remain naturally snow-reliable and in particular, low-elevation ski areas would likely disappear.

At the Swiss level, up to now, no specific study looks at the quantitative socio-economic impact of climate change on tourism for the country. Only few studies, which consider also at other aspects of the Swiss economy, look at it (Meier, 1998; Ecoplan/Sigmaplan, 2007; FIF, 2007). Meier (1998) estimated in his projection for 2050 (+2°C above 1990 temperature) an annual loss of 1.8 - 2.3 billion CHF_{1995} in the Swiss tourism industry due to climate change. Costs are principally

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[3] Seasonality, a temporal imbalance in the phenomenon of tourism, creates or exacerbates problems in gaining access to capital, in obtaining and holding full-time staff. It also generates low returns on investments (which generate consequent high risks in operations), peaking and overuse of facilities (Butler in Baum & Lundtorp, 2001).

generated by snow pack reduction in the Pre-Alps/Jura (1.6 – 2.1 billions CHF_{1995}), to decreased tourist flow caused by reduced attractiveness in winter tourism (150 millions (Mio) CHF_{1995}), and to losses in revenue in glacier skiing (30 Mio CHF_{1995}). Gains are generated in summer mountain tourism from summer coolness (100 Mio CHF_{1995}). Meier concluded that winter tourism is one of the most affected sectors among those considered. The Ecoplan/Sigmaplan report (Ecoplan/Sigmaplan, 2007) also considered 2050 as time-scenario for its evaluation of the costs and benefits generated by climate change in the Alpine region of Switzerland. In general, a loss in revenue of 120 Mio CHF_{2007} (0.03% GDP) was estimated for the winter sport sector. The report describes as additional possible factors the increase of danger in the alpine traffic infrastructure. It also outlines the benefits caused by a gain of summer attractiveness because of mountain coolness in comparison to other tourism destinations. Also in this report, tourism appears to be one of the most affected industries of Swiss economy. Besides Meier (1998) and the Ecoplan/Sigmaplan report (Ecoplan/Sigmaplan, 2007), there is one further study focusing specifically on winter tourism and on the '100-days rule'[4] for snow availability in the Bernese Oberland (FIF, 2007). The FIF study evaluated possible impacts of climate change on tourism for the Bernese Oberland and for year 2030 (1.8°C above 1990 temperature) by means of a statistical analysis of data and literature overview. It also referred to experts in order to assess the main challenges for tourism enterprises and destinations and to define possible mitigation and adaptation strategies. The authors found that the changes in tourism revenue, including adaptation measures, would result in a 20% increase in investments, which corresponds approximately to 75 Mio CHF_{2007}. Without adaptation, climate change will cost to the winter tourism industry 200 Mio CHF_{2007} annually (-30% of the revenues, divided between day-tourism (82 Mio CHF_{2007}) and overnight-tourism (118 Mio CHF_{2007})). Summer tourism industry would gain approximately 79 Mio CHF_{2007} yearly, which corresponds to 7% of the revenues of the industry. These gains are generated by an increase in attractiveness of mountain regions for their summer coolness to the detriment of other tourism destinations (e.g. the Mediterranean). 46 Mio CHF_{2007} are generated from day-tourism, 33 Mio CHF_{2007} from overnight-tourism. The report concludes that winter tourism will be strongly affected by climate change, and that adaptation measures are highly necessary. It also assesses that losses will be partly compensated by revenues in summer tourism.

3. Vulnerability

Vulnerability can be defined 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' (IPCC, 2007b, Appendix I;

[4] The '100-days rule' (Wilmer, 1986) states that in order to successfully operate a ski area, a snow cover sufficient for skiing should last at least 100 days per season. This is not a strict rule, but rather a working tool widely accepted among ski-operators (Abegg, 1996).

pag. 93). 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 II et al., 2003 in Perch-Nielsen, 2008), 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 et al., 1996).

3.1. Exposure, sensitivity and adaptive capacity

According to the IPCC Report (IPCC, 2007a), the concept of vulnerability towards climate change can be perceived as a function of three components (see Figure 3): exposure, sensitivity and adaptive capacity. First, it is a function of **exposure** to direct (such as changes in temperature and rainfall average) and indirect (e.g. increased risk of natural hazards or snow pack reduction) impacts. Secondly, it is function of **sensitivity** of the region to them. This sensitivity could be environmental (e.g. land use), human (e.g. social structure), and/or economic (e.g. income per capita). Finally, it depends from its (biophysical, social, technological and economic) **adaptive capacity**.

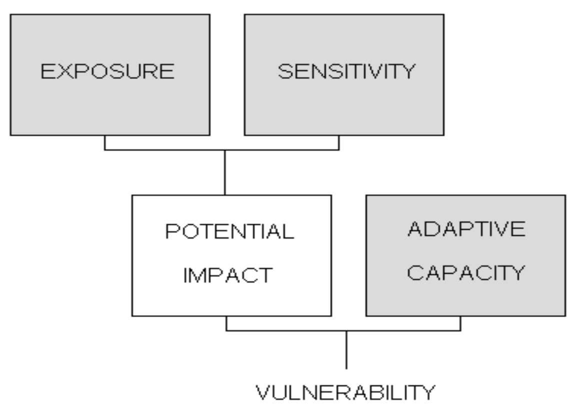

Figure 3. Components of vulnerability (Allen Consulting Group, 2005).

The first two components - exposure and sensitivity - depict the gross vulnerability of a system (as a region or process). They therefore provide an indication of its potential susceptibility (or **potential impact**) towards adverse impacts. On the other hand, the third component - adaptive capacity - reflects the ability of the system to manage, and thereby reduce, gross vulnerability (Preston et al., 2008). The potential impacts for a region are, for example, particularly high if – say – this suffers from an increase in the frequency and/or intensity of flooding events caused by climate change and triggered by an higher intensity in heavy rainfalls (increase in exposure), that this region is densely urbanized and that the buildings are not particularly resistant (high sensitivity). Moreover, a region is highly vulnerable if it does not have the economic, social, technological and environmental resources to adapt (i.e. it has a low adaptive capacity and thus could be defined as a hotspot of vulnerability. Hotspots of vulnerability are regions deemed critical, or at "high risk" (Dow, 2005), that are highly exposed, sensitive and less able to adapt and where therefore adaptation interventions may be required (De Sherbinin, 2008).

Worldwide, a small number of studies deal with assessing vulnerability in relation to climate change, often focusing on a particular impact (earthquakes, volcanoes, landslides, floods, drought, and cyclones in Dilley et al. (2005)), a given region (India in O'Brian et al. (2004), the Sydney Coastal Councils Group in Preston et al. (2008), Germany in Zebisch et al. (2005), the Sakai Sub location (Kenya) in Mutua (2006), Switzerland in Priceputu and Greppin (2005), global cities in De Sherbinin et al. (2007), South-east Asia in Yusuf and Francisco (2009), the coastal zone of Poland in Zeidler (1997)) or a particular sector (the ecosystem in Priceputu and Greppin (2005) and in the LIFE+ project (2007)). Only few deal specifically with assessing vulnerability in relation to tourism (Prettenthaler et al., 2006; Perch-Nielsen, 2008). From one side, Prettenthaler et al. (2006) analyse 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. Perch-Nielsen, on the other hand, presents an index approach to assess the global vulnerability of beach tourism to climate change. Aggregate results on an annual level show that the large developing countries and small islands might be among the most vulnerable (Perch-Nielsen, 2008). To the best of our knowledge, there are no studies up to now at the Swiss level.

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 would be obtained. Shall they be qualitative or quantitative? Participative or data-driven? Use complex models or transparent processes? Adapted to local or global analysis? Be dynamic or static? A list of possible methods and tools is given in Füssel (2007) and in particular in the UNFCCC compendium (UNFCCC, 2008[5]). We consider here the more relevant ones in relation to our objectives.

Expert judgement is an approach for soliciting informed opinions from individuals with particular expertise. One issue of these studies is that it should be given special attention to the choice of experts, in order to cover the full spectrum of options on a climate issue. 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. An example can be found in Brooks et al. (2005).

Participatory Geographic Information System (PGIS) uses local people's direct experience or historical 'folk memories' of floods, water-logging, landslides, avalanches, storm damage, coastal inundation, etc. in order to determine the extent of the hazard and the degree of risk (MC Call, 2008). These studies may draw maps to represent people's perception or to emphasize relative results. As stated by Forrester et al (2003); the clearness and conciseness of 'citizen maps' consents to decision makers to take into account citizen inputs which used to be ignored. This method is particularly suitable for regional studies. It is less appropriate for analyses carried out on a national or bigger level. More information can be found in PPgis.net[6].

[5] See http://unfccc.int/
[6] See http://ppgis.iapad.org/pgis.htm

Multicriteria analysis (MCA) is also a participative method, which allows including in the decision process different types of actors. It generally consists in collecting data on the region and in using GIS tools in order to managing, producing, analyzing and combining them. Criteria cover political economic, social and environmental aspects (Bell et al., 2003; UNFCCC compendium). The family of criteria used, to which actors assign a weight, allows considering different consequences and providing the basis for comparison of choices and consequently facilitate the selection of a satisfactory one. Multicriteria analysis is a method that is particularly applicable to cases where a single-criterion approach (such as cost-benefit analysis) falls short, in particular where significant environmental and social impacts cannot be assigned monetary values. MCA allows decision makers to include a full range of social, environmental, technical, economic, and financial criteria (UNFCCC compendium).

Another method is the sensitivity matrix described in the wiiADAPT website[7]. The sensitivity 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 consists in first listing the livelihoods in the case study region. In a second step, the possible impacts are enumerated (the list is set starting from stakeholders perceptions) and given a score. By weighting 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 (Yin et al. in Kulkarni et al. (2008)).

Finally, vulnerability mapping is a technique that partially includes some of those methods mentioned above. It is by far the most used method to assess vulnerability, even if carried out in different ways. Often political economic, social and environmental data on the given region are collected and analysed using GIS tools. It is an attractive approach to analyse the different possible impacts, and the interrelations between them; it also allows creating a general view of the areas where - according to the climate scenarios - the effects of climate change can have a major 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 has been made to standardize the methodological framework (Benioff et al., 1996; Kelly & Adger, 2000; Füssel, 2007; IPCC, 2007a; UNFCCC, 2008) or the choice of indicators for the three components 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

[7] See www.weadapt.org

vulnerability research (Vulnerability Network, 2009).

4. Adaptation

The concept of vulnerability is closely related to the concept of adaptation (Hilpert et al., 2007). The more a region (or a sector or a society) is vulnerable, the more severe the consequences of climate change are and the more it is important to implement adaptation measures. Adaptation was often neglected in early socio-economic impact assessments; it is now however widely recognized as an equally important and complementary response to greenhouse gas mitigation in addressing climate change (Agrawala & Fankhauser, 2008). There are different ways of categorizing adaptation, depending on five elements: (1) the spatial scale, (2) timing of action, (3) the actor, (4) the method, and (5) the driving force. Concerning the special case of Swiss tourism industry, these elements imply the following:

(1). Spatial scale: local, vs. regional, cantonal, national, international adaptation

Local and regional adaptation considers localized problems, generated for example by snow pack reduction, glacier melting or slope instability in a tourism resort or a region. Cantonal adaptation often consists in policy measures and financial incentives, designed to solve problems faced in different areas of the territory. So does also adaptation on a national or international level.

(2). Timing of action: proactive vs. reactive adaptation

In proactive adaptation, action is taken in anticipation of future climate change, whereas in reactive adaptation, action is taken in response to observed climate impacts.

(3). Actor: private vs. public adaptation

Private adaptation is an action taken by an individual (including firms), whereas public adaptation is an action taken by a group or government which acts to protect the group's interest (Mendelsohn & Neumann, 1999). Efficient private adaptations are likely to occur even if there is no official (governmental) response to global warming.

(4). Method: technological vs. behavioural adaptation

Technological adaptation focuses on technical measures given by technology. Examples of technological adaptation in relation to ski area operators are landscaping, slope development, a move to higher altitudes and north facing slopes, glacier skiing, and artificial snow making. Behavioural adaptation focuses, on the other hand, on operational practices, financial tools and new business models. Examples are all-year tourism, withdrawal, and a move towards the diversification of activities.

(5). Driving force: autonomous vs. 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 activities to summer ones or from skiing to wellness). Planned adaptation measures are conscious policy options or response strategies, often multisectorial, whose purpose is modifying the adaptive capacity of tourism or facilitating specific adaptations. For example, financial aid for investment projects, taking the form of subsides, interest-free loans, tax relief, etc.

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 & Fankhauser, 2008). Worldwide, there is nowadays a relatively large amount of literature on adaptation costs at a sectoral level (see, among others, Stern, 2006; UNFCCC, 2007; Oxfam, 2007; UNDP, 2007; World Bank, 2009).[8] This literature is, however, unevenly distributed across geographical areas and sectors, with particular weight given on the estimation of the costs and benefits of adaptation measures in coastal zones. Recently, a complete analysis of the cost of adaptation has been published by Parry et al. (2009). This study qualitatively discusses the estimates and illustrates the uncertainties of several recent studies reporting world-wide adaptation costs for climate change[5], rather than to develop new cost estimates. It pointed out how under-estimation can be generated by three main reasons: (i) sectors not included in an assessment of cost (in particular tourism, ecosystems, and energy); (ii) 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. Parry et al. (2009) stressed out 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, it stressed out how a major problem is the absence of case studies on a regional or national level to test the top-down form of these world-wide analyse.

4.1. Worldwide and national economic estimates of adaptation measures in tourism

Concerning tourism, the coverage of estimates of adaptation cost and benefits is very limited and often it only addresses winter and the ski tourism industry (Agrawala and Fankhauser, 2008; Parry, 2009). Summer and all-season tourism and the benefits that could be generated are often omitted. Some studies (e.g. Mathis et al., 2003; CIPRA, 2004; Agrawala, 2007; Teich et al., 2007; Perruchoud-Massy & Délétroz, 2004, and Bosello et al., 2007b) assess the costs and benefits of adaptation measures in the winter tourism industry and some of the costs provided for technological adaptation. Behavioural adaptation is also addressed, but is more difficult to assess in monetary terms. The following are examples of technological adaptation:

- protection of glaciers with white sheets: 3 Euros/m^2 (Agrawala & Fankhauser, 2008);
- extension of ski areas to high elevations in Switzerland: 25-30 Mio Euros (Mathis et al, 2003);
- investment costs for snow-making material (in France in the winter season 2003-04): 60 Mio Euros (Mathis et al., 2003);

8 See Agrawala & Fankhauser (2008) for an overview.

- production of artificial snow: 1-5 Euros/m^3 (after Association of Austrian Cableways in Agrawala & Fankhauser, 2008), 3-5 Euros/m^3 or 136,000 Euros/ha (CIPRA, 2004);
- operational costs for producing artificial snow in Switzerland: 19,000-32,000 Euros/km (Mathis et al., 2003);
- operational costs for snow making material (in France in the winter season 2003-04): 9.4 Mio Euros (Mathis et al., 2003);
- maintenance costs for snow making material in Switzerland: approximately 8.5% of the income (Bosello et al., 2007a).

However, this kind of adaptation is not necessarily sustainable in the long term (because of energy and water consumption, ecosystem degradation, and glaciers melting) and it could generate negative externalities. These externalities have not been taken into account until now, and their inclusion may increase costs significantly (Agrawala & Fankhauser, 2008). Gonseth (2008) analysed the achieved level of investments towards snowmaking facilities and the future commitment of Swiss cantonal authorities in the adaptation process. He found that the overall financial support (the overall equivalent subsidy) reached in 2006 12.5 Mio CHF_{2006}.

4.2. Adaptation in the Swiss policy

The Swiss Confederation tackles both climate change causes (mitigation) and consequences (adaptation) (FOEN, 2009). Specific legislation dealing with the subject of climate change[9] only partially addresses the latter, and generally with concern for financing adaptation measures in developing countries[10]. Legislation on adaptation is generally sector- and problem-specific and often implicitly included in already existing legislation[11]. Instruments consist in both technical regulation and economic mechanisms. This 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 in the competence of the different cantons and communes. The Confederation assists with data acquisition, consulting, information, formation and subsides. 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, the existing measures being already effective. Concerning natural hazards, on the recent years, the tendency has been to pass

[9] RS 641.71 'Loi fédérale sur la réduction des émissions de CO2 (Loi sur le CO2)'.

[10] RS 0.814.01 'Convention-cadre des Nations Unies du 9 mai 1992 sur les changements climatiques' and RS 0.814.011 'Protocole de Kyoto du 11 décembre 1997 à la Convention-cadre des Nations Unies sur les changements climatiques'.

[11] 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'.

from remediation to the prevention of their occurrence. Therefore more and more importance is given to the evaluation of the risks, to risk mapping, monitoring, to the development of technical measures, to early warning systems and to the limitation of residual risks. The adaptation strategy includes both the adjustment and reinforcement of these mechanisms to the new frequency and intensity of already existing events (floods, avalanches) and their adaptation 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. For tourism, legislation mainly deals with economic promotion and regional development. Its application mainly consists in support policies carried out at federal, cantonal and communal level. These policies mainly refer to financial aid for investment projects taking the form of subsidies, interest-free loans, loan's guarantees, tax relief, debt forgiveness, etc. (Gonseth, 2008).

In general, the Confederation, the cantons and the communes try to avoid the implementation of what is called 'maladaptation': adaptation measures which contribute in enhancing climate change (DETEC, 2007). This are for example snow making[12] and climate control of buildings. It also privileges 'no-regret' adaptation measures, adaptation measures that have benefits if climate does not change.

Conclusion

After decades during which the subject of socio-economic impacts and of possible adaptation measures was scarcely addressed, it is now gaining exponential attention. More and more studies appear which are specially dealing with the social and economic aspects of climate change and with the estimation of the socio-economic effects of possible adaptation measures. Research is still in its infancy and there is an urgent need for more precise values and estimations. It is in this optic that we see this work filling some of the many gaps, and addressing some of the many questions that still need to be answered. Assessing the impacts and the vulnerability of the tourism industry in Switzerland will allow evaluating which tourism regions will, on the near future, win or lose due to climate change. It will also outline which ones more urgently need start implementing adaptation measures. In addition, the vulnerability assessment could help identifying possible similarities between areas and it will therefore outline where the implementation of collaboration and information sharing could be enhanced. The creation of a vulnerability map is the future line of this research. The subject of the ongoing work is of particular importance due to the vulnerability of the industry 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 in a broad context due to the urgent need for more detailed assessments of adaptation costs.

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[12] This is a contradiction, seeing that in reality snow-making is broadly diffused and supported by cantons (Gonseth, 2008).

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