The vulnerability of Swiss Alpine tourism to climate change – an analysis of its causes, magnitude, and spatial heterogeneity[1]

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Abstract

In this work, we analyze the vulnerability of tourism to climate change in 53 Swiss alpine regions. 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 these areas. Simulations on the possible impacts and statistical data were collected for the different regions. The obtained results consent to identify the most important drivers influencing vulnerability. They moreover permit to assess spatial heterogeneity in vulnerability. Finally, they allow recognizing hotspots – areas where the implementation of adaptation measures is more crucial.

Keywords: vulnerability, Swiss tourism, climate change, Multicriteria Analysis, GIS tools

1 Introduction

Climate change has and will have several consequences for tourism in Switzerland. In particular, 7 impacts appear to play a major role: 1) changes in climate suitability for tourism activities, 2) snowpack reduction, 3) glaciers melting, 4) permafrost melting, 5) natural hazards, 6) water scarcity, and 7) changes in landscape and scenic beauty. Hotter summers in the south of Europe, in urban centres and in the lowlands make these regions less suitable for summer tourism. Tourists do, and will even more in the future, move to higher and cooler locations (the North, the Alps, lakes) in search of summer coolness. Mountainous and lake regions in Switzerland benefit therefore from the evolution. With an increase in temperatures, on the other hand, lowland regions are increasingly lacking of snow. Consequently, winter tourism in these regions suffers from worse supply conditions and a lower attractiveness. Though, the relative good situation of some Swiss regions in comparison to the rest of the Alps (high altitude ski resorts in Valais and Graubünden) brings some advantages to these areas also in winter. With higher temperatures, glaciers and permafrost are affected as well. Glaciers have a high power of attraction on tourists

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for their beauty. They also play an important role as water reservoirs during summer. Permafrost (frozen soil) stabilises the slopes at high altitudes. With the melting of the two, tourism suffers from losses in attractiveness (lower scenic beauty, water supply, higher dangers for human lives due to glacial lakes, rockfalls, etc.) and from higher costs generated on infrastructure from permafrost melting. Moreover, climate change modifies the intensity, location and frequency of natural hazards such as floods, landslides, or debris flow. This alters once again the attractiveness and the costs on infrastructure of a region. In addition, tourism depends on water in many ways. If water becomes scarce because of lack of precipitations or because a higher consumption for snowmaking; this will generate conflicts with other sectors, as for example energy production and agriculture. Finally, higher temperature marks high-alps scenery. Many aspects of landscape (vegetation, soil and – as seen before – glaciers) are and will be affected by climate change. The upward shift of the treeline can decrease the attractiveness of a region and therefore also affect tourism demand. Three reports presenting these impacts, their socio-economic consequences, and the possible mitigation and adaptation strategies have been made available to stakeholders so far (Müller & Weber 2007; Müller & Weber 2008; Abegg 2011). Additional information can be found in Matasci and Altamirano-Cabrera (2010a, 2010b). Various studies analysed more in detail some of these impacts, sometimes considering the entire country, sometimes looking at a specific case study region. Serquet and Rebetez (2011) looked at climate suitability and analysed the effect of hot summer air temperatures on tourism demand. They found that alpine tourist resorts could benefit from hotter temperatures at lower elevations under future climates. Bürki (1995), Elsasser et al. (1995), Abegg (1996), König & Abegg (1997), Bürki (2000), Elsasser & Messerli (2001), Elsasser & Burki (2002), and Abegg et al. (2007) looked at winter tourism and at the effects of snow pack reduction. They all outlined the high vulnerability of lowland regions in relation to this impact. Some pointed out the relative benefits for higher locations. To our knowledge, the effects of other climate change impacts on Swiss alpine tourism have not been studied specifically up to now. Finally, some studies tried to quantify the economic impacts of climate change on tourism. Müller and Weber (2007) looked at the regional impacts for the Bernese Oberland, whereas Meier (1998) and Ecoplan/Sigmaplan (2007) looked at the country level. Even if they gave different numbers, the two studies carried out at the Swiss level agreed in defining tourism as one of the most affected sectors in Switzerland. Nonetheless, none of them looked at vulnerability and how specific regions within Switzerland will be differently affected by climate change.

This paper tries to fill this gap. The aim of the study is hence to define the vulnerability of Swiss Alpine tourism to climate change, to analyse its causes, its magnitude and its spatial heterogeneity. Often stakeholders guess the large transformations that climate change could bring to the current tourism structure. People in the field are the first to detect landscape and climate transformations and changes in tourism behaviour. However, often climate change is placed on a lower priority level than other, more direct, threats to their business. This work wants to raise stakeholders' awareness and attention on the many challenges that the sector is already facing and will face in the future because of climate change. A higher consciousness of the prob-

lem, together with a higher awareness of the environmental impacts of the sector, could be a first step towards the beginning of a sustainable adaptation process in the different – and in particular in the more affected – regions. This study does not want to give a precise estimation of the risks that the different regions are going to face. Doing this is still difficult because of data gaps and the lack of an objective assessment of the relative importance of the impacts. Results should give an idea of what could be: 1) the most important drivers influencing vulnerability; 2) spatial heterogeneity in vulnerability; 3) hotspots – areas where the implementation of adaptation measures is more crucial; and 4) data gaps and fields where more research should be carried out. The work aims, therefore, at being more an instrument that allows stakeholders to compare results with their own subjective perceptions of vulnerability in their region, and that encourages them to discuss and share information.

2 Background

To address our research questions, we have chosen to do a vulnerability mapping. Vulnerability is 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" (Appendix I; pag. 93). We examine this aspect because considering only climate impacts in themselves does not allow defining the entire social, economic and ecological consequences of climate change. The local structures of the society, of the economy, of the institutions, etc. do also play a role.

Research on vulnerability is still not very widespread, even if an increased number of studies have emerged in the last years. A common methodology does – and perhaps could – not exist (each case faces different problems and research questions). Here a mix of several methods is used: in a first step, a literature review and a follow-up discussion with experts and stakeholders allowed for defining the more relevant impacts and indicators depicting the vulnerability of tourism in Switzerland in relation to climate change. Experts were then interviewed using a Pairwise Comparison (AHP) Multicriteria Analysis (MCA) 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. Information on the indicators was then collected for the 53 different tourism regions considered in our study. Data was mainly obtained from different Swiss Federal Offices and from research groups working in simulating the future impacts. For some indicators, data was not available at the moment or was otherwise difficult to obtain for the entire set of considered regions. Indicators with missing values were nonetheless considered in the research in order to define data gaps, areas where more research should be carried out. Next, the data was treated, aggregated and presented as maps using GIS tools (ArcGIS 9.3).

3 Data

70 indicators were selected in order to depict the exposure, the sensitivity and the adaptive capacity of the different tourism regions[2]. Data was mainly supplied by – or calculated starting from information delivered by – research groups and projects working on simulating future scenarios (ENSEMBLE[3], PESETA[4], GLIMS[5]), the Federal Office for the Environment (FOEN), the Federal Office of Topography (SwissTopo), the Federal Statistical Office (BFS), the Swiss Federal Institute for Forest Snow and Landscape (WSL), Laurent Vanat (Consulting on winter tourism for Switzerland), and by the CEAT ('Communauté d'études pour l'aménagement du territoire') at the Swiss Federal Institute of Technology of Lausanne (EPFL). GIS tools were used for the calculations. A comprehensive description can be obtained by contacting the author. Some of the chosen indicators depict positive exposure or sensitivity. For example, a high climate suitability for tourism activities or an elevated percentage of mountainous or lake areas in the regions have very probably a positive effect in the development of summer tourism in the region as an alternative to the heat of the lowlands and of the urban centres. In the same perspective, ski resorts at high elevation will have an advantage over ski resorts located in the lowlands, which are affected by snowpack reduction. Finally, information is not available for all the retained indicators (data gap). For example future water availability is an important factor defining the exposure of the region (less water for tourism activities, competition for water with other sectors). Information on this aspect has been recently delivered and will be included in the analysis in a next step[6].

4 Method

Alpine tourism regions were defined in a way to which tourism-related stakeholders could easily associate and that possess in some degrees an internal homogeneity in tourism structure. The selection of the regions was carried out considering the 13 Swiss tourism regions defined by MySwitzerland[7]. These regions were further divided in 85 smaller units by taking – when available – possible internal subdivisions proposed by the 13 regions themselves. Additionally, experts were asked to give feedback on the generated map. This allowed further enhancing the quality of the subdivision.

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[2] A first list is presented in Matasci and Altamirano-Cabrera (2010b) Nonetheless, some modifications were made For a more up-to-date list of the indicators used, a description of their meaning, sources or other, please contact the author

[3] http://www ensembles-eu org (accessed: 10/12/2009)

[4] http://peseta jrc ec europa eu (accessed: 03/02/2010)

[5] http://www glims org/ (accessed: 09/03/2010)

[6] Data have been provided by the Mountain Hydrology and Torrents unit of the WSL (http://www wsl ch/fe/gebirgshydrologie/index_EN, accessed: 01/05/1011), where a study on the future impacts of climate change on the Swiss hydrology is being carried out

[7] http://www myswitzerland com/en/destinations html (Swiss tourism regions at the 2010 state) (accessed: 26/06/2010)

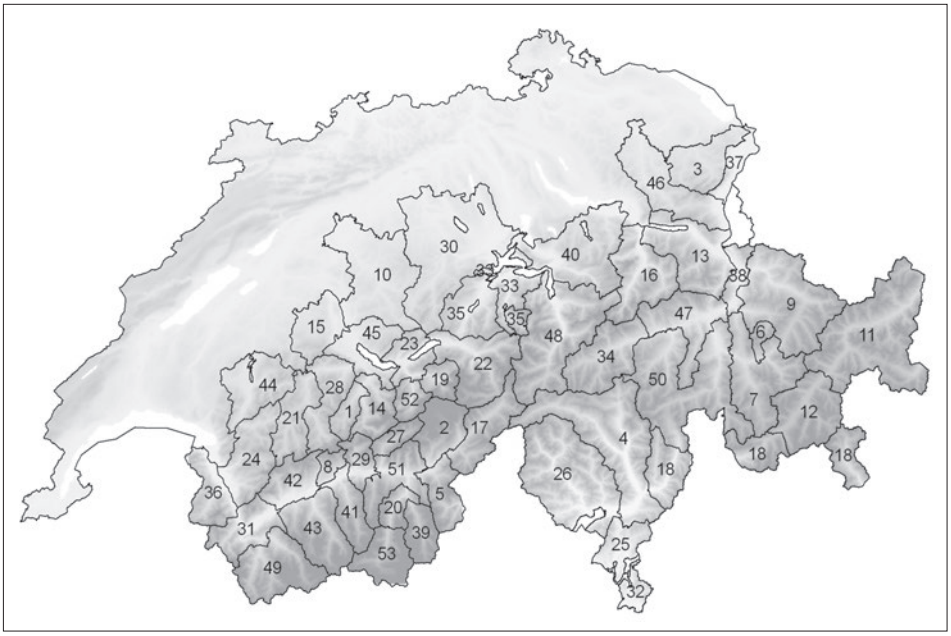

Figure 1: The 53 tourism regions considered in this study: 1. Adelboden, 2. Aletsch, 3. Appenzellerland, 4. Bellinzona and Northern Ticino, 5. Brig – Belalp, 6. Central Graubünden – Arosa, 7. Central Graubünden – Lenzerheide, Savognin, Bergün, 8. Crans-Montana, 9. Davos Kloster, Prättigau, 10. Emmental, 11. Engadin Scuol, 12. Engadin St. Moritz, 13. Ferienregion Heidiland, 14. Ferienregion Lötschberg, 15. Gantrisch Region, 16. Glarnerland, 17. Goms, 18. Graubünden – Italian-speaking area, 19. Grindelwald, 20. Grächen-St. Niklaus, 21. Gstaad-Saanenland, 22. Haslital, 23. Interlaken, 24. Lake Geneva Region – Alps, 25. Lake Lugano, 26. Lake Maggiore and Valleys, 27. Lauchernalp – Lötschental, 28. Lenk – Simmental, 29. Leukerbad, 30. Luzern Region, 31. Martigny Region, 32. Mendrisiotto, 33. Nidwalden, 34. Obere Surselva, 35. Obwalden, 36. Portes du Soleil – Chablais, 37. Rheintal, 38. Rhine Valley, Bündner Herrschaft, Chur, 39. Saas-Fee/Saastal, 40. Schwyz, 41. Sierre – Anniviers, 42. Sion Region – Anzère, 43. Sion Region – Les 4 vallées et Evolène, 44. The Pre-Alps – Gruyères – Moléson, 45. Thunersee, 46. Toggenburg, 47. Untere Surselva, 48. Uri, 49. Verbier St-Bernard, 50. Viamala, 51. Visp Region, 52. Wengen-Mürren-Lauterbrunnental, and 53. Zermatt Matterhorn.

Only the 53 regions covering the Alpine arc were kept for this analysis (Figure 1).

The main climate change impacts of particular relevance for tourism in Switzerland, as also the indicators depicting exposure, sensitivity and adaptive capacity were selected based on the published literature on climate change impacts (using the SWIDCHI[8] database) and on vulnerability assessment (Brooks et al. 2005; Perch-Nielsen 2008; Preston et al. 2008). Discussions with experts and stakeholders (in particular in the frame of the ClimAlpTour project[9]) allowed improving the choice. Finally, 70 indicators were selected. 13 depict exposure, 40 depict sensitivity, and 17 depict adaptive capacity. Information was gathered for the 70 indicators and for the

[8] See http://swidchi epfl ch/ (accessed: 22/09/2011)

[9] 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/ (accessed: 26/05/2011)

53 tourism regions. Proxy data representing each variable were acquired from a variety of sources. Care was taken in choosing indicators that were well-founded, accurate, non-ambiguous, comprehensible, relevant, responsive to changes, with high information content, available, and homogeneous data (after Perch-Nielsen 2008; based on Atkins et al. 1998; OECD 2001; Kaly et al. 2003; Esty et al. 2006). Adaptive capacity is the more critical component of the three; the choice of its indicators being particularly subjective and trustworthy information being often difficult to obtain. Some of the chosen indicators are ambiguous (in their interpretation, they can go on two different directions), some are missing. We are aware of the drawbacks, but decided to consider them nonetheless because believing them to carry important information.

Pairwise Multicriteria analysis was used in order to assess the relative importance of each indicator in depicting vulnerability. Multicriteria Analysis aims at investigating a number of choices in the light of multiple criteria and conflicting objectives (Voogd 1982), and generating rankings or weights of the choice of alternative indicators. It is a participative method, which is designed to help decision-makers to investigate the different alternatives or options to attain a specific goal. In vulnerability assessment, this method has the advantage to consider social, political, and environmental indicators that would otherwise be difficult to translate in monetary terms, for example in a cost-benefit analysis. Because of the high number of indicators, and the consequent high number of choices, the Analytic Hierarchy Process (AHP) was selected. 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. The method has the advantage of being highly trustworthy and quite precise in comparison with the others (Thill 1999). An explanation of the methodology can be found in Saaty (1977) and Saaty (1987). Pairwise comparisons between the 70 selected indicators were subsequently broken down into thematic categories, and classified into 5 different levels. 23 matrices and 204 pairwise comparisons were generated as a result. Multicriteria analysis was performed by carrying out face-to-face interviews with 13 Swiss experts. Experts were chosen in regard to the possession of the following criteria: 1) a very good knowledge of Swiss Tourism; 2) a good knowledge of climate change related topics; 3) 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); 4) working on the subject at the present time; and 5) willing to participate. Care was also taken in selecting people coming from different horizons (scientists, tourism operators, directors and members of the administration of tourism- and nature-related corporations and organisations, etc.) in order to enclose different perceptions of the problem. Because of the high number of pairwise comparisons requested by the MCA, it was asked of each expert to fill only some of the matrices. Care was taken, however, in having always at least 3–4 answers for each matrix in order to have a minimum variety of opinions. The consistency of the results was checked, and when necessary it was asked of experts to rethink and modify their results in order to avoid inconsistency (e.g. $A >\sim B >\sim C >\sim A$). Results were considered consistent when a Consistency Ratio lower than 0.1 was obtained (Saaty 1987). When experts did not modify a ma-

trix, this was excluded from the analysis. Data elaboration was carried out using GIS (ArcGIS 9.3) tools. Values of each indicator were ranked between regions by giving a 1–10 relative score. Indicators were then pondered using the weights generated by the MCA. Finally, a hierarchical cluster analysis was performed using R v2. 11.1 (2010). This was done in order to establish similarities between regions.

5 Results

5.1 Most important drivers influencing vulnerability

Discussions with experts and the Multicriteria Analysis allowed us to establish the most important drivers influencing vulnerability (Figure 2). 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 appears to play the most important role (79/100 against 21/100 for feasibility). In the feasibility sub-category, mainly the economic (30/100) and the technological (23/100) aspects appear to play the largest role. 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). Afterwards these were 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 from the tourism sector in this direction (29/100) and the political framework (results of a 2008 vote related to the right of appeal of organisations) (14/100) (both in the adaptive capacity category) account for 43/100 of the total vulnerability score. Other indicators follow with a far smaller grade. After experts' judgement, 24 indicators (over the 70) account for 80/100 of the score. Results given by experts were particularly homogenous in assessing the relative score of exposure, sensitivity and adaptive capacity and of the two compo-

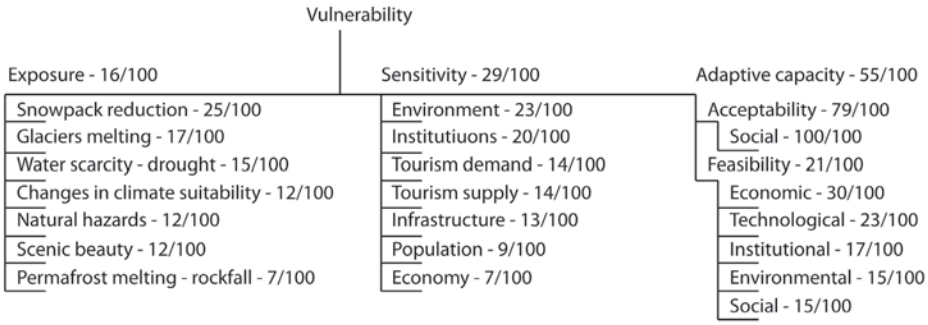

Figure 2: Scores generated by the MCA.

nents of adaptive capacity (feasibility and acceptability). They did, however, sometimes diverge in the other categories. A sensitivity analysis allows us to consider this point. Interestingly, scores for adaptive capacity correspond particularly well with was what found by Greiving et al. (2011) in their Delphi analysis for the ESPON Climate project[10].

5.2 Data gaps

As we mentioned previously, not all the indicators could be described quantitatively. Data gaps indicate to researchers where more investigation should be carried out or where more information should be gathered. On the 70 indicators selected, 18 were not available. Of them, some do not exist at the moment but will be available in a near future (e.g. calculations on future water availability), some need a more thoughtfully 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), 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 communes). Finally, some are difficult to quantify (possibility of self green energy development, landscape beauty). All of them, however, carry important information in defining vulnerability. Regrettably, data is missing mostly where more importance was given by experts. Considering the weights given to each indicator, 34% of adaptive capacity and 30% of sensitivity information is lacking. The missing data is lower for exposure (15%). In this category, only information on future water availability is not available for the present analysis. Data gaps in the sensitivity category mainly concern the environment, the economy and the infrastructure, whereas in the adaptive capacity, only technological and institutional feasibility seem to be well depicted. Ongoing collection of the missing data, where possible and more needed – will allow us to decrease the data gap from the actual 48% to only 11% of the total.

5.3 Spatial heterogeneity in vulnerability

Because of the importance given by experts to adaptive capacity, and because the difficulty in depicting this aspect clearly (large data and knowledge gaps), it is still problematic to define spatial heterogeneity in vulnerability. At the moment, the map reflects mostly the political framework described in the social acceptability of adaptive capacity. Precisely because of the high relevance of data gaps, we will not consider this map as definitive. It is more an intermediate result that needs supplementary and deeper investigation. We therefore present in Figure 3 only the three desegregated maps depicting respectively exposure, sensitivity and adaptive capacity.

[10] http://www.espon.eu/ (accessed: 14/06/2011)

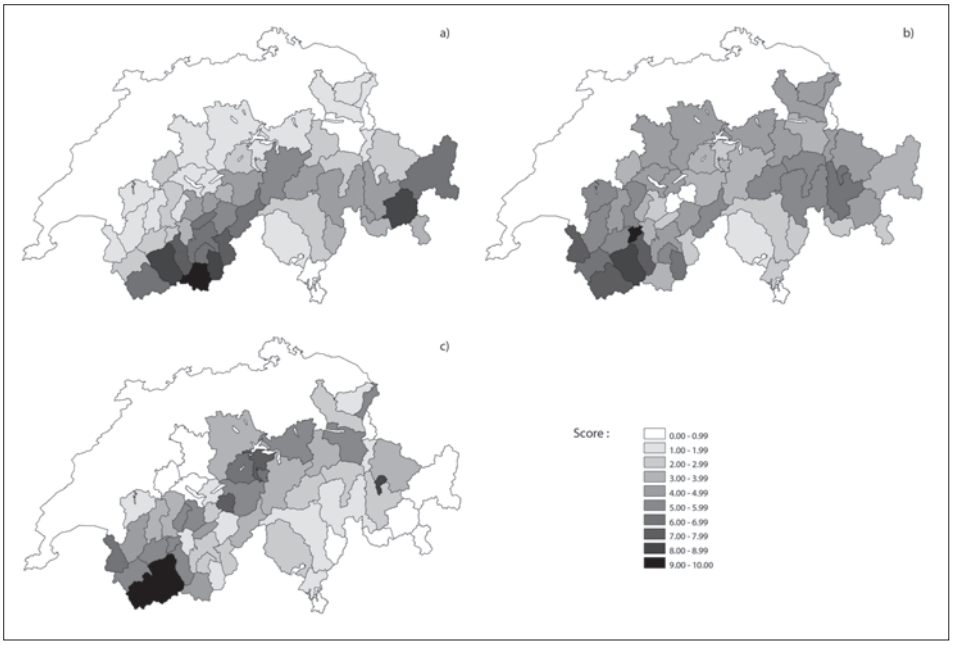

Figure 3: Representation of respectively a) exposure; b) sensitivity, and c) adaptive capacity of the 53 regions in Switzerland analysed. The higher the score (and the darker the region), the higher the exposure and the sensitivity and the lower the adaptive capacity. The adaptive capacity map needs to be considered with care.

5.4 Hotspots – areas where the implementation of adaptation measures is most crucial

Because of the abovementioned problems with adaptive capacity, we will also avoid defining hotspots at the moment. More research on adaptive capacity is needed before making any sound assessment. In particular, more information on the acceptability of adaptation measures and on the willingness to adapt of both the population and stakeholders is needed. Also needed is information on the possible barriers hindering the process. Looking only at greatly exposed regions (Figure 3a), highly located Valais and Graubünden tourism areas seem to be more affected. Zermatt Matterhorn and Engadin St. Moritz appear to be two of the most exposed regions. Generally, Valais regions appear to be fairly more sensitive, as could be seen in Figure 3b. The top 3 more sensitive regions being located in this canton (Crans-Montana, Sion Region – Les 4 vallées et Evolène, Sierre – Anniviers). Also Central Graubünden (Arosa and Lenzerheide, Savognin, Bergün) is particularly concerned. Concerning adaptive capacity, as said, the map reflects at the moment mostly the political framework described in the social acceptability of adaptive capacity. This is represented here mainly by the scores of a vote on the right of appeal of organisations in relation to environmental protection and regional planning. Verbier St-Bernard, Sion Region – Les 4 vallées et Evolène, and Central Graubünden – Arosa showed a particularly strong opposition to this right.

6 Discussion

The vulnerability assessment carried out in the frame of this study should give an idea of the most important drivers influencing vulnerability; of the spatial heterogeneity in vulnerability; and the hotspots – areas where the implementation of adaptation measures is more crucial. Concerning the drivers influencing vulnerability – perhaps unexpectedly – the higher importance was given by experts not to exposure but to adaptive capacity. This has as a consequence that those regions that are highly exposed, but in where people are willing to adapt and to grasp the opportunities given by climate change, appear to be less vulnerable compared to places where people are less open to innovations in the sector. It appears also that the local environment is an important asset, to which experts give a high importance in defining the sensitivity of the regional tourism. Results also illustrate how climate change affects tourism in a far much broader way that is commonly discussed. Snowpack reduction is not the only impact affecting the sector. Other aspects, such as glaciers melting, water scarcity and drought, changes in climate suitability, natural hazards and scenic beauty are also relevant and their effects should be considered when developing local tourism adaptation strategies. It is still difficult at the moment to define hotspots. This because of the high importance given by experts to adaptive capacity, and because of the lack of information on this subject. Indicators of adaptive capacity are difficult to identify, as adaptive capacity is not directly measurable (Brooks & Adger 2005; Adger & Vincent 2005). More research has to be carried out before making any sound statement. Highly located regions in Valais and Graubünden appear to be the most exposed, they will however not be necessarily the more vulnerable. Finally, the analysis of data gaps shows the limits of the methodology. Data is still lacking, and more research and effort should be carried out to fill these knowledge gaps.

7 Conclusions

As mentioned above, this research should not be taken as a precise estimation of the impacts of climate change on tourism in Switzerland, nor be a tool to establish where money should be allocated. It should be more an instrument allowing stakeholders to compare results with their own subjective perceptions of vulnerability in their region, to define where more research should be carried out, and that consents them to discuss and share information. Its final goal is to raise stakeholders' awareness and to be an enticement for the starting of local adaptation processes. In addition, what still misses in this research is a better definition of adaptive capacity. The next step to this research is to better define this concept and to collect feedbacks from the various stakeholders. This will be done by mean of a virtual platform of exchange. The tool will allow giving access to information and raising climate change awareness among decision-makers and stakeholders. At the same time, this platform will allow collecting missing data at the regional level, permitting to refine the present vulnerability assessment.

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