Climate change and tourism – scenario analysis for the Bernese Oberland in 2030

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Abstract

Purpose – *The purpose of this paper is to evaluate possible impacts of climate change on tourism on a regional level and therefore to provide a basis for discussion for tourism destinations.*

Design/methodology/approach – *By means of a statistical analysis of data and a comprehensive desk research, the ecological consequences of climate change on regional level were outlined. In expert workshops, the effects on tourism were discussed and the main challenges for tourism enterprises and destinations were derived.*

Findings – *The ecological consequences of climate change are shown for the different destinations in the Bernese Oberland. The economic effects on tourism under changed conditions are estimated. The changes in tourism revenue, including adaptation measures, would result in annual losses of approximately 70 million CHF, or about – 4 per cent.*

Research limitations/implications – *There are many uncertainties regarding climatic development, effects on tourism and adaptability of the industry. In addition, the impacts depend heavily on local conditions and the structure of tourism.*

Practical implications – *The paper provides a useful basis for discussion for alpine tourist destinations planning to set climate change and its consequences on the agenda and develop strategies to face these new challenges.*

Originality/value – *This paper presents an analysis of ecological consequences of climate change and possible implications on tourism on a regional level and points out the challenges as well as possible mitigation and adaptation strategies.*

Keywords *Climatology, Global warming, Tourism, Switzerland*

Paper type *Case study*

Background and objective

Climate change is expected to bring substantially higher temperatures and to impact particularly severely on the alpine region (OcCC, 2002). In addition to warming, changes are being forecast in connection with rain and snowfall (precipitation) and other aspects of the climate. Tourism is very vulnerable to changes in climate and the natural environment, not only because of its economic importance in mountain areas, but also because of its degree of exposure.

Those immediately affected will inevitably have to concern themselves with the new challenges in good time and to reflect on possible future strategies. The Bernese Oberland wants to be at the cutting edge of this process, so the study commissioned by the nine destinations was to highlight the possible implications of climate change for tourism in the Bernese Oberland, to enable them to conduct a well-informed discussion about potential adaptation and prevention strategies. Although there are already some studies dealing with the consequences of climate change on alpine tourism, most of them did not focus on a regional level. In addition, not only the impacts of climate change on the skiing industry was to be analysed, but also possible impacts on summer tourism were integrated, so that a basis for the discussion of adaptation and mitigation measures resulted for the tourism destinations of the Bernese Oberland.

Methodology and structure

Main objective of the study was to evaluate the relevance of different impacts of climate change for the nine destinations and to outline the possible processes in two scenarios. The scenario-method seemed to be the most adequate because looking in the future means dealing with many uncertainties. A scenario is the description of a future situation and the relevant development patterns. The scenario method can be used to combine isolated ideas about positive and negative changes in individual development factors in the future in order to form comprehensive pictures and models (see von Reibnitz, 1991). A scenario is a model of the future that is prepared using specific assumptions with the soundest possible scientific foundation.

Comprehensive analysis of the present situation is a prerequisite for understanding the interactions involved. Furthermore, the influence parameters have to be recorded and assessed, taking account of imponderables and knowledge gaps.

There are no model calculations for the ecological consequences because scientific research as it currently stands provides no detailed information about the interrelationships, so the repercussions are usually not quantifiable. That is why, on the basis of the scenarios outlined, the study aims merely to identify trends and to make a qualitative assessment of developments. Despite major imponderables, an attempt is made to bring out the ecological consequences for the individual tourism destinations in the Bernese Oberland. However, climate change developments can only be broken down to regional scale to a limited extent. Sometimes there are microclimatic differences between the destinations or alpine valleys that can only be hinted at because the climate models are not sufficiently fine-meshed. That is why this study does not aim to present all possible developments but to select specific sequences and deduce corresponding trends.

The following multi-level procedure was adopted, taking the evaluation of existing studies and statistics as its starting point:

1. Out of the findings from secondary studies the potential impacts of the changes on the destinations were estimated.
2. The results were submitted to a group of stakeholders and discussed in depth at a workshop with representatives of all branches of tourism.
3. The results of the workshop were prepared and discussed a second time in the accompanying working group.
4. The inputs out of these workshops were finally adjusted and integrated in the paper.

The emphasis was on stakeholders connected with mountain railways and ski schools, accommodation (particularly the hotel industry) and providers of outdoor services (especially mountain guides), as well as on tourism organisations and local authorities.

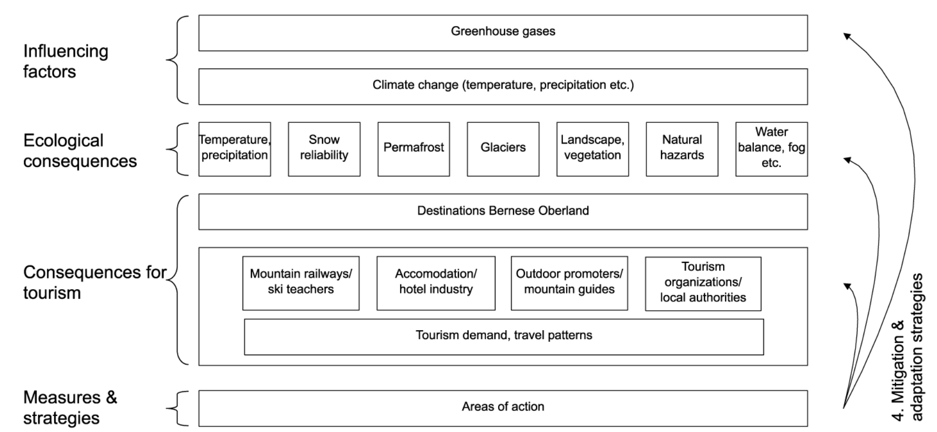
Attention focused exclusively on factors directly connected to climate change (see Beniston, 2003). The climate change-tourism system is not just a simple matter of cause and effect but a multi-stage functional chain with several levels as shown in Figure 1.

Influencing factors

Even though the scale of the contribution of greenhouse gases to climate change cannot be exactly quantified, it is an acknowledged fact that there is a significant link between anthropogenic emissions and climate change. The climate changes in respect of temperature and precipitation forecast by the International Panel of Climate Change (IPCC) (IPCC, 2001, 2007; Wigley and Raper, 2001) serve as a basis for this.

Because there is major uncertainty both about the scale of climate change and its consequences, the range is covered by a minimum and a maximum scenario:

Figure 1 Scenario analysis model diagram



Source: Müller and Weber (2007, p. 16)

- *Ecological consequences.* There is considerable uncertainty about the repercussions on various natural environments. The possible ecological consequences are assessed and described for both scenarios.
- *Consequences for tourism.* The degree to which the individual destinations are affected is outlined in a subsequent step. Then, the importance of the changes for the various tourism stakeholders is established, with only one picture being shown for both scenarios. Lastly, the possible financial consequences of additional investments and/or costs as well as the revenue implications of changing tourism demand can be deduced.
- *Strategies and measures.* Although anthropogenic interventions are excluded from the scenario design process for the time being, the ultimate objective is to identify possible adaptation and prevention strategies.

Starting-point scenarios until the year 2030

Table I shows the probabilistic temperature projection and Table II shows the most probable precipitation projection for the north side of the Alps in Switzerland with changes to the seasonal precipitation mean.

Rising temperatures can be expected in any event. While summers will be drier, more precipitation can be expected in winter – in the form of rain at lower altitudes and of snow at higher ones. The range of uncertainties in these projections forms the basis for the minimum and maximum scenarios without, however, calculating specific probabilities. The starting points for the minimum scenario are the smallest probable increase in temperature and minimum changes in precipitation compared with the status quo, while the maximum scenario assumes the biggest possible increase in temperature on the basis of the calculations as well as the maximum deviations as regards precipitation. Admittedly, the

Table I Temperature change 1990-2030 (degrees Celsius)

	Probability	*0.025 (Min. scenario)*	*0.5*	*0.975 (Max. scenario)*
Northern Switzerland	Winter (DJF)	0.4	1	1.8
	Spring (MAM)	0.4	0.9	1.8
	Summer (JJA)	0.6	1.4	2.6
	Autumn (SON)	0.5	1.1	1.8

Source: Frei (2004)

Table II Changes in precipitation 1990-2030 (in percent)				
	Probability	*0.025*	*0.5*	*0.975*
Northern Switzerland	Winter (DJF)	−1	+4	+11
	Spring (MAM)	−6	0	+5
	Summer (JJA)	−18	−9	−3
	Autumn (SON)	−8	−3	0

Source: Frei (2004)

most probable values lie somewhere between the scenarios, but this approach covers the range of possible changes best.

Ecological consequences

The impacts of climate change on various ecological parameters are presented in the following section. To know about these ecological changes is crucial for the valuation of the future tourism in the Alps, because most of them are of great importance for tourism in a direct or indirect way.

Snow reliability

Investigations of snow depth variations between 1931 and 1999 reveal a steady increase in the amount of snow, the duration of snow cover and the number of days on which snow fell until the early 1980s. Since the Eighties however, the data for all the variables studied show a sharp downturn (Laternser and Schneebeli, 2003).

The trend towards less snow depends on altitude. While ski areas situated higher than 2,000 metres above sea-level show almost no tendency towards less snow, the decrease is all the more pronounced the lower a resort lies. For resorts at an altitude of less than 2,000 metres, the 1990s were by far the decade with the least snow since 1930 (Laternser and Schneebeli, 2003). The increase in winter precipitation will also bring more snow at higher altitudes, while there will be more rain in lower locations. According to a rule of thumb, the snow line rises roughly 100 to 150 metres with each degree of temperature. In Switzerland, an area is regarded as having guaranteed snow when there has been a minimum snow depth of 30 centimetres that is suitable for winter sports from 1 December to 15 April for a minimum of 100 days during at least seven out of ten winters (Abegg, 1996).

An OECD study (Abegg *et al.*, 2007) clearly highlights the consequences of an increase in temperature for winter tourism in the Alps in general and in Switzerland in particular (see Table III).

An analysis of meteorological data shows four snow reliability trends for the Bernese Oberland.

Warmer winters. Between 1955 and 1989, the average winter temperature was 2.4°C and, between 1990 and 2006, 2.9°C (Interlaken Measurement Station). Over the past 50 years, winters in Interlaken have warmed up considerably, and this also applies to higher resorts. Figure 2 shows the snow depths at Christmas in Wengen over the last 50 years.

Later snow. Taking 25 December as the reference date reveals a trend towards a thinner covering of snow even at higher altitudes at that point in time. Over the past 50 years, the average snow depth at Christmas has fallen by about half. Between 1991 and 2006, there was much less snow than on average for 1955 to 1990.

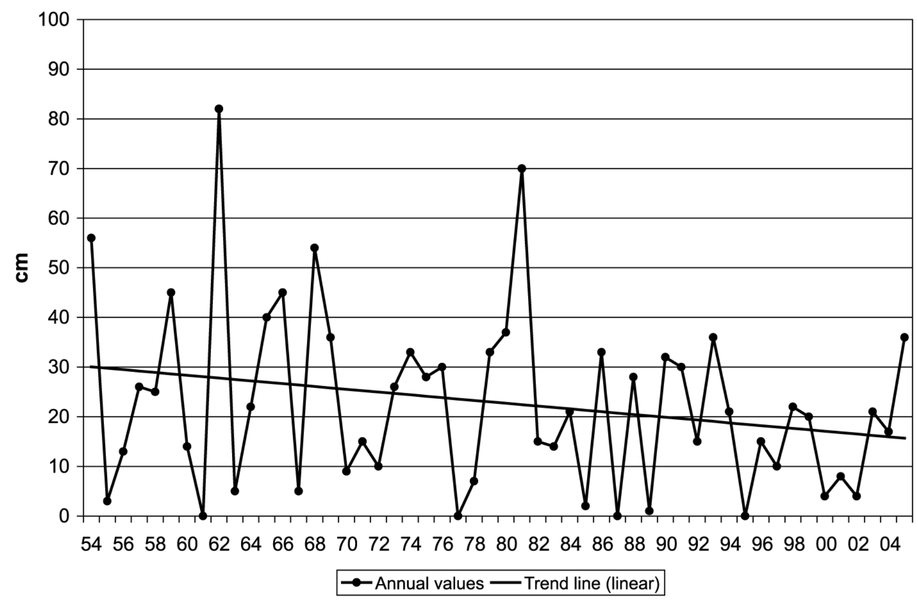
More winters with little snow. In many places, the snow cover has thinned in recent years compared with the long-term average. The trend towards little snow is not due to a reduction in precipitation but to rising temperatures. At higher altitudes, the decrease in snow depth is less pronounced, while at lower altitudes the lack of snow is particularly marked.

Table III Ski areas with guaranteed snow in Switzerland

				Warming					
		Today		*+1°C*		*+2°C*		*+4°C*	
Region	Ski areas	Number	%	Number	%	Number	%	Number	%
Vaud and Fribourg	17	17	100	11	64.7	9	52.9	1	5.9
Valais	49	49	100	49	100	49	100	39	79.6
Berne (without Jura)	26	25	96.2	22	84.6	16	61.5	3	11.5
Central Switzerland	20	18	90	15	75	11	55	4	20
Ticino	4	4	100	3	75	2	50	0	0
Eastern Switzerland	12	10	83.3	7	58.3	7	58.3	1	8.3
Grisons	36	36	100	35	97.2	35	97.2	30	83.3
Switzerland	164	159	97	142	86.6	129	78.7	78	47.6

Source: Abegg *et al.* (2007)

Figure 2 Snow depth at Christmas in Wengen (alt. 1,310 metres)



Source: SLF (2006)

Shorter winters. The averaged values of different gauging stations show that almost every winter since 1990 has been shorter than the long-term average, as the result of the later arrival of snow and its earlier disappearance.

Conclusion. Snow reliability will be a growing problem, above all for ski areas with manned lifts at lower altitudes:

- *Minimum scenario.* With a 0.4°C increase in winter temperatures, a snow-line rise of 40 to 60 metres can be assumed.
- *Maximum scenario.* If the average winter temperature rises by 1.8°C, the snow line will rise by 180 to 270 metres.

Permafrost

The permafrost line currently lies around 2,600 metres above sea-level. Four to 6 percent of Switzerland's territory consists of permafrost regions, roughly twice as much as the area now covered by glaciers. The permafrost's thickness varies between just a few metres and several hundred metres. Besides summer temperatures, snow depth is a particularly decisive factor in this thickness because of its insulating effect.

Permafrost in the Swiss Alps has been the subject of scientific studies only for the past 20 years, and since 2000, these observations have been coordinated nationwide under the umbrella of Permafrost Monitoring Switzerland (PERMOS). In addition to areas where soil temperatures are measured, there are also various measurement stations that do drilling. Data from the Geophysical Measurement Station on the Schilthorn reveal that the exceptionally hot summer of 2003 alone caused thawing to a depth of almost nine metres.

Conclusion. In the past, the impact of climate change on permafrost areas has been virtually impossible to predict. There are uncertainties about the extent of the permafrost, bedrock ice content and the complex influence of climate change. On the whole, the thawing of permafrost areas will progress with climate warming, leading to more massive and more frequent rock falls and avalanches. In conjunction with heavy precipitation, the thawing of scree-covered slopes can lead to more and bigger debris flows, thus endangering areas not affected to date:

- *Minimum scenario.* Melting of the permafrost will continue to increase slightly but, overall, will be subject to major fluctuations. An increase in natural hazards will only be noticeable in particularly hot summers.
- *Maximum scenario.* If average summer temperatures were to rise sharply, the permafrost would thaw at greater depths, thus greatly increasing the threat of falling rock and rock slides.

Glaciers

Since glaciers were last at their maximum extent, at the end of the Little Ice Age around 1850, glaciers in Switzerland have been generally on the retreat. At present, there are still some 2000 glaciers, covering approximately 1,050 km^2, i.e. 2.5 per cent of Switzerland's total area. Between 1850 and 2000, the area covered fell by over 40 per cent and the volume of all glaciers declined by around 50 per cent (Spreafico and Weingartner, 2005). The alpine glaciers lost a further 5 to 10 per cent of their remaining volume during the 2003 heatwave alone (BUWAL, BWG, MeteoSchweiz, 2004).

A temperature increase of 2°C can be expected to cause the equilibrium line to rise 300 metres compared with 1990. This means that 1,436 of Switzerland's glaciers would disappear – this corresponds to 75 per cent of the total number of glaciers and 17 per cent of the area they cover (Maisch *et al.*, 2000). Glaciers can cause various hazards, such as changes in longitudinal profiles and geometry, glacial flooding or falling ice. These three types of hazard may be closely interrelated and may lead to dangerous events that are hard to forecast.

All glaciers in the Bernese Oberland have clearly shrunk in recent years, with the lowest-lying ones losing more than 100 metres in length every year.

Conclusion. Retreating glaciers are probably the most obvious consequence of climate change. Not only does this diminish their attractiveness, it may also harbour serious threats to tourism:

- *Minimum scenario.* Glaciers will continue to shrink, though the changes in longitudinal profile will be slightly less marked than in recent years.
- *Maximum scenario.* The disappearance of glaciers will progress faster than the average for recent years. Changes like those that occurred in the summer of 2003 will occur more frequently. The threat of glaciers causing natural hazards escalates considerably.

Landscape, vegetation

Many features of the landscape, such as glaciers, permafrost, vegetation or soil are very sensitive to climate and will undergo major changes. Accordingly, there will also be changes in provisions for dealing with natural hazards, the dynamics of processes, the areas affected by natural hazards and the attractiveness of the landscape. In particular, the alpine landscape with its glaciers and snowfields will alter, but flora and fauna too will adapt to the new conditions.

In the longer term, there will be changes in vegetation. Vegetation belts tend to move upwards in the event of warming. However, it is assumed that this shift could take a very long time and that the adjustment of present tree species distribution to the changed conditions could even be a matter of centuries. Similarly, extreme events – especially storms – can disrupt ecological functions at short notice and reshape the landscape (OcCC, 2007).

Technical measures such as river flood barriers can also considerably affect the natural scenery. However, it is virtually impossible to forecast how much this alters the landscape's attractiveness. Perceptions of beauty are extremely subjective, and people quickly become accustomed to change.

Conclusion. Natural scenery is an important factor in tourism promotion and is fundamentally affected by the climate. Climate change will prompt flora and fauna to adapt, and will lead to geomorphological modifications which are, however, usually spread over longer periods. On the other hand, changes to the landscape as the result of shrinking glaciers and the vestiges of natural events become visible fairly quickly:

- *Minimum scenario*. The impact of climate change on the landscape will not alter it faster than today. Glaciers will be the only thing to alter more, and the changes to them will be clearly visible.
- *Maximum scenario.* Besides melting glaciers, vegetation will change too though only slowly. Local natural events may also affect the appearance of the landscape.

Natural hazards

The question of whether extreme weather events will become more frequent as the climate changes is very hard to answer, as such events are by definition rare. The more extreme – and therefore the rarer – an occurrence and the shorter the period for which records have been kept, the less likely they are to demonstrate a trend. As knowledge currently stands, it looks as though warming of the atmosphere will affect the intensity and frequency of extreme weather conditions. Although individual extreme events cannot be linked directly to climate change, an increase in various types of events is expected in future (see Bloetzer *et al.*, 1998; Beniston, 2004).

The Advisory Body on Climate Change (OcCC) collected and published the current scientific knowledge of the connection between climate change and extreme events. (OcCC, 2003) Following changes in the development of natural hazards in regard to climate change are presented:

- *Heatwaves*. The expected increase in temperatures means that there will be more frequent heatwaves. As early as around the end of the twenty-first century, every second summer could be as hot as the summer of 2003 (Schär *et al.*, 2004). Heat waves seriously undermine the water balance and also impact on the landscape and vegetation.
- *Flooding*. An increase in the frequency and intensity of heavy precipitation can be reckoned with. The threat of flooding increases on the basis of heavier winter precipitation and less snow at altitudes between 1,000 and 1,500 metres.
- *Mass movements (slumps, rock slides and rock avalanches)*. Slope stability which has been changed by shrinking glaciers and long-term thawing of permafrost, in conjunction with more intensive and more frequent precipitation, results in more mass movements, such as slumps or debris flows.
- *Storms.* Storms are almost impossible to predict, though more extreme storms are expected to become more frequent.
- *Avalanches*. So far, no clear trends can be ascertained on the basis of long-term data about snow volumes and avalanches. Some researchers assume that the increase in (heavy) winter precipitation will mean an increase in avalanche activity (OcCC, 2003).

Conclusion. An increase of certain extreme events in relation to climate change is expected:

- *Minimum scenario*. Extreme natural events will continue to occur very sporadically. The recurrence interval of certain events will become slightly shorter. In particular, the trend towards heaver precipitation will increase.
- *Maximum scenario*. Events regarded as rare occurrences will become considerably more frequent. Besides the more frequent occurrence of summer heatwaves, there will be a marked increase in the risk of mass movements and flooding.

Results for destinations

As a result of an analysis of the cantonal hazard maps, past events, the topography of the destinations and in consideration of the estimates of local entrepreneurs and experts the relevance of ecological consequences for the destinations had been estimated in a qualitative way. The discussion in two workshops with tourism stakeholders allowed to precise the assessments. Therefore, the following assumptions can be made about the degree to which the individual destinations in the Bernese Oberland will be affected by the ecological impact of climate change in the minimum and the maximum scenarios. The differences in the relevance are primary due to the altitude, the topography and the expositions of the destinations (see Tables IV and V).

Financial implications of climate change for tourism

The consequences of climate change described may have direct economic repercussions, both as regards costs and revenue (see Scott *et al.*, 2002). Quantifying the effects and calculating the monetary implications involve many imponderables. Besides open questions about the development of global CO_2 emissions and their consequences for the climate, there is considerable uncertainty about tourism's ability to adapt. The following three steps are an attempt to approximately ascertain the financial consequences of climate change for tourism in the Bernese Oberland considering the ecological consequences listed above:

1. Changes in numbers and revenue, not including any adaptation measures by tourism stakeholders (except for the ones already taken).
2. Costs of adaptation measures due to climate change.
3. Changes in numbers and revenue, taking account of any adaptation measures by tourism stakeholders.

Assumptions and methodological approach

The maximum scenario (i.e. temperature increases in winter of 1.8°C and in summer of 2.6°C) provided the starting point for assessing the financial implications of warmer winters between 1990 and 2030. Turnover is considered from the cost and revenue angles, using the numbers, daily expenditure and investments taken from the value-added study conducted by Canton Berne (Rütter *et al.*, 1995), adjusted by 10 per cent for inflation.

In a first step, based on these numbers, the potential changes had been estimated for overnight visitors and day-trippers in summer and winter. Then, the estimations were presented to the working group consisting of tourism experts and practitioners of the tourism industry and local authorities and discussed in depth considering the specific local conditions of the region. The findings of this workshop then were integrated in the paper claiming to be ''roughly right rather than precisely wrong''.

Effects on tourism without adaptation measures (step 1)

It is assumed that winter tourism will be hard hit, while summer will become more attractive. In contrast with other countries, high-altitude ski areas in Switzerland may however be able to benefit from concentration processes – an aspect which is difficult to factor in, especially because Grisons or Valais will still have skiing areas at much higher altitudes (see Table VI).

The drop in winter day-trippers together with the drop in daily expenditure (increased use of cheaper alternatives to skiing) results in an annual revenue loss due to climate change of 82

Table IV Minimum scenario: effects on destinations in the Bernese Oberland

	Destinations								
	Adelboden-Frutigen	*Alpine region*	*Grindelwald*	*Gstaad-Saanenland*	*Interlaken*	*Lenk-Simmental*	*Lötschberg holiday region*	*Lake Thun*	*Wengen/Mürren/Lauterbrunnen Valley*
Temperature and precipitation	×	×	×	×	×	×	×	×	×
Snow reliability	×	×	×	× ×	× × ×	×	× ×	× × ×	×
Permafrost	×	× × ×	× ×			×	× ×		×
Shrinking glaciers	×	× × ×	× ×	×		×	× ×		× ×
Changes to landscape	×	×	×				×		×
Mass movements	× ×	× ×	× ×	×	× ×	× ×	× ×	×	×
Flooding	× ×	× × ×	× ×	×	× ×	× ×	× ×	× × ×	×

Note: Scale: × = little relevance-×××× = high degree of relevance
Source: Müller and Weber (2007, p. 41)

Table V Maximum scenario: effects on destinations in the Bernese Oberland

					Destinations				
Destinations	*Adelboden-Frutigen*	*Alpine region*	*Grindelwald*	*Gstaad-Saanenland*	*Interlaken*	*Lenk-Simmental*	*Lötschberg holiday region*	*Lake Thun*	*Wengen/Mürren/Lauterbrunnen Valley*
Temperature and precipitation	× ×	× ×	× ×	× ×	× ×	× ×	× ×	× ×	× ×
Snow reliability	× ×	× ×	× ×	× × ×	× × × ×	× ×	× × ×	× × × ×	× ×
Permafrost	× ×	× × × ×	× × ×	× ×		× ×	× × ×		× ×
Shrinking glaciers	× ×	× × × ×	× × ×	× ×		× ×	× × ×		× × ×
Changes to landscape	× ×	× ×	× ×			×	× ×		× ×
Mass movements	× × ×	× × ×	× × ×	× ×	× × ×	× × ×	× × ×	×	× × ×
Flooding	× × ×	× × × ×	× × ×	× ×	× × ×	× × ×	× × ×	× × × ×	× ×

Note: Scale: × = little relevance-× × ×× = high degree of relevance
Source: Müller and Weber (2007, p. 41)

Table VI Financial implications 2006-2030 (without adaptation measures)

Proceeds	*2006* *Estimation*	*Proceeds (in millions of CHF)*	*Changes (in %)*	*2030* *Perspectives*	*Proceeds (in millions of CHF)*	*Changes due to climate (in %)*	*Changes due to climate (in millions of CHF)*
Winter							
Day trippers							
Frequencies	3,400,000	194	−35	2200000	112	−42	−82
Daily expenditure	57		−10	51			
Overnight visitors							
Frequencies	4,100,000	484	−25	3,100,000	366	−24	−118
Daily expenditure	118		0	118			
Total winter (in CHF)		678			478	−29	−200
Summer							
Day trippers							
Frequencies	7,700,000	447	10	8,500,000	493	10	46
Daily expenditure	58		0	58			
Overnight visitors							
Frequencies	6,200,000	663	5	6,500,000	696	5	33
Daily expenditure	107		0	107			
Total summer (in CHF)		1,110			1,189	7	79
Total (in CHF)		1,788			1,667	−7	−121

Source: Müller and Weber (2007, p. 56)

million CHF. Winter overnight visitors (many of them loyal holiday-accommodation users) will be less affected with a total annual revenue loss due to climate change of 118 million CHF.

This gives annual climate-related revenue losses in winter of approximately 200 million CHF, or about −30 per cent.

Due to the coolness in the mountains in summer an increase in numbers of day trippers of 10 per cent is expected, what would lead to an annual increase in revenue due to climate change of 46 million CHF. In addition, an increasing number of summer overnight visitors (5 per cent) will lead to an annual increase in revenue of 33 million CHF.

This gives an annual climate-related increase in revenue in summer of approximately 80 million CHF, or about +7 per cent.

On balance, climate-related changes in revenue (with the present structural conditions) would result in annual losses of approximately 120 million CHF, or about −7 per cent.

Additional adaptation costs for tourism due to climate change (step 2)

Tourism is constantly being forced to adapt to social, economic and ecological conditions, and such measures inevitably involve costs for tourism service providers and the State. Higher costs are incurred in particular through investments in safety, adaptation of services (e.g. providing artificial snow), additional insurance premiums as well as more costly bank loans because of greater risks.

It is however very difficult to demarcate the percentage of expenditure that is due to climate change. In line with the working group's estimates, it is assumed that tourism-generated investment requirements on the basis of direct or indirect climatic effects will rise by approximately 20 per cent. For the Bernese Oberland, this would probably mean overall investment totalling between 400 and 450 million CHF (adjusted figures, based on Rütter *et al.* (1995)).

Additional annual investments due to climate change can be estimated at around 70 to 80 million CHF.

Impact on tourism with adaptation measures (step 3)

Certain adaptation measures for specific amenities may be able to absorb some (about 20 to 30 per cent) of the negative effects. Realistically speaking, the economic impact of tourism as per Step 1 needs to be corrected as shown in Table VII.

A drop in numbers of winter day-trippers of 25 per cent and of daily expenditure of 5 per cent due to climate change is expected. This leads to an annual revenue loss of 54 million CHF due to climate change. With the fall in overnight visitors of about 20 per cent, an annual revenue loss of 95 million CHF due to climate change is estimated.

This gives annual climate-related revenue losses in winter of approximately 150 million CHF, or about −22 per cent. The annual climate-related increase in revenue in summer of approximately 80 million CHF, or about +7 per cent, remains the same with or without adaptation measures.

On balance, the changes in revenue due to climate, including adaptation measures, would result in annual losses of approximately 70 million CHF, or about −4 per cent.

Summing up

It is not surprising that winter tourism will suffer considerable losses in revenue. However, these are not excessive because the Bernese Oberland has some high-altitude ski areas that will benefit from the concentration processes that will take place. Other areas (above all in Germany, Austria or in the alpine foothills of Switzerland) will be worse hit by the negative consequences of such concentration processes. What is more, the Bernese Oberland is known for its exceptionally strong summer tourism which can partly offset revenue losses. Diversification of tourism amenities results in seasonal and structural shifts in revenue.

The impact on different service providers will vary considerably. Providers that have specialised in winter tourism will be hardest hit, especially the mountain railways, ski schools or winter sports destinations. Major regional differences may also arise. For instance, most lower-lying ski areas will not have the option of maintaining skiing conditions with artificial snow and will have to close, while higher-altitude areas will benefit from the customer shifts. Knock-on effects such as problems with recruiting young winter sport enthusiasts following

Table VII Financial implications 2006-2030 (with adaptation measures)

	2006			*2030*			
Proceeds	*Estimation*	*Proceeds (in millions of CHF)*	*Lessened change (20-30 %)*	*Perspectives*	*Proceeds (in millions of CHF)*	*Changes due to climate (in %)*	*Changes due to climate (in millions of CHF)*
Winter							
Day trippers							
Frequencies	3,400,000	194	−25	2,600,000	140	−28	−54
Daily expenditure	57		−5	54			
Overnight visitors							
Frequencies	4,100,000	484	−20	3,300,000	389	−20	−95
Daily expenditure	118		0	118			
Total winter (in CHF)		678			529	−22	−149
Summer							
Day trippers							
Frequencies	7,700,000	447	10	8,500,000	493	10	46
Daily expenditure	58		0	58			
Overnight visitors							
Frequencies	6,200,000	663	5	6,500,000	696	5	33
Daily expenditure	107		0	107			
Total summer (in CHF)		1,110			1,189	7	79
Total (in CHF)		1,788			1,718	−4	−70

Source: Müller and Weber (2007, p. 57)

the disappearance of small ski areas near urban agglomerations are virtually impossible to assess. Though there are still many uncertainties in connection with the impact of climate change, one thing is for sure: winter tourism in the Bernese Oberland faces major challenges.

There is a risk of the expected additional investment costs resulting in a sharp increase in the price of the product, which may impact negatively on demand. Price reductions to compensate for loss of attractiveness are also risky as they encourage an increase in demand in the short term but mean fewer resources are available for investment needs in the longer term. So the price-performance gap would widen as shown in Figure 3. The only way of absorbing winter business slumps and minimising negative effects is to adopt a far-sighted approach to climate change and to introduce the appropriate adaptations.

Advice to tourism destinations

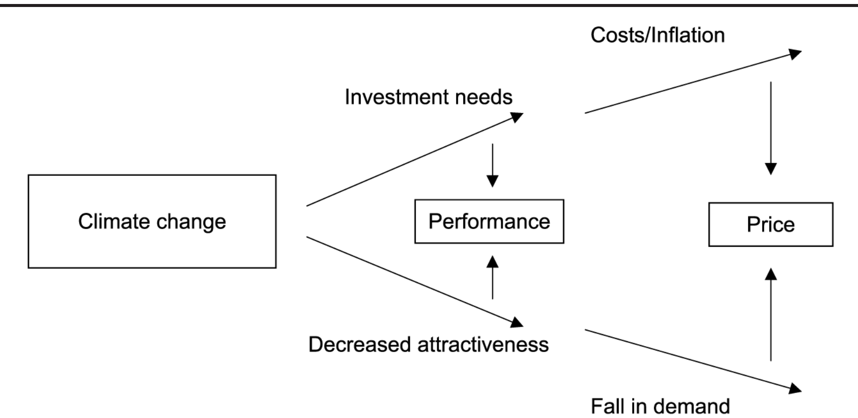
The actual impact of climate change on tourism is greatly dependent on the measures taken to adapt. In principle, the measures to be taken are the same for both scenarios. Both short- and long-term measures are called for. While adaptation measures are primarily needed in the short term, putting climate-related measures on the agenda is only credible if mitigating measures are taken too. The necessary pressure in this direction is building up.

Mitigation strategies

Tourism is not just affected by climate change – it also partly responsible for causing it. Individual travel in particular makes a major contribution to the emission of gases that affect the climate. Improved accessibility, increased motorisation and a growing eagerness to travel after the Second World War considerably boosted traffic in the Alps. Travel-intensive short-break and second-home tourism is also rising. In addition to traffic emissions, the energy required to heat and (increasingly) to cool accommodation is adding to tourism-related greenhouse-gas emissions, with second homes having a special impact. Its shared responsibility in this respect means that tourism must not only react but must, wherever possible, also see mitigation as an opportunity, hence the priority of measures to reduce emissions:

- promotion of public transport;
- consistent application of the ''polluter pays'' principle;
- improved traffic management;
- reduction of heating-system energy consumption and emissions; and
- compensation for CO_2 emissions.

Figure 3 Price-performance ratio under pressure



Source: Müller and Weber (2007, p. 60)

Adaptation strategies

At the same time, tourism has to adapt to the new conditions brought about by climate change. The many different negative repercussions can however be only partially offset: the lack of ''winter atmosphere'' without snow is hard to compensate for, and indoor attractions are only limited alternatives. An important strategy to higher competitiveness is regional cooperation. In general, it is important for tourism to react early and flexibly and for it to perceive and make the most of the chances that become available:

- encouragement of innovation and diversification;
- reinforcement of hazard prevention and technical measures;
- risk reduction through organisational management;
- clear positioning and targeted marketing; and
- intensification of research, raising public awareness.

Tourism stakeholders have to face the challenge of adapting their services to the new situation and of working out coordinated, comprehensive concepts. The diversification of amenities, adapting to new tourism activities or shifting emphasis/priorities, providing new sports, creativity courses, culture and further training packages are possibilities of reaction as well as extending the season using appropriate products (temporal expansion) or expanding the interpretation of healthy lifestyle in terms of air, altitude, light, nutrition and culture. The forced break of traditional winter sport tourism could become a chance to discover new niches and promote sustainable tourism particularly for small and low-lying tourist destinations.

Conclusions

This paper has shown possible impacts of climate change on tourist destinations in the Bernese Oberland in the year 2030. Although the development of tourism in Switzerland is influenced by many factors, which can strengthen or also compensate the effects of climate change, the study shows that under assumptions as mentioned winter tourism is particularly sensitive to climatic changes.

Most affected are mountain railways and ski teaching business, especially in low-lying areas. Nevertheless, there could be some chances as well. An increase in visitor arrivals is expected for the summer season. And even in winter, there could be some dislocation effects, since not all regions are equally affected by snow poverty.

Still many uncertainties exist both regarding the future emissions of greenhouse gases as well as their climatic effects on regional level. In addition, it has to be considered that there are big differences as far as regional conditions, vulnerability of tourism and its adaptability are concerned. It is little explored, how tourism demand reacts to the changed conditions. The guest behaviour will be a crucial component whether tourist destinations will succeed with new offers. In any case, tourist destinations and enterprises are demanded to constantly adapt to the new conditions and thereby not to neglect efforts in climate protection.

The paper has emphasised the importance of new and sustainable strategies in order to efficiently deal with changed conditions in relation to climate change and therefore not to destroy the bases of tourism through tourism. Then certainly, climate change will continue to be a central challenge for Alpine tourism also in the future.

References

Abegg, B. (1996), *Klimaänderung und Tourismus. Klimafolgenforschung am Beispiel des Wintertourismus in den Schweizer Alpen*, vdf Hochschulvelag, Zurich.

Abegg, B., Agrawala, S., Crick, F. and De Montfalcon, A. (2007), ''Climate change impacts and adaptation in winter tourism'', in Agrawala, S. (Ed.), *Climate Change in the European Alps: OECD Study*, OECD, Paris, pp. 25-60.

Beniston, M. (2003), ''Climatic change in mountain regions: a review of possible impacts'', *Climatic Change*, Vol. 59 Nos 1-2, pp. 5-31.

Beniston, M. (2004), ''Extreme climatic events: examples from the alpine region'', *Journal de Physique*, Vol. 121, December, pp. 139-49.

Bloetzer, W., Egli, T., Petrascheck, A., Sauter, J. and Stoffel, M. (1998), *Klimaänderungen und Naturgefahren in der Raumplanung*, Synthesebericht NFP31, vdf Hochschulverlag AG, Zurich.

BUWAL, BWG, MeteoSchweiz (2004), *Auswirkungen des Hitzesommers 2003 auf die Gewässer*, Schriftenreihe Umwelt Nr. 369, BUWAL, BWG, MeteoSchweiz, Berne.

Frei, C. (2004), *Die Klimazukunft der Schweiz – Eine probabilistische Projektion*, Institut für Atmosphäre und Klima, ETH Zurich, Zurich.

IPCC (2001), *Climate Change 2001: The Scientific Basis. Contribution of Working Group I to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge and New York, NY.

IPCC (2007), *Climate Change 2007: The Physical Science Basis. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, Cambridge University Press, Cambridge and New York, NY.

Laternser, M. and Schneebeli, M. (2003), ''Long-term snow climate trends of the Swiss Alps (1931-99)'', *International Journal of Climatology*, Vol. 23 No. 7, pp. 733-50.

Maisch, M., Wipf, A., Denneler, B., Battaglia, J. and Benz, C. (2000), *Die Gletscher der Schweizer Alpen: Gletscherhochstand 1850, aktuelle Vergletscherung, Gletscherschwund-Szenarien*, Schlussbericht NFP 31, vdf Hochschulverlag AG, Zurich.

Müller, H.R. and Weber, F. (2007), *Klimaänderung und Tourismus – Szenarien für das Berner Oberland 2030*, Forschungsinstitut für Freizeit und Tourismus der Universität Bern, Berne.

Organe consultatif sur les changements climatiques (OcCC) (2002), *Das Klima ändert – auch in der Schweiz*, OcCC, Berne.

Organe consultatif sur les changements climatiques (OcCC) (2003), *Extremereignisse und Klimaänderung*, OcCC, Berne.

Organe consultatif sur les changements climatiques (OcCC) (2007), OcCC, Berne, Klimaänderung und die Schweiz 2050. Erwartete Auswirkungen auf Umwelt, Gesellschaft und Wirtschaft.

von Reibnitz, U. (1991), *Szenario-Technik: Instrumente für die unternehmerische und persönliche Erfolgsplanung*, Gabler, Wiesbaden.

Rütter, H., Müller, H., Guhl, D. and Stettler, J. (1995), *Tourismus im Kanton Bern. Wertschöpfungsstudie*, FIF, Berne.

Schär, C., Vidale, P.L., Lüthi, D., Frei, C., Häberli, C., Liniger, M.A. and Appenzeller, C. (2004), ''The role of increasing temperature variability in European summer heatwaves'', *Nature*, No. 427, pp. 332-6.

Scott, D., Jones, B., Lemieux, C., McBoyle, B., Svenson, S. and Wall, G. (2002), ''The vulnerability of winter recreation to climate change in Ontario's Lakelands tourism region'', Department of Geography Publication Series Occasional Paper 18, University of Waterloo, Waterloo.

Spreafico, M. and Weingartner, R. (2005), *Hydrologie der Schweiz: Ausgewählte Aspekte und Resultate*, Bundesamt für Wasser und Geologie (BWG), Berne.

Swiss Federal Institute for Snow and Avalanche Research (SLF) (2006), *Diverse Winterberichte*, SLF, Davos.

Wigley, T.M.L. and Raper, S.C.B. (2001), ''Interpretation of high projections for global-mean warming'', *Science*, Vol. 29, pp. 451-4.

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