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## **Climate Change and Winter Sports: Environmental and Economic Threats**

### **1. Introduction**

For many alpine areas winter sports are the most important source of income, and snow-reliability is one of the key elements of the touristic offers. Skiing and snowboarding, but also snow related sports such as cross-country skiing or snow hiking depend on enough snow.

Mountain areas are sensitive to climate change. Implications of climate change can be seen, for example, in less snow, receding glaciers, melting permafrost and more extreme events like landslides. Furthermore, climate change will shift mountain flora and fauna. Second order impacts will occur in mountain agriculture, mountain hydropower and, of course, mountain tourism. However, climate change is a severe threat to snow related sports such as skiing, snowboarding and cross-country skiing. Lower earnings in winter tourism will reinforce economic disparities between urban areas and the less developed alpine regions. Additionally, the ski tourism industry will “climb” up the mountains to reach snow reliable areas at high altitude. This process will lead to a concentration of winter sport activities, and will put further pressure on the sensitive environment of high mountains.

Clearly, it should be emphasised that climate is only one of many factors influencing snow tourism. However, less snow threatens the winter tourism industry in mountain areas. Good snow conditions are a necessity, although that is not the only prerequisite for a financially viable mountain cableway company. Without enough snow, however, profitable ski tourism will scarcely be possible. Mountains without snow are like summer without a sea. Apart from having sufficient snow at the right time – and particularly during the Christmas/New Year holidays – a key role is also played by the weather conditions (predominantly at the weekends). Since weekend and day guests are planning their trips at ever-shorter notice, it is not just the actual weather conditions that are a growing factor of influence, but the weather forecasts too.

Climate impact research on the winter tourism industry has been undertaken in various countries such as Canada, the U.S.A., Australia, New Zealand, Austria, Switzerland, France and the U.K. (see Koenig 1998 or Buerki 2000 for an overview). All these studies show severe implications for the winter tourism industry if climate change were to occur. While some regions may be able to maintain their winter tourism with suitable, but expensive adaptation strategies (e.g. artificial snowmaking), others would lose their winter tourism industry due to a diminishing snow pack.

Global mean temperature has increased by about 0.6 - 1°C over the last 100 years (IPCC 2001). The years at the end of the nineties were the warmest over the last centuries. Global temperature will increase in the future. Of course, there are a lot of uncertainties and the range of scenarios of the future warming is quite big. However, IPCC estimates a temperature increase of 1.4 to 5.8°

until 2100. Global warming will be stronger on land surface, the northern hemisphere and in winter: that is the location and the season of mountain winter tourism.

## **2. Climate change and potential impacts on winter tourism**

### *Snow*

The financial viability of the winter tourism industry depends on sufficient snow conditions. It was the winters with little snow at the end of the Eighties (1987/88 – 1989/90) that caused a stir in the Alps. The big difference to the situations at earlier periods with little snow is that the capital intensity of ski tourism had considerably increased. However, the most important link between climate change and mountain tourism is less snow and, as a consequence, less earnings in ski tourism.

### *Glaciers*

There is a measured increase in the retreat of glaciers all over the world. Since 1850, Swiss Glaciers have lost more than a quarter of their surface. In 2030, 20 to 70% of Swiss glaciers will have disappeared. This is not only a severe loss of mountain aesthetic, but also a problem for ski slopes on glaciers in winter and summer skiing.

### *Permafrost*

Global warming increases melting of permafrost and makes many mountain areas vulnerable to landslides. Mountain cableway stations, lift masts and other buildings in permafrost soil become instable. To brace and to anchor such buildings in melting permafrost-soils causes high costs. However, warming in mountain areas also makes hiking and climbing more dangerous due to increasing rockfall.

### *Changing weather conditions*

On the one hand, the future climate will be warmer, on the other hand, the future climate will change its pattern. More precipitation or a higher fog level will lead to new conditions for mountain summer tourism such as hiking, trekking or biking. More and stronger extreme events are another threat for tourism activities and tourism infrastructure. Besides, with warmer winter temperatures ice fishing would be increasingly impossible.

## **3. Climate change and snow-deficient winters**

### *Results from the Alps*

The economy in alpine regions is highly dependent on tourism. If the assumptions of the impacts of climate change hold true, snow cover in the Alps will diminish which will, in turn, jeopardise the tourism industry. The crucial factor for the long-term survival of mountain cableway companies is the frequency and regularity of winters with good snow conditions, or, put the other way round, the number of snow-deficient winters that can be withstood. It is not possible to give a definitive answer here, since the economic situation of the companies varies too much. The experience acquired by various ski resorts, however, shows that a ski resort can be considered

snow-reliable if, in 7 out of 10 winters, a sufficient snow covering of at least 30 to 50 cm is available for ski sport on at least 100 days between December 1 and April 15.

Today, 85% of Switzerland's 230 ski resorts can be considered to be snow-reliable (tab. 1). However, even today a lot of ski resorts in the Prealps are not snow-reliable. If the line of snow-reliability were to rise to 1'500 m as a result of climate change (year 2030 – 2050), the number of snow-reliable ski resorts would drop to 63%. The Jura, Eastern and Central Switzerland, Ticino, and the Alps in the cantons of Vaud and Fribourg will be particularly jeopardised by global warming. The ski regions of Valais and the Grisons will experience virtually no major problems, since the mean altitude of the cableway terminals in these regions is higher than 2500 m above sea level. If the line of snow-reliability were to rise to 1800 m, which is a possible scenario, there would be a further serious deterioration in conditions: only 44% of skiing regions could be designated as snow-reliable. Even in the cantons of Grisons and Valais, approximately a quarter of the ski resorts would no longer be snow-reliable.

Table 1: Snow-reliability of Swiss ski resorts (Buerki 2000)

Region	Number of ski resorts	Snow-reliability					
		1200 masl		1500 masl		1800 masl	
		No.	%	No.	%	No.	%
Jura	15	4	27	1	7	0	0
Alps (Vaud + Frib.)	19	16	84	7	37	4	21
Valais	54	54	100	52	96	40	74
Bern (ex. Jura)	35	30	86	20	57	12	34
Central Switzerland	35	26	74	13	37	7	20
Ticino	8	8	100	3	38	2	25
Eastern Switzerland	18	11	61	6	33	3	17
Grisons	46	46	100	42	91	33	72
Switzerland	230	195	85	144	63	101	44

A survey among tourists shows, that skiers will respond flexibly to changing snow conditions. During a period of snow-poor seasons, as expected more often under a changing climate, 49% of the skiers would change to a ski resort that is more snow-reliable. 32 % of the skiers would ski less often. Although only 4% of the respondents would give up skiing, it can be concluded that climate change would have serious impacts on the number of skier days. The most vulnerable ski resorts in the lower regions of the Alps have to deal with a significant decrease of younger guests, day tourists and novice skiers, which is exactly the target group of these resorts (Buerki 2000).

The potential annual costs of climate change in Switzerland can be estimated at CHF 2.3 to 3.2 billion (US \$ 1.5 to 2.1 billion) by the year 2050, which is 0.6 to 0.8% of the Swiss gross national product for 1995. CHF 1.8 to 2.3 billion (US \$ 1.2 to 1.6 billion) would be accounted for by tourism. Even if there are many reservations that can be voiced regarding this calculation, it nevertheless shows that tourism is the economic sector that would be most affected by climate change in Switzerland and that this influence is of an order of magnitude that cannot be neglected.

Climate change will lead to a new pattern of favoured and disadvantaged ski tourism regions. If all other influencing factors remain the same, snow related sports would concentrate in the high-altitude areas that are snow-reliable in the future too. Ski resorts at lower altitudes will withdraw from the market sooner or later because of the lack of snow. The only areas with good prospects will be those with transport facilities that provide access to altitudes higher than 2000 m. The regions at higher altitudes may experience greater demand, prompting a further expansion in quantitative terms. The pressure on ecologically sensitive high-mountain regions will increase.

The call for ski resorts with snow-reliability is the main argument for the current boom in concept studies to open up high mountain regions, or, in other words, climate change is the reason for opening up high mountain regions to tourism. In Switzerland more than 100 projects exist to extend ski sport infrastructure, a lot of them sponsored by subsidies. In the Alps as a whole, there are at least 300 projects, including, for example, new lifts, snow machines (including water reservoirs) and flattened slopes.

The impacts of climate change on winter tourism may be even more severe in countries such as Germany (for example resorts in the Black Forest area or in Allgaeu) and Austria, due to the lower altitudes of their ski resorts. The famous tourist town of Kitzbuehel, for example, lies at the low altitude of 760 m. In Austria, the present snow line will rise 200 to 300 metres higher with climatic change in the next 30 to 50 years. Many mountain villages, above all in the central and eastern parts of Austria, will lose their winter tourist industry because of climate change (Breiling & Charamza 1999). In Italy, half of the winter sport villages are below 1,300 metres. Some of these are already facing major problems with snow cover. In future, there will only be a few winters with a winter atmosphere – that means with snow – in these ski resorts. If the altitude for snow reliability rises to 1,500m because of climatic change, winter sports would only be possible in the higher zones of the ski areas and many resorts would have no economic viability in the future.

However, the winter of 1998/99, in particular, February 1999, showed that the possibility of winters with a great deal of snow cannot be excluded in the future. In a study of the ‘avalanche winter’ of 1999, the direct losses incurred by mountain cable-ways as a result of avalanches and the large quantities of snow were estimated at CHF 15 million (US \$ 10 million). In total, 36 facilities were damaged, including 20 ski-lifts, 11 chair-lifts, 4 cable railways and 1 funicular. The mountain railway companies had to spend an extra 77% on snow clearing, compared with previous years. Roughly 25% more than in normal winters was spent on securing the ski slopes. All in all, the avalanche winter of 1999 probably caused losses in excess of CHF 200 million (US \$ 130 million), the major portion of these having been indirect losses (SLF 2000).

### *Results from Australia*

In order to find out how climate change may influence the snow-reliability of Australia’s ski fields, impacts of different regional climate scenarios on the number of days with snow-cover were examined (Koenig 1998, tab. 2). Assuming the best-case scenario, all but one resort match the ‘60 days rule’ in 2030. Assuming the worst-case scenario for 2030, a financially viable ski operation would only be possible in Charlotte Pass, but it would not be possible in three resorts at lower altitudes. At all other resorts, ski operation would concentrate on the highest areas of today’s ski fields, while top to bottom skiing would not be possible in most resorts. With the worst case scenario in 2070 none of today’s ski resorts would be operating a profitable ski industry.

However, a concentration of the ski industry to the highest ski fields is expected due to climate change. Assuming today’s snowmaking technology, the lower resorts would have to close down.

In higher ski fields, where skiing would concentrate, expensive snowmaking might be intensified and environmental problems (waste water, rubbish) are likely to increase. This would undoubtedly result in conflicts with both conservation groups and the Australian Alpine National Parks.

Table 2: Snow-reliability of Australian ski resorts (Koenig 1998)

Ski resort	'Best case' 2030		'Best case' 2070		'Worst case' 2030		'Worst case' 2070	
	$\Delta T$	$\Delta P$	$\Delta T$	$\Delta P$	$\Delta T$	$\Delta P$	$\Delta T$	$\Delta P$
	= +0.3°C	= 0%	= +0.6°C	= 0%	= +1.3°C	= -8%	= +3.4°C	= -20%
<b>Charlotte Pass</b>	+		+		+		-	
<b>Thredbo</b>	+		+		?/+		-	
<b>Perisher-Blue</b>	+		+		?/+		-	
<b>Falls Creek</b>	+		+		?/+		-	
<b>Hotham</b>	+		+		?/+		-	
<b>Mt Buller</b>	+		?/+		?		-	
<b>Mt Buffalo</b>	+		?/+		-		-	
<b>Selwyn</b>	+		?		-		-	
<b>Mt Baw Baw</b>	-		-		-		-	

- (+) indicates that the prerequisite in terms of natural snow-cover duration for a financially viable ski operation (60 days rule) are accomplished.
- (?) indicates that the prerequisite in terms of natural snow-cover duration for a financially viable ski operation are questionable.
- (-) indicates that the prerequisite in terms of natural snow-cover duration for a financially viable ski operation are not accomplished.

$\Delta T$  = change of temperature;  $\Delta P$  = change of precipitation

### Results from Canada

The impacts of climate change in Australia, Canada and the U.S.A. may be not as severe as in Europe because of the high level of artificial snowmaking. Recognising that snowmaking is an integral component of the ski industry the results indicate that ski areas could remain operational in a warmer climate, particularly within existing business planning and investment time horizons (into the 2020s) (Scott et al. 2003). The economic impact of additional snowmaking requirements remains an important uncertainty. Under climate change scenarios and current snowmaking technology, the average ski season at the case study ski area in Canada (Lakelands tourism region) was projected to reduce by 0-16% in the 2020s, 7-32% in the 2050s and 11-50% in the 2080s. Without snowmaking the season would decline substantially by 37 – 57% in the 2050s.

Concurrent with the projected ski season losses, the estimated amount of snowmaking required increased by 36-144% in the scenarios for the 2020s. Required snowmaking amounts increased by 48-187% in the scenarios for the 2050s. The ability of individual ski areas to absorb additional snowmaking costs may be the crucial factor in remaining economically viable.

## 4. Adaptations of tourism representatives

The tourism representatives at a political, entrepreneurial, operational and organisational level are not sitting back idly contemplating the consequences of a climate change. They are adapting right now in the expectation of climate change. The experiences with snow-deficient winters have shown them that the climate does not determine their economic activities, but, instead, constitutes a key resource and framework condition. The results of a focus group study among tourism representatives in Switzerland can be summed up as follows.

Climate change has been recognised as a problem for winter tourism. Those responsible for tourism know that what they can offer is highly dependent on snow and that they are at risk from snow-deficient winters. They are familiar with the potential consequences of climate change for winter tourism. While achieving snow-reliability constitutes a central topic, potential climatic change is seen as being only of relatively minor importance.

Climate change is not regarded as a catastrophe for winter tourism. The tourism representatives think that climatic change is presented in a highly exaggerated form by the media – and also in science and politics. Although climate change could intensify the problems that already exist in ski areas at lower altitudes and speed up structural changes in the sector, the majority of ski resorts at medium and high altitudes, however, would scarcely be affected.

Climate change is already affecting the strategies and plans of the winter sport resorts today. The discussions held in the focus groups clearly revealed an ambivalent relationship to climate change. On the one hand, the representatives strongly distrust the information disseminated about climate change and play down its potential consequences, but on the other hand, they use climate change to legitimate forward strategies. Climate change and global warming, together with international competition, have been used as the key arguments for constructing artificial snowmaking facilities, as well as for extending existing ski runs and opening new ones in high-alpine regions (at above 3000 m).

The tourism representatives all agree that winter sports can only survive in the Alps if snow-reliability is guaranteed. Precisely, the smaller ski fields at lower altitudes either have their hands bound or can scarcely finance the necessary investments (e.g. snow cannons, levelling out ski slopes, opening higher-altitude chambers in skiing areas). On the one hand, they do not have financial resources of their own, and on the other hand, banks are (now) only prepared to grant very restrictive loans to ski resorts at altitudes below 1500 m, which are not particularly profitable. Nevertheless, the representatives believe that smaller ski fields in the Alpine foothills play a key role in promoting the importance of skiing. Opinions frequently differ a great deal, however, on whether non-profitable ski regions of this type should be retained and how their financing can be guaranteed. While a number of people are in favour of dismantling non-profitable cable-way and ski-lift operations and regard a certain ‘healthy shrinkage’ of the sector as necessary, others believe that there is an obligation to retain these ski fields for regional economic reasons. This is also increasing pressure for cableway companies to receive subsidies.

## **5. Strategies**

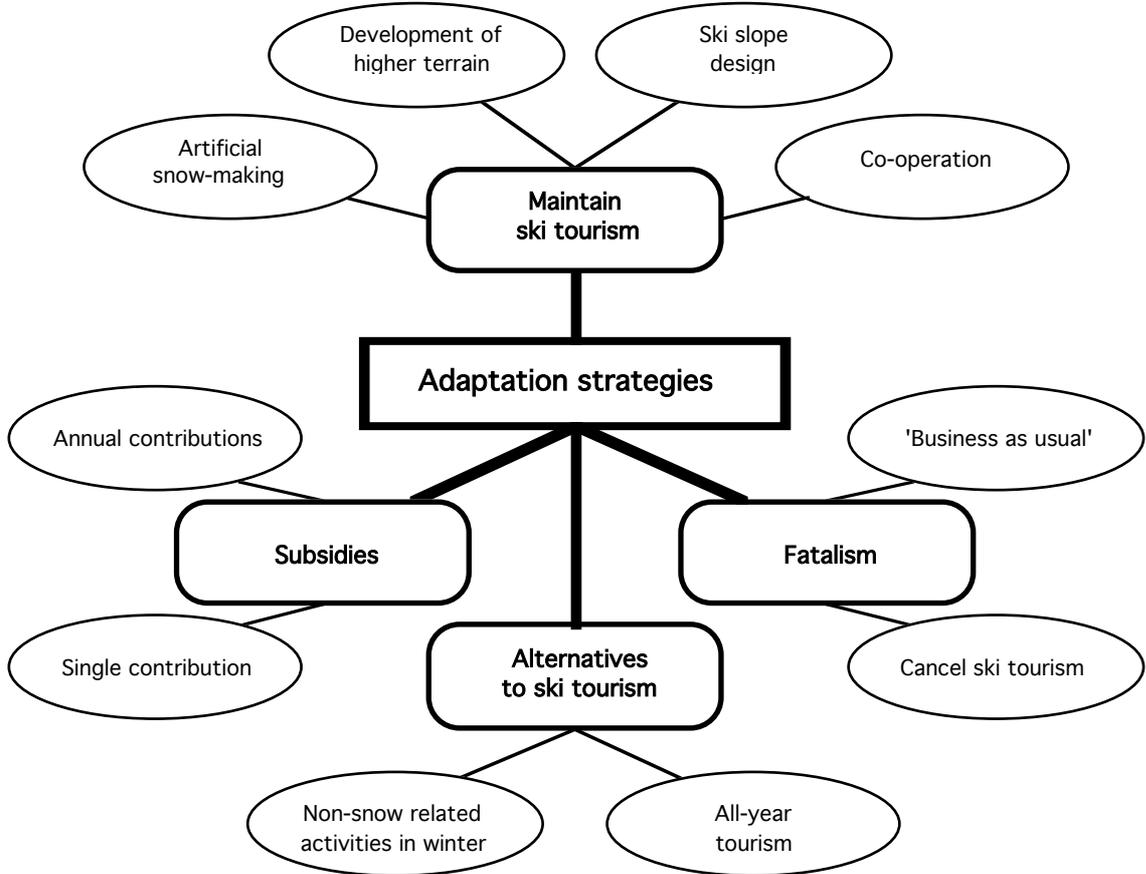
Climate change represents a new challenge for tourism, and particularly for winter tourism in mountain areas. It is not, however, the case that tourism’s initial position will undergo a sudden, radical change. Instead, climate change has to be viewed as a catalyst that will reinforce and accelerate the pace of structural change in the tourist industry and more clearly highlight the risks and opportunities inherent in tourist developments even now. The emergence of a 2-tier society in the winter tourism sector – a few resorts and cableway-companies at a high profit and most resorts and companies unprofitable - will not be due to climate change alone, but to the

general change in a competitive market as well. On the one hand, we have the top resorts with their already varied and attractive offers and high snow-reliability and, on the other hand, we have the smaller locations with their less-extensive developments, less-refined offers and restricted opportunities for further development.

Since climate change is a relatively long-term development in comparison to other trends in tourism, tourism managers and tourists will have every opportunity to adjust to the different constraints and adopt the corresponding strategies and measures (fig. 1). One of the most familiar measures in the struggle against snow-deficient winters is the construction of high cost artificial snowmaking facilities.

Adopting a fatalistic attitude towards climate change and its impacts should not be considered as a true strategy in this respect. Such attitudes are manifested by the fact that neither suppliers nor consumers alter their behaviour. This could also be described by using the term ‘business as usual’. Another approach that can be classified under the heading of ‘fatalism’ is when tourist transport facilities that were used for winter sports are closed down and dismantled without any attempt at promoting and reinforcing other types of tourism – in other words, when withdrawal from ski tourism is not actively planned. A fatalistic attitude of this type is most readily evident amongst the operators of small, isolated ski-lifts at lower altitudes who experienced severe financial difficulties as a result of the snow-deficient winters.

Figure 1: Adaptation strategies



## 6. Conclusions

Global warming is a challenge for the tourism industry in mountain areas. But warmer temperatures and a longer summer season are of minor importance. Over all, climate change is a threat for mountain tourism due to less snow, less glaciers, but more extreme events (e.g. landslides).

Winter tourism depends on good snow conditions and is highly sensitive to snow-deficient winters. Climate research findings show that there will be an increase in the number of winters with little snow on account of climate change. The tourism representatives will not just sit back idly in the face of climate change. They are reacting to the deteriorating snow conditions and the changes in demand. Technical measures, especially artificial snowmaking, to maintain ski tourism rank at the forefront. Tourists demand good snow conditions, and hence, this is what has to be offered by the ski resorts. In any case, the impacts of climate change will involve significant costs for tourism. One of the most important questions will be, how young people would start skiing/snowboarding, if there is only little snow in the big towns and if the little and cheap ski lifts for families at small distances to these towns will be dismantled due to climate change. Although indoor skiing is a growing industry in European towns, it is uncertain that indoor ski domes can replace the role of little ski resorts for beginners in the foothills.

As a sector of the economy that is severely affected by climate change, however, tourism needs to focus more on mitigation strategies in its own best interests. This holds particularly true for the traffic generated by national and international tourism and, above all, for air traffic. Tourist development and tourist projects not only need to be verified and evaluated in terms of their social and environmental compatibility but must also be assessed from the climate-compatibility angle.

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