Impacts of Climate Change on Winter Tourism in the Swiss Alps

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This paper examines the impacts of three consecutive snow-deficient winters at the end of the 1980s on the winter tourism industry in Switzerland. It is shown that ski areas in lower areas suffered severe consequences. Ski areas at higher altitudes (in particular glacier ski resorts) on the other hand increased their transport figures and therefore profited from the lack of snow in lower areas. The snow-reliability of all Swiss ski fields under current climate conditions and under a 2°C warming are investigated. Under current climate conditions 85% of all Swiss ski areas are snow-reliable. This number would drop to 63% if temperatures were to rise by 2°C. This is likely to threaten the regionally balanced economic growth which winter tourism has provided. Possible strategies for the winter tourism industry to adopt if climate change occurs are presented.

Introduction

The Swiss economy depends highly on tourism. The tourism industry is the third most important export industry for Switzerland providing approximately 300,000 full time jobs. For the alpine area in Switzerland, winter tourism is the most important source of income, with this industry providing regional economic growth for these rural areas. The commercial viability of winter tourism, however, depends on sufficient snow conditions. If the assumptions of the impacts of climate change hold true, snow cover in the Swiss Alps will diminish which will, in turn, jeopardise the tourism industry. This paper examines the impacts of snow-deficient winters between 1987/88 and 1989/90, which are perhaps the precursors of global warming, on the tourism industry in the Swiss Alps. The possible impacts of global warming on the alpine snow cover and the Swiss ski fields are also examined. Special attention is given to the importance of glacier ski resorts. Furthermore, different strategies for the tourism industry to adopt are presented.

Impacts of Snow-deficient Winters on the Tourism Industry

The three winters 1987/88 to 1989/90 in the European Alps were generally too warm and, for successful operation of ski resorts, up to the end of January or mid-February, extremely snow-deficient. Switzerland has seen snow-deficient winters in 1949/50, 1955/56, 1959/60 and 1963/64. However, to experience three consecutive winters with such poor snow conditions was most unusual.

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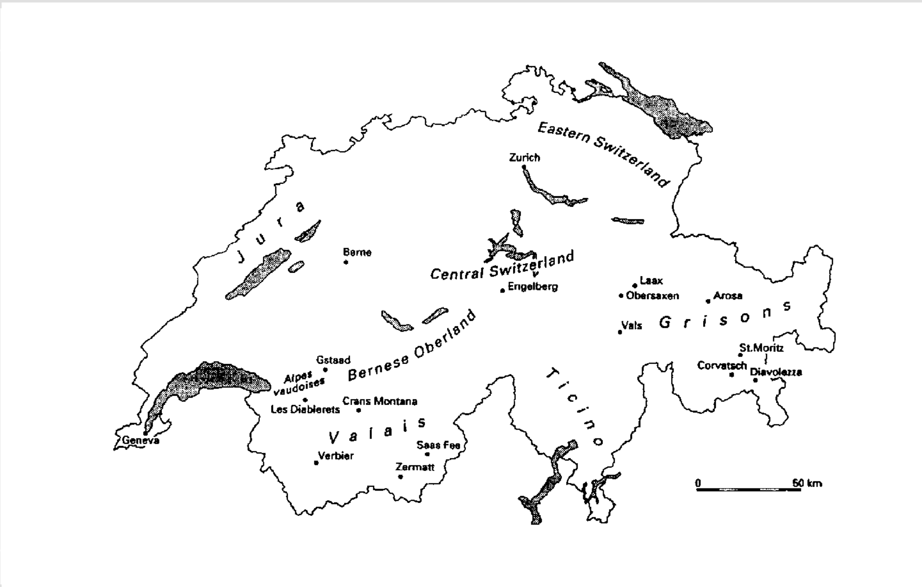

Figure 1 Switzerland with examined resorts (Cartography by Martin Steinmann)

Impacts on the tourism industry in general

The impacts of the three snow-deficient winters on ski resorts and on the entire tourism industry differed greatly among regions. The losses for the entire tourism industry — especially in the accommodation sector — were smaller than those of the transport companies (cable-cars, T-bars, chair-lifts). For example, in the Canton of Grisons, the decreases in the number of overnight stays were nowhere as serious as the drops the transport sector had to cope with. In the Bernese Oberland on the other hand, the accommodation sector was seriously affected. In the winter of 1989/90, the number of overnight stays dropped 12% compared to the preceding period (Abegg & Froesch, 1994).

In general, ski resorts at lower altitudes suffered more from the lack of snow. A number of transport companies were in financial difficulties and there were even a few bankruptcies. Some of the companies which were not able to sustain their business with their own resources received financial aid from local and state governments (Kaspar, 1992).

Impacts on demand

The unfavourable snow conditions had direct impacts on the demand for ski tourism. In some regions, heavy drops in passenger numbers were reported. In other regions, the patronage of the transport facilities increased. Figure 2 shows the number of people transported per year from 1984 to 1990 in four ski resorts located in the Canton of Grisons. The ski resorts are of different sizes and altitudes. None is located on a glacier. Although the extent and pattern of reduction varies, it can be seen that they all showed drops in transport numbers in the three examined winters.

Glacier ski resorts — all situated at high altitudes above 3000m — benefit in this situation from the unfavourable snow conditions in lower areas. Figure 3

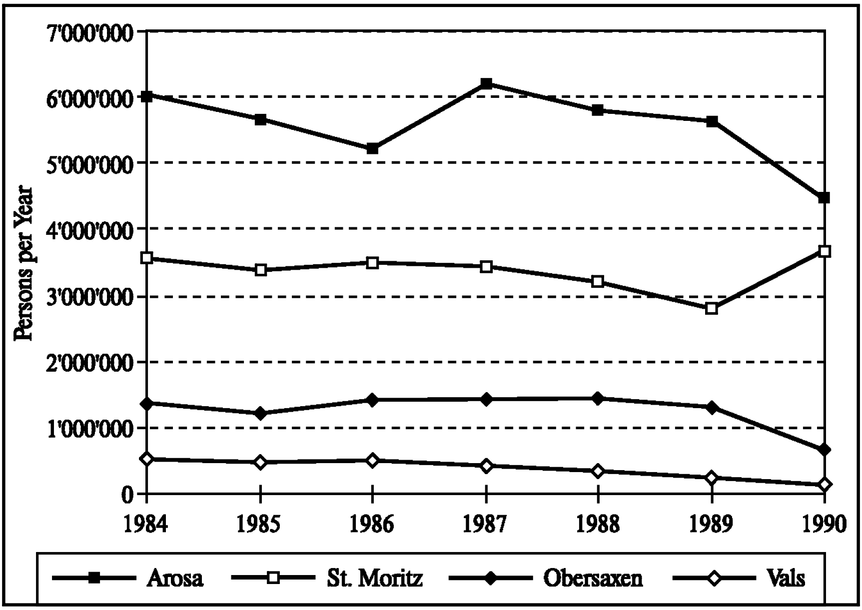

Figure 2 Number of people transported per year from 1984 to 1990 in ski resorts without glacier

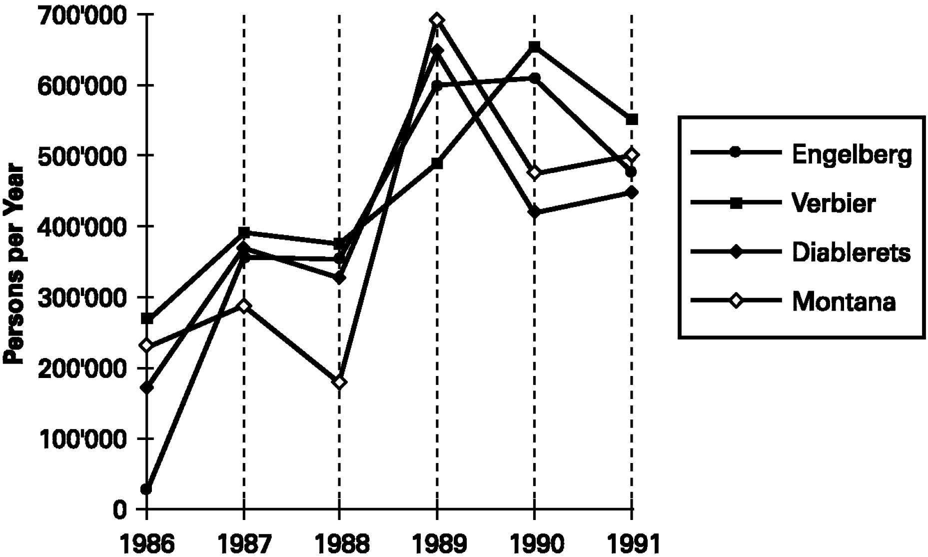

Figure 3 Number of persons transported in glacier ski resorts during snow-deficient winters (1987–1990)

shows that the number of passengers using transport facilities on glaciers is extremely high in snow-deficient winters.

While the ski resorts at lower altitude suffered from a lack of snow, those resorts with glaciers could provide both an early start to the ski season and

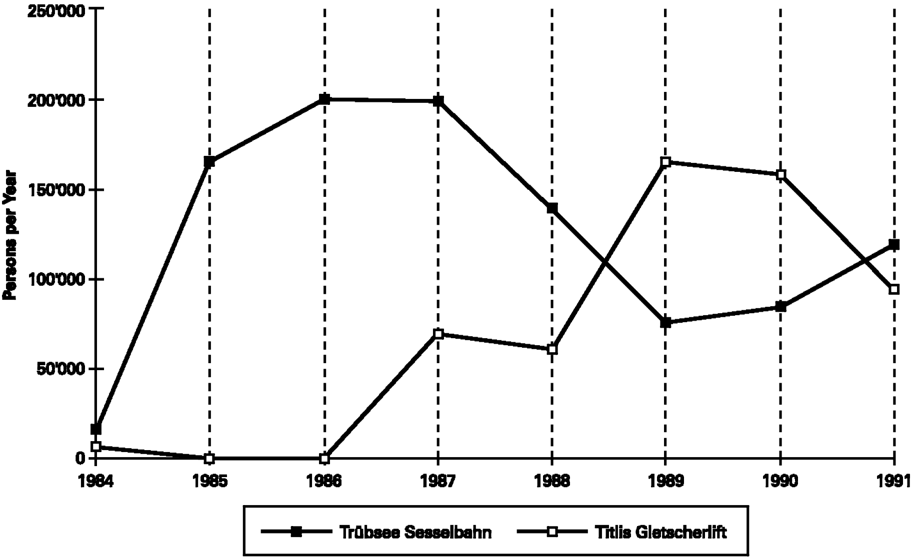

Figure 4 Comparison of transport numbers of a chair-lift (Truebsee Sesselbahn, not on a glacier) and a glacier T-bar (Titlis Gletscherlift)

reliable snow conditions throughout the winter season. To illustrate this, Figure 4 compares the transport numbers of a chair-lift (Truebsee Sesselbahn, situated at low altitude, not on a glacier) and of a T-bar on a glacier (Titlis Gletscherlift) in Engelberg.

As the above figure shows, in years with normal snow pack, the chair-lift transported more people than the ski-lift. In the three snow-deficient winters, the transport numbers of the chair-lift dropped heavily due to the lack of snow, while the transport numbers of the glacier T-bar increased. Transport facilities on glaciers therefore saved the transport companies in glacier ski resorts from big financial losses during the snow-deficient winters.

Impacts of Climate Change on Snow Cover

Assuming that climate change will occur, the Intergovernmental Panel on Climate Change (IPCC) scenario A (Business-as-usual) predicts a temperature rise of + 0.3°C/decade (IPCC, 1990). Given this scenario, the following consequences can be sketched for the snow pack in the Swiss Alps until the middle of the next century (+2°C) (Foehn, 1991; Programmleitung NFP 31, 1992). The snowline in winter would rise by 300m in the Central Alps and by 500m in the Prealps so that the first snowfall of the season would be delayed, would melt prematurely, and the duration of the snow cover would be reduced by one month compared to the present conditions. At the same time, the depth of snow would certainly be considerably reduced (cf. Figure 5).

It is very difficult to predict climate change on a regional scale; however, recent research for the Swiss Alps has sketched the most unfavourable combination of warm and dry winters (Wanner, 1994).

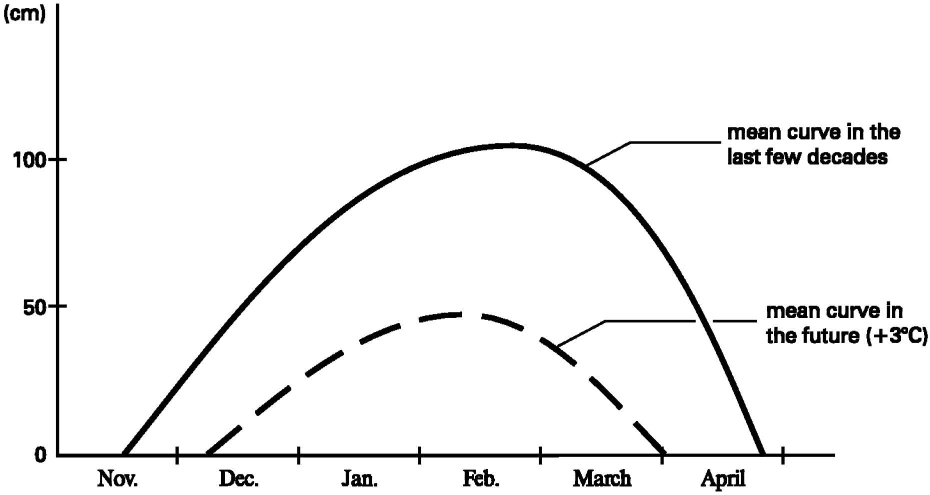

Figure 5 Snow depth and duration of snow cover at an altitude of 1500m in the last decades and in the future (schematic illustration). *Source*: Foehn, 1991

Impacts of Climate Change on the Swiss Ski Fields

Climate impact research on the winter tourism industry has previously been undertaken in Austria (Koch & Rudel, 1990; Oesterreichische Akademie der Wissenschaften, 1993; Breiling, 1993a,b), Australia (Galloway, 1988; Ecosign, 1990; Keage, 1990; Haylock *et al.*, 1994; Whetton *et al.*, 1996), Canada (Wall, 1985; McBoyle *et al.*, 1986; Lamothe & Périard Consultants, 1988; Badke, 1991; Lipski & McBoyle, 1991; Brotton & Wall, 1993; Wall, 1993), New Zealand (Barringer, 1991; Chinn, 1990) and Switzerland (Foehn, 1990, 1991; Pfund, 1993; Bultot *et al.*, 1994; Abegg *et al.*, 1994; Koenig, 1994; Buerki 1995). Studies also exist for Scotland (Smith, 1991), the Czech Republic (Sebek, 1990) and Turkey (Wall & Badke, 1994). In general, most of these studies show severe consequences for the winter tourism industry if climate change occurs: while some regions may be able to maintain their winter tourism with suitable adaptation strategies, others would lose their winter tourism industry due to a rising snowline.

Most of the research undertaken in Switzerland used a case study approach investigating impacts of climate change on the winter tourism industry in single regions. Hence, the aim of our investigation is to analyse the snow-reliability of all existing Swiss ski fields under current climate condition and under a changed climate regime.

Assumptions

Different criteria have been discussed in the literature in order to assess the snow-reliability of ski areas (Risch & Bonorand, 1972; Bezzola, 1975; Wanner & Speck, 1975; Krippendorf & Annasohn, 1976; Elsasser *et al.*, 1977; Witmer, 1984). The so-called 100 days-rule, first suggested by Witmer (1986), summarises the results of most of these studies and states that to operate a ski area with profit, snow cover sufficient for skiing (i.e. 30cm) should last at least 100 days per season (between the first of December and the end of April).

The studies of Foehn (1990) and Pfund (1993) showed that most of the Swiss ski areas above 1200m have matched the 100 days-rule in the past and that therefore a minimum altitude of 1200m ('line of snow-reliability') is required in order to operate a financially viable ski industry under current climate conditions in Switzerland. It was mentioned above that if significant atmospheric warming were to take place (+2°C) the snowline in the Central Alps would rise by 300m. We assume that the 'line of snow-reliability' for ski areas would rise by the same amount and that therefore only ski areas with a minimum altitude of 1500m would be able to operate a commercially viable ski industry if temperature should rise by 2°C. We therefore define ski areas with minimum altitude of 1200m as snow-reliable today and ski areas with minimum altitude of 1500m as snow-reliable if temperature rises by 2°C.

Method

To examine the implications for skiing in different parts of Switzerland, it was necessary to work on a regional scale. The country was subdivided into eight tourism regions, well known from different studies on recreation and tourism in Switzerland. In all, 230 ski areas and 122 ski-lifts were analysed. Statistics on transport facilities in Switzerland (BRP & BAV, 1992 and REKA, 1994) and information handouts of the ski resorts (winter 1994/95) were used when investigating the altitudinal range of transport facilities.

All transport facilities used for skiing, except small lifts (covering less than 100m in length), were analysed. The ski fields were divided into ski areas and single lifts. Ski areas encompassed at least two transport facilities. Large ski areas were separated into different ski areas, where geographically and technically (ticket sale) possible. The aim is to show for all ski areas, whether there are any transport facilities higher than the minimum altitude (1200m and 1500m respectively) and whether these transport facilities can be reached. A ski-lift covering an altitudinal range from 970m to 1320m and a ski area with two lifts (1050m to 1360m and 1350m to 1610m) for example would both be considered as not being snow-reliable under current climate conditions (threshold value 1200m).

It should be mentioned that other criteria which may influence the snow-reliability of a ski areas such as aspect, regional climatological features and human adaptation strategies (e.g. artificial snow-making) were not taken into consideration.

Results

The results for the ski areas and the ski-lifts are presented in Tables 1 and 2. Eighty-five per cent (195 of 230) of the ski areas are snow-reliable at present. If climate change should occur as outlined above, the number of snow-reliable ski areas would drop to 144 (= 63%). The corresponding figures for single ski-lifts are 40% and 9% respectively.

On a regional level, even stronger consequences can be noticed. There are a few ski areas which have to cope with unreliable snow conditions in general.

Table 1 Snow-reliability of Swiss ski areas

Region	*Number of ski areas*	*Mean altitude of the highest point in the ski area*	*Snow-reliable 1200m*		*Snow-reliable 1500m*	
			abs.	%	abs.	%
Jura	15	1400m	4	27	1	7
Alpes vaudoises/ fribourgeoises	19	1866m	16	84	7	37
Valais	54	2534m	54	100	52	96
Bernese Ober- & Mittelland	35	1930m	30	86	20	57
Central Switzerland	35	1783m	26	74	13	37
Ticino	8	1910m	8	100	3	38
Eastern Switzerland	18	1646m	11	61	6	33
Grisons	46	2515m	46	100	42	91
Switzerland	230	2104m	195	85	144	63

Table 2 Snow-reliability of single ski-lifts

Region	*Number of single ski-lifts*	*Mean altitude of the top of the ski-lift*	*Snow-reliable 1200m*		*Snow-reliable 1500m*	
			abs.	%	abs.	%
Jura	18	1213m	2	11	0	0
Alpes vaudoises/ fribourgeoises	8	1411m	3	38	1	13
Valais	15	1670m	15	100	4	27
Bernese Ober- & Mittelland	17	1342m	6	35	0	0
Central Switzerland	18	1265m	7	39	1	6
Ticino	4	1280m	1	25	0	0
Eastern Switzerland	26	1100m	3	12	0	0
Grisons	16	1589m	12	75	5	31
Switzerland	122	1335m	49	40	11	9

These marginal ski areas are located in the Jura mountains and the northern Prealps (Eastern Switzerland). On the other hand, ski areas in the Canton of Grisons and Valais are extremely snow-reliable and still will be in the future. From Table 1 it is evident that, in a warmer climate, all but these two regions will be faced with an increasing number of endangered ski areas. This is true especially for the Jura mountains and the lower parts of the Ticino, Eastern, Central and Western Switzerland (Alps vaudoises et fribourgeoises).

As can be seen in Table 2 the single ski-lifts are most affected by unreliable snow conditions. Many of them are already marginal under the present climate. Due to lack of snow, single ski-lifts will have to cope with additional problems in the future. The results indicate that the usefulness of the majority of the ski-lifts, mainly located in the lower parts of the Swiss mountain ranges, will be seriously endangered. On the other hand, the basic criteria used in this analysis may be too restrictive (100-day rule) i.e. to be economically viable it may be not necessary to run a single ski-lift during a period of 100 days.

In general, the changing climate will have negative effects on the attractiveness of many ski areas in middle altitudes. Tourists will be faced with a diminished supply of ski-runs because parts of the ski areas are no longer snow-reliable. In addition, skiing close to the ski resorts in the valleys will become more difficult. A possible scenario is a ruinous competition between ski resorts leading to a concentration of winter tourism in the most favourable areas with good natural conditions. Simultaneously, ski resorts at low altitudes will lose their ski tourism and therewith their economic base. This is particularly true for ski resorts which have no 'four season' tourism and thus depend strongly on sufficient snow conditions, i.e. winter tourism.

In the higher areas where the tourism industry concentrates, environmental problems such as waste water and rubbish are likely to increase. A shortage of snow at ski resorts in lower parts of the mountain range may initiate the building of new resorts and ski-runs at higher locations. This is likely to increase the pressure on what remains of the natural environment. Due to losses in the lower areas, the regionally balanced economic growth which tourism has provided is threatened. Furthermore, with the elimination of small businesses, a part of the diversity of commercial services will be lost, which is one of the strong points of Swiss tourism.

Significance of Glacier Ski Resorts in a Warmer Future

Due to the '100% snow-reliability' even in snow-deficient winters, increases in the number of transported passengers in glacier ski resorts are to be expected. To meet the increasing demand, extension projects may need to be undertaken. These will also increase the pressure on remaining sections of the natural environment. This is particularly so with isolated glacier ski resorts (for example Les Diablerets) which will have to cater for the migration of ski tourists from the nearby endangered ski resorts at lower altitudes. Glaciers, therefore, provide an important advantage in the competition among ski resorts. While glaciers are becoming increasingly important for winter skiing, summer skiing, which used to be an important feature is likely to decline. During the seventies, summer skiing was very popular in Switzerland. Nine glacier ski resorts offered summer skiing: Saas Fee, Zermatt, Verbier, Crans Montana, Les Diablerets, Engelberg, Laax, Corvatsch, Diavolezza (see Figure 1). Over the last 15 years however, patronage of summer skiers in Switzerland steadily decreased. This reduction in tourism numbers is significantly greater than the recently observed general declining trend of overnight stays in Switzerland and has occurred for two reasons. Firstly, there has been a pattern of warmer weather conditions over the last 30 years, causing a great reduction in snow cover on glaciers and correspondingly high rates of glacial melt. Secondly, the reduction in number of summer skiers has also been attributed to the changing preferences of the skiers: with new summer sports such as mountain biking and paragliding being offered, it now seems summer skiing is not as interesting and exclusive as it used to be 15 years ago.

If there were to be a rise in temperature it is expected that substantial

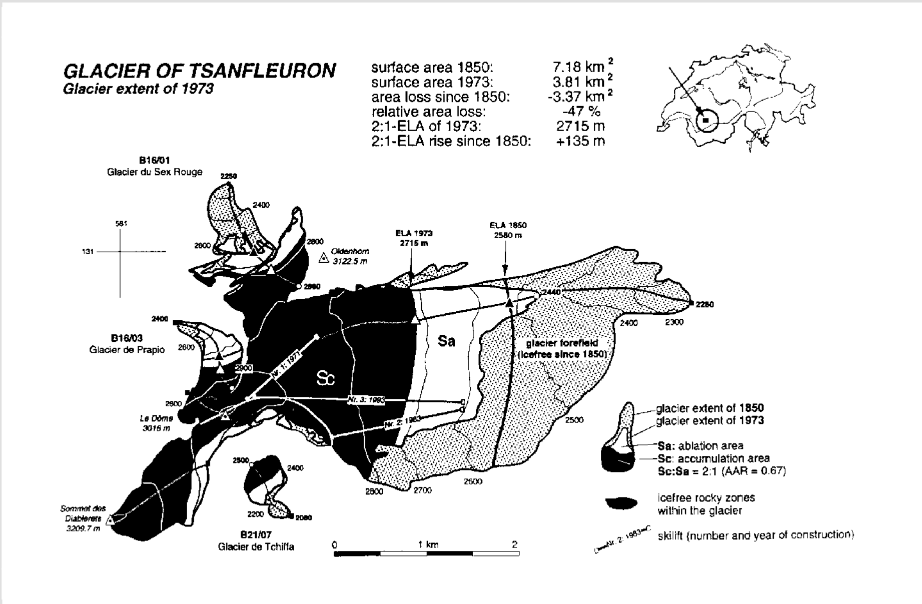

Figure 6 Glacier de Tsanfleuron (Les Diablerets): Glacier extent 1850 and today

reductions in the use of summer ski resorts would occur. A further problem will be the continuing concentration of demand on the two well-established summer ski resorts at Zermatt and Saas Fee. This will result in unused and, therefore, unnecessary transport facilities in other resorts becoming obsolete.

As an example of the high rate of glacier melt under climate change, the shrinking of the 'Glacier de Tsanfleuron' in Les Diablerets (see Figure 1) is shown in Figures 6 and 7.

In Figure 6 the glacier extent 1850 (last maximum extent, advanced period) and today (1973) is presented. All ski-lifts are still located on ice. Figure 7 shows the glacier melt with a temperature rise of 0.6°C. Given the IPCC Scenario A, this temperature rise will occur in 2010. It will then not be possible anymore to use ski-lifts Nos. 2 and 3 in summer. Only ski-lift No. 1 will still be located on ice. Although glaciers will lose their importance in summer skiing, glacier ski resorts will still have a significant advantage in the winter sport market due to their high altitude.

Response Strategies

As a consequence of the three snow-deficient winters at the end of the 1980s and the possibility of climate change, several response strategies are being discussed among tourism researchers and Swiss tourism promotors. Due to the high variability of today's climate, some of these adaptation strategies are worth considering, even if climate change does not result.

Development of higher skiing areas

As illustrated, ski areas at higher altitudes have a significant advantage in the ski-tourism market. Tourism promoters such as the transport companies demand further development even on protected areas of the high mountain

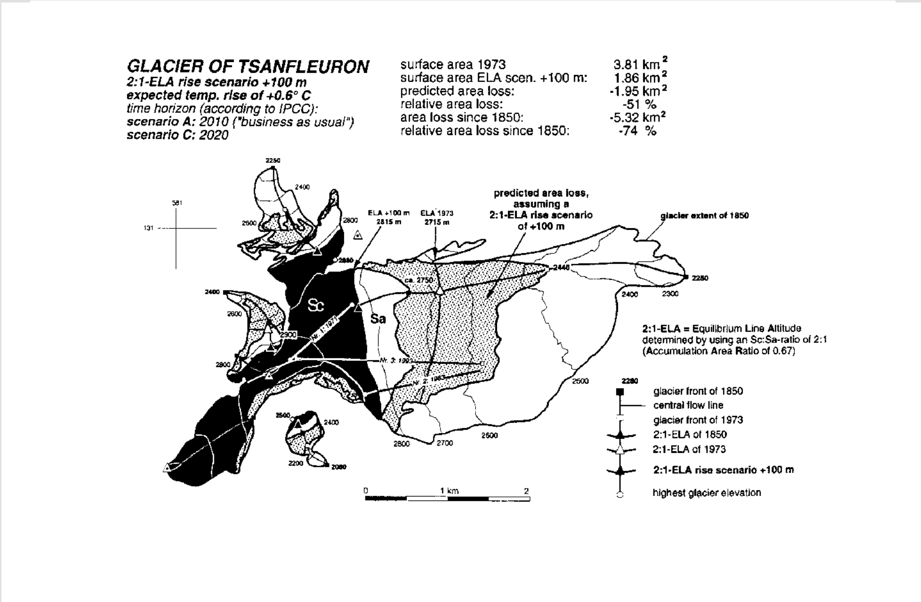

Figure 7 Glacier de Tsanfleuron (Les Diablerets): Glacier extent with an expected temperature rise of + 0.6°C

range. This strategy may save a few transport companies from bankruptcy. However, the development of remote mountain areas should be rejected for environmental reasons.

Snow-making

The area of artificial snow-making in Switzerland doubled between 1993 and 1995, covering 7.9km^2 in 1995. This is 3.6% of the groomed ski area (Theus, 1995). Most winter resort managers in Switzerland request further expansion of the artificial snow areas. Swiss tourists, however, are very critical about artificial snow-making: a study by Studer & Christoffel (1990) showed that a white strip of snow in a green landscape is not what tourists would like on their winter holidays. Swiss ski tourists therefore seem to be much more critical of artificial snow than for example ski tourists in Canada or in Australia (Buckby *et al.*, 1993).

Other points worth raising about snow-making include:

(1) The already existing problem of the lack of water supply for artificial snow-making.
(2) Rising temperatures due to global warming will also endanger the snow production.
(3) The ecological impacts of artificial snow-making in the alpine area have to be taken in consideration (for example the impacts on the flora and fauna) (CIPRA, 1989).

However, for smaller areas of the ski slopes which are congested or exposed to sunny conditions, artificial snow-making still seems to be a reasonable strategy for maintaining snow cover.

Diversification

Winter ski resorts can diversify into other activities outside conventional ski-tourism. Successful examples of diversification into the cultural sector are reported from Arosa and Gstaad (theatre and music festivals). These activities and other entertainment and sports events can also help to improve summer business.

Co-operation

Nowadays there are mostly small and local companies in the tourism transport business in Switzerland. By business co-operation or fusion of companies, rationalising effects can be obtained and the financial base of the companies can be improved. There is a possibility of better co-ordination of investment strategies. The pressure of competition which forces companies to expand continually can be moderated. (Abegg & Froesch, 1994). Successful examples of co-operation were observed in Les Diablerets (Koenig, 1994).

Conclusions

This paper examined the impacts of the three snow-deficient winters at the end of the 1980s on the tourism industry in Switzerland. It was shown that transport companies in lower areas suffered severe consequences. Ski areas at higher altitudes on the other hand (in particular glacier ski resorts) profited from the lack of snow in lower areas. The figures of the transport companies in higher areas increased significantly in years with poor snow conditions.

The snow-reliability of the Swiss ski fields under current climate conditions (ski fields higher than 1200 are snow reliable) and under a 2°C warming (ski fields higher than 1500m are snow-reliable) was then investigated. It was shown that under current climate conditions 85% of all Swiss ski areas are snow-reliable. This number would drop to 63% if temperatures were to rise by 2°C. The corresponding figures for single lifts are 40% and 9% respectively. Examination on the regional level suggested that the Jura mountains, the lower parts of Ticino, Eastern, Central and Western Switzerland would lose their winter tourism industry if temperatures were to rise. This would threaten the regionally balanced economy which winter tourism has provided. The ski fields in the Canton of Grisons and Valais on the other hand would still be snow-reliable with a temperature rise of 2°C. In these areas, the expected concentration of winter tourism is likely to increase environmental impacts on the fragile ecosystems of the high mountain ranges.

Possible strategies for the winter tourism industry to adopt if climate change were to occur were presented. While an extensive expansion of the area of artificial snow-making and the extension of ski fields into higher areas should be rejected for environmental reasons, diversification and co-operation strategies are worth further consideration. The future of winter tourism in Switzerland largely rests with the outcomes projected by the climate change scenarios. Faced with a tourism industry which is highly climate-sensitive, tourism planning in the alpine area of Switzerland has to take the possible impacts of climate change into account.

Future research should — instead of working with average climate data — take the high interannual variability of snow cover and snow depth into account. Furthermore, it is necessary to examine how resort operators and tourists perceive the occurrence of climate change and to investigate how they think they would adapt.

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