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Perception and Adaptation to Climate Change in Low Altitude Ski Resorts in Austria

Author:

Christoph Wolfsegger

Poscherberg 21

4230 Pregarten

Austria

e-mail: wolfseggerchrist@hotmail.com

Phone: +43 72366704

Supervisor:

PhD, Stefan Gössling

Lund University – Campus Helsingborg

Sweden

e-mail: stefan.gossling@msn.lu.se

Phone: +46 42356620

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Abstract

Ski tourism is an important industry in Austria. Due to climate change, this industry is threatened. Ski resorts are dependent on a temperature sensitive resource: Snow. Previous studies found out that low altitude ski resorts are more sensitive to climate change than high altitude ski resorts. A questionnaire was conducted to investigate if low altitude ski resorts are aware of threats due to climate change. Furthermore, it was asked what the ski industry is doing to adapt to climate change. 71 ski resorts formed the target population and 36 valid questionnaires were returned. The questionnaires were filled out by decision makers of ski resort operators. The study results in three major findings. First, it was found out that the ski industry seems to be aware of the threats climate change entails. For a majority, climate change is an issue concerning the expected impacts in the future. However, to date, little financial damage has been reported. Second, although future impacts are considered severe, climate change is not seen as a catastrophe because the industry believes in adaptation. Snowmaking is a widespread technology that is considered appropriate to compensate the potential lack of natural snow. Environmentalists criticize snowmaking for a number of negative impacts on the environment. Also other strategies are considered appropriate to avoid a collapse of the ski industry, but the focus is clearly on snowmaking. The author argues that the high perceived adaptive capacity should give reason to investigate deeper into the adaptive capacity. If the adaptive capacity is overestimated, negative outcomes for the environment, as well as for the economy can be expected in the long run. Third, the inconsistency of answers to particular questions confirms that the mental picture of climate change is based on subjective perception. Therefore, a Causal Loop Diagram was constructed to explain the complexity and the dynamics of perception and adaptation to climate change.

Keywords: climate change, adaptation, adaptive capacity, perception, ski resorts

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1 Introduction

"*Weather and climate have profound influence on life on Earth*" (IPCC – Intergovernmental Panel on Climate Change, 2001a, p. 87). This statement is neither new nor surprising, but has been receiving enhanced attention in contemporary life on Earth. In the last two decades the Earth's climate has been in the spotlight of environmental and social research due to observable changes of climate patterns and resulting impacts on natural and human systems. Natural and human systems are adapted to a mean climate over a long period of time. Consequently, any change from this mean climate makes any system vulnerable.

Due to its environmental and socio-economic impact potential, climate change became part of the international political agenda with the establishment of the United Nation Framework Convention on Climate Chance (UNFCCC) in 1992. Generally, one distinguishes between two different policy responses to climate change. Those two strategies are mitigation and adaptation. Mitigation is considered as a strategy to reduce greenhouse gas emissions and alter land use patterns in order to limit the impacts of the anthropocentric greenhouse effect in the future. Since the beginning of modern climate change research, mitigation studies seem to be the focus of academia. The second strategy, which is an adequate adaptation to climate conditions, is a less investigated field. However more recently, the global society realized the importance of adaptation to climate change because further impacts seem to be inevitable even under radical mitigation measures (Grothmann & Patt, 2005).

"Adaptation has the potential to reduce adverse affects of climate change" (IPCC, 2001b, p. 6). Hence, the need to for a better understanding of adaptation potentials and limitations is pointed out by the IPCC. In contrast to mitigation, adaptation has a regional relevance. The impacts of climate change were observed to be very different in different regions of the world. The IPCC (2001b) and a number of individual studies emphasize that some regions will be more affected than others. Extreme weather events like storms, flooding, droughts, heat waves and consequences of long term climate change such as sea level rise are only some of the key concerns. As those phenomena appear on a regional scale, adaptation measures need to be regional as well. Adaptation has to be carried out by the effected system. If and what adaptation measures are taken is substantially dependent on the adaptive capacity of the affected system. Current studies have a tendency to focus on financial, technical and institutional criteria in order to evaluate the adaptive capacity (Haddad, 2005). One factor has almost been entirely omitted by a majority of researchers: Perception. How can one adapt to climate change in an adequate way if he does not perceive the current and future climate change as a reality? The value of the above mentioned criteria should not be neglected, but it is reasonable to argue that the first step towards adaptation is the perception of the problem. If perception does not correspond with reality, all the financial or technical resources might be used too much, too little or resources might even be

spent for wrong measures. Although a number of researchers (Lazo et al. 2000, Adelekan & Gradegesin, 2005, McDaniels et al., 1996, Axelrod et. al, 1999, O'Connor et al, 1999, Langford, 2002, Stedman, 2004) have stated that perception is an issue for climate change adaptation, there is still lacking research in that crucial factor (Grothmann & Patt, 2005).

Due to the focus on criteria, which are related to a nation's wealth, many climate change adaptation case studies deal with concerns in developing countries. The sea level rise in sensitive coastal areas or the impacts of droughts in Africa are a few examples (Brooks et al, 2005). This study is taking a contrary viewpoint and uses a case from a developed country perspective: The Austrian ski tourism industry. It is an important employer and can be described as the engine of the rural economy in many parts of the country. The alpine tourism is very much dependent on a climate sensitive resource: Snow. Regular snowfall and favorable temperatures for snow conservation are important for ski resorts. The available studies, which were conducted by different researches in Austria and Switzerland show a common trend for the alpine region. Measurements have shown that snow cover duration and depth have been reduced since the 1980's (Latenser & Schneebeli 2003). The snowline, which is the essential indicator for winter sports, is predicted to move towards higher altitudes. It is also predicted that many low lying ski resorts will face problems (Breiling & Charamaza, 1999, Hantel et al., 2000). A natural system is strongly linked with a human system. A change of the natural system poses a threat to the human system. This threat needs to be perceived well in order to develop adequate adaptation measures.

It is not only science that is dealing with the risk of climate change for ski resorts. Nowadays, media (BBC, 2005, International Herald Tribune, 2005) and international organizations (EEA, 2004, World Tourism Organization, 2003) took the results from the scientists and released publications which identify climate change as a severe risk for alpine ski tourism industry. But how does the ski industry itself, or the decision makers of the industry, perceive the risk of climate change? The decision maker's perception is supposed to be the most influential as their decision decides over adaptation measures. According to the author's knowledge, a comprehensive risk perception of the Austrian ski industry has not been assessed yet. It will be done in this paper. **The main aim of the paper is to investigate how the ski industry perceives the threat of climate change. Additionally, the paper will find out what strategies the Austrian ski industry is using to adapt to the predicted lack of snow.** Scott's (2005) conclusion about climate change and ski resorts favors the author's research approach:

"Innovative research is required to advance our understanding of the vulnerability of the global ski industry to climate change. Future inquiry into the adaptive decision-making of process of key stakeholder, their

perceptions of the relative risk posed by climate change […] would be important contributions to the tourism literature."

Ultimately, this paper wants to aid in understanding of climate change adaptation in general and discusses the findings in a broader context. Therefore, the thesis will introduce a detailed theoretical model which explains the decision making process for adaptation to climate change.

2 Methods and Structure

2.1 Integrated Assessment

It is beneficial to conduct climate change research from a transdisciplinary view. This study will take use of the transdisciplinary process of the Integrated Assessment. An Integrated Assessment is able to analyze the causal chain of climate change in general, but also adaptations to climate change. Specialized data from impact assessments is needed to carry out such an Integrated Assessment. An Integrated Assessment

"combines, interprets, and communicates knowledge of diverse scientific disciplines from the natural and social science to investigate and understand causal relationships within and between complicated systems". (IPCC, 2001b, p. 25).

This thesis will combine the psychology of climate change with natural science impact assessments in order to answer the research question. By conducting such an assessment, *"one can identify where the value of information is highest and where additional research may have the highest payoff from a policy perspective"* (IPCC, 2001b, p. 119).

Integrated Assessments are a frequently used method in climate change studies. Up to date, Integrated Assessments have been focused on mitigation research and *"only secondarily on issues of impacts, vulnerability and adaptation" (IPCC, 2001b, p.25).* IPCC (2001b) points out the need for Integrated Assessments in adaptation research. This paper will do so. Furthermore, it will do so in a participatory way. Such a Participatory Integrated Assessment allows the *"combination of evaluation of experts and lay people"* (Behringer et al., 2000). By using a questionnaire, it will include actors who are affected by climate change and who authorized to decide over adaptation strategies. Apart from the questionnaire, several secondary sources are used for the thesis. Theoretical research about risk perception, adaptation to climate change as well as impact assessments are supposed to construct theory and background for the survey.

2.2 The Basic Model and the Research Approach

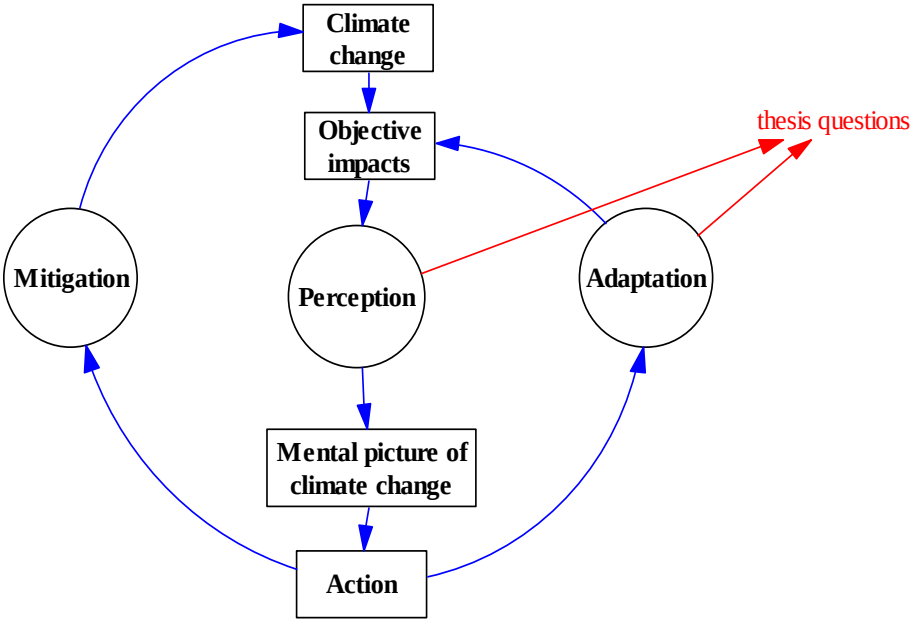

Figure 1: Basic Model for Perception and Adaptation to Climate Change
Source: after Storch & Stehr in Bürki 2000

The model incorporates sub-steps from the actual climate change to the response of the exposed system. Climate change itself is on the top of the process. It has impacts on an exposed system. The impacts are just what they are. They are not influenced by personal feelings or opinions. What is causing a system to react is not the objective impact itself. First, the impacts need to be perceived. The perception of the impacts creates a personalized mental picture of climate change. Only this mental picture of climate change leads to actions. Actions may include adaptation and mitigation. Adaptation has the ability to alter the impacts of climate change. Mitigation can influence climate change itself. However, mitigation is beyond the scope of this thesis and will not be discussed.

At this point, the model should give a rough overview of the research approach and support the basic arguments. A deeper understanding of the model will be possible after having read the first part of the thesis. Eventually, the model serves a main purpose: It should help to answer the research questions.

Research questions with sub-questions:

How does the ski industry perceive the threat of climate change?
Is the ski industry aware of climate change and its impacts?
Is their perception consistent and how does it relate to current scientific understanding?

What are the causes of misconceptions regarding climate change?
What is the perceived adaptive capacity to climate change?
What is the perceived vulnerability from climate change?
What is the perceived severity of climate change?

What are the adaptive strategies of the industry?
What are the perceived limitations for adaptation?

Perception and adaptation strategies are assessed by the author. A questionnaire was considered to be an adequate tool. Towards the end of the paper, the questionnaire results will be used to modify the model. This should improve the understanding of the adaptation process.

Limitation of the model
Perception determines the social mental picture of climate change. But a number of other variables like socio-demographic and socio-economic factors or ideological orientations influence perception and the mental picture of climate change (Stedman, 2004, Sjöberg, 1995). However, those external factors are excluded from the survey as they are beyond the scope of the paper.

2.3 Survey

A questionnaire was sent to decision makers in Austrian ski resort. This questionnaire should assess the perception of current and future climate change as well as current and likely adaptation strategies. It consisted of 21 different questions. Open, closed and ranking scale questions were used in the questionnaire. In general, the questionnaire had a quantitative research approach, however, some open questions called for a qualitative analysis.

Section 4.2 will show that low altitude ski resorts are expected to be especially sensitive to climate change. Consequently, the survey wants to limit its target group to low altitude ski resorts. Also the size of the ski resort was considered. It was assumed that the local socio-economic importance of very small ski resorts is rather small and therefore, very small ski resorts were not a part of the survey either. Criteria, which allowed for categorization of ski resorts needed to be developed:

Criterion 1, Size: the ski resort should have more than 10 km of ski runs

Criterion 2, Altitude: the altitude range between the bottom and the top ski lift station was considered: 50 % of that range should be located under 1500 m above sea level. This criterion was chosen according to the results of Latenser & Schneebeli (2003) (see 4.2).

Two different online ski resort databases (Tiscover, 2005, Bergfex, 2005) were used to gather relevant information about ski resorts. By applying the criteria set, a homogenous group of ski resorts was formed. From a total number of 306 ski resorts, 71 ski resorts fit the criteria set and formed the research population.

The questionnaire was personally addressed to decision makers of ski resort operators. This should increase the response rate and avoid that non decision makers would fill out the questionnaire. Decision makers are defined as persons who are authorized to take investment or strategic decision in the ski resorts. The contact addresses of decision makers were gathered by two different approaches. First, an e-mail was sent to the official ski resort address in order to ask for the personal e-mail address of a decision maker. Additionally, an already established contact list of decision makers, which the author had to his disposal from the national ski resort operator association (Seilbahnen), was used for data gathering. This list helped to fill the gap of missing e-mail addresses.

An online questionnaire program (Survey Monkey, 2005) was utilized for the survey. Among other beneficial features, it guaranteed that respondents could not return to previously answered questions to change their responses afterwards. The way some questions were asked would have had influence on answers of other questions. Therefore, questions needed to be separated from each other and it was essential that answers were not alterable. An advantage of sent questionnaires is that recipients don't feel pressure from the researcher. Hence, their answers might be of better quality. On the other hand, compared to personal interviews, no interaction is possible with the interviewed person, and consequently, the gathered information is less detailed. It is also hard to control the completion of the questionnaire (May, 1997). A number of recipients only answered some questions and left the rest of the questions unanswered. However, considering the population size of 71, personal interviews would have been very time consuming. By using a standardized questionnaire, it was possible to apply statistical methods.

The survey was carried out between September 18th and October 12th 2005. After sending two reminders, 42 responses were received. 6 invalid responses could not be included in the analysis. Therefore, 36 responses were used for the analysis. This is a response rate of 51 %. This group represents the low altitude ski resorts in Austria. The results are not biased towards one part of the population. No significant pattern, which would indicate that different types of ski resorts responded more often than others was observed. The bottom ski stations are located between 550 – 1100 m (x=852 m). They can be found in 7 out of 9 Austrian federal

states and differ considerably in size (10 – 160 km of ski runs). A common heuristic probably influenced the results: The availability heuristic. *"It is well established that people tend to think that events are more probable if they recall an incident of their occurrence"* (Sunstein, 2002). In August 2005, one month before the questionnaire was sent out, severe flooding occurred in the Austrian Alps. According to the availability heuristic, this event most probably biased the results towards a higher expectation of extreme events and future impacts of climate change.

Results from closed and rating scale questions can easily be used for statistical methods and generalizations. On the other hand, answers from open questions have a qualitative character. It was the author's task to identify common trends in attitudes and perceptions.

Limitation of the method
Assessing the perception of an entire company is not possible based on a single decision maker's response. The single decision maker can show a tendency of the company's attitude towards the risk and the adaptation strategies, but it is not suitable to represent the entire organizations attitude. However, a survey with includes a reasonable number of decision makers of an industry, can give an overview of the industry's perception.

2.4 Structure

First, the exposure unit of the assessment will be introduced. A short chapter about the alpine tourism industry (chapter 3) will serve that purpose. Afterwards, a rather detailed discussion about climate change and the impacts for ski tourism (chapter 4) is presented. Knowing that ski tourism is a contributor to local and national wealth, and that the industry is threatened by climate change underlines the relevance of this thesis. After that chapter, one knows who needs to adapt and to what they need to adapt to, but what one does not know yet is the underlying theoretical framework about adaptation to climate change and perception. Hence, this framework is presented in chapter 5. The survey results are presented in chapter 6 and the thesis questions will be answered. The results are explained and discussed in chapter 7. Finally, a concluding chapter will summarize the findings of the thesis (chapter 8).

3 Ski Tourism in Austria

3.1 Tourism in Austria and the Economic Relevance of Ski Tourism

Austria has a population of 8.1 million with an area of 83,871 km². There is an estimation of about 120 million overnight stays of about 28 million tourists visiting Austria annually (Statistik Austria, 2005).

Globally, Austria is considered the country with the highest tourism income per capita (apart from some small island states) (UNECE, 2005). Concerning international tourism arrivals in absolute numbers, Austria is ranked 7th globally (World Tourism Organization, 2004).

Those figures can be explained by the geographical position of Austria. It is located centrally in Europe. Tourist from densely populated and industrialized countries with considerable purchasing power only need to travel short distances on a well developed roads and air traffic nets to get to Austria. A rather diversified offer, which is favored by seasonal climate conditions, includes city tourism (e.g. Vienna, Salzburg), summer tourism (e.g. lakes, hiking) and winter tourism (e.g. skiing, snowboarding) promotes Austria as a tourism destination.

For ski tourism, the magazine *Business Week* (2000) favored Austria's price-value relationship among other alpine competitors like France or Switzerland. The thesis uses the term ski tourism, but it includes all forms of winter sports that are dependent on slopes and snow (e.g. snowboarding, tobogganing).

Although the relevant winter and summer tourism figures (tourist arrivals, over nights stays) are evenly distributed (Statistik Austria, 2005), winter tourism is especially economically significant because the spent money per tourist is considerably higher during winter holidays (Ministry of Economy, 2005). Ski tourism incorporates extra expenditures apart from the basic transport and accommodation costs. Skiing equipment and lift tickets need to be purchased. It can also be argued that in many alpine areas, winter tourism has created the base for summer tourism. Without the infrastructure, like cable cars and hotels, which is built upon a financially lucrative winter season, summer offers might be less attractive.

Ski resorts are mainly found in rural areas. Many industries avoid those areas due to its unpleasant geographical and weather conditions. The traditional income source farming has become less attractive due to better income possibilities in tourism. A high percentage of the rural alpine population is nowadays directly or indirectly dependent on tourism. A great number of service suppliers in the accommodation industry, restaurants, sport shops, ski schools, tour operators, and ski resort operators are directly involved in the industry and provide employment and income. The added value of direct and indirect effects of the supply chain for ski tourism is big and a collapse of ski tourism would have consequences for the local and national economy. The socio-economic value of ski tourism highlights the relevance of research like this one.

3.2 A Major Service Supplier – Ski Resorts Operators

The over 306 different ski resorts are run by different ski resort operators and operate 3,190 ski lifts (Ministry of Transport, 2005, Tiscover, 2005). Those operators are responsible for more 6000 km of ski runs, which form a 0.28 % share of the Austrian land mass (Seilbahnen, 2005b). Ski resorts are scattered all over Austria, but they are usually bigger, located at higher altitudes and have a higher density in the western part of the country (Breiling & Charamaza, 1999). Only the very east of Austria is not suitable for skiing.

Ski field operators have a special status in the supply chain of winter tourism. The role of Austrian ski resort operators is mainly limited to the skier's transportation, ski run development and maintenance (Seilbahnen, 2005b), whereas other parts in the supply chain (hotels, shops, ski schools, etc.) are run by other private actors. However, all remaining parts of the supply chain are dependent on the services of the operators. Without the service of the operators, ski tourism would not be possible in the current form. The grooming, snowmaking (see 4.4) and transportation facilities foster skiing as a form of mass tourism. By using a relative small share of community land (e.g. 6 % in Saalbach-Hinterglemm, 3 % in Ischgl and Kitzbühel) they manage to generate the major share of local income (Seilbahnen, 2005b).

4 Climate Change and Skiing

4.1 Global Anthropocentric Climate Change

The Intergovernmental Panel on Climate Change (IPCC, 2001a, p. 2), which is the main international body for climate research and publications emphasizes that anthropocentric climate change is happening and has already had impacts on natural and human systems: *"An increasing body of observations gives a collective picture of a warming world and other changes in the climate system"*. Temperature increase is a major variable in climate change and there is evidence of changes in physical and biological systems due to that variable.

"Examples of observed changes include shrinkage of glaciers, thawing of permafrost, later freezing and earlier break-up of ice on rivers and lakes, lengthening of mid- to high-latitude growing seasons, poleward and altitudinal shifts of plant and animal ranges, declines of some plant and animal populations, and earlier flowering of trees, emergence of insects, and egg-laying in birds." (IPCC, 2001b, p. 3)

Temperature is the best studied variable of climate change. But temperature increase could also alter other climate patterns like precipitation. Consequently, increased temperatures could trigger extreme events such

as floods, droughts or storms in different regions. Although some indications are available, a lack of long term data about such events makes conclusion difficult (IPCC, 2001a).

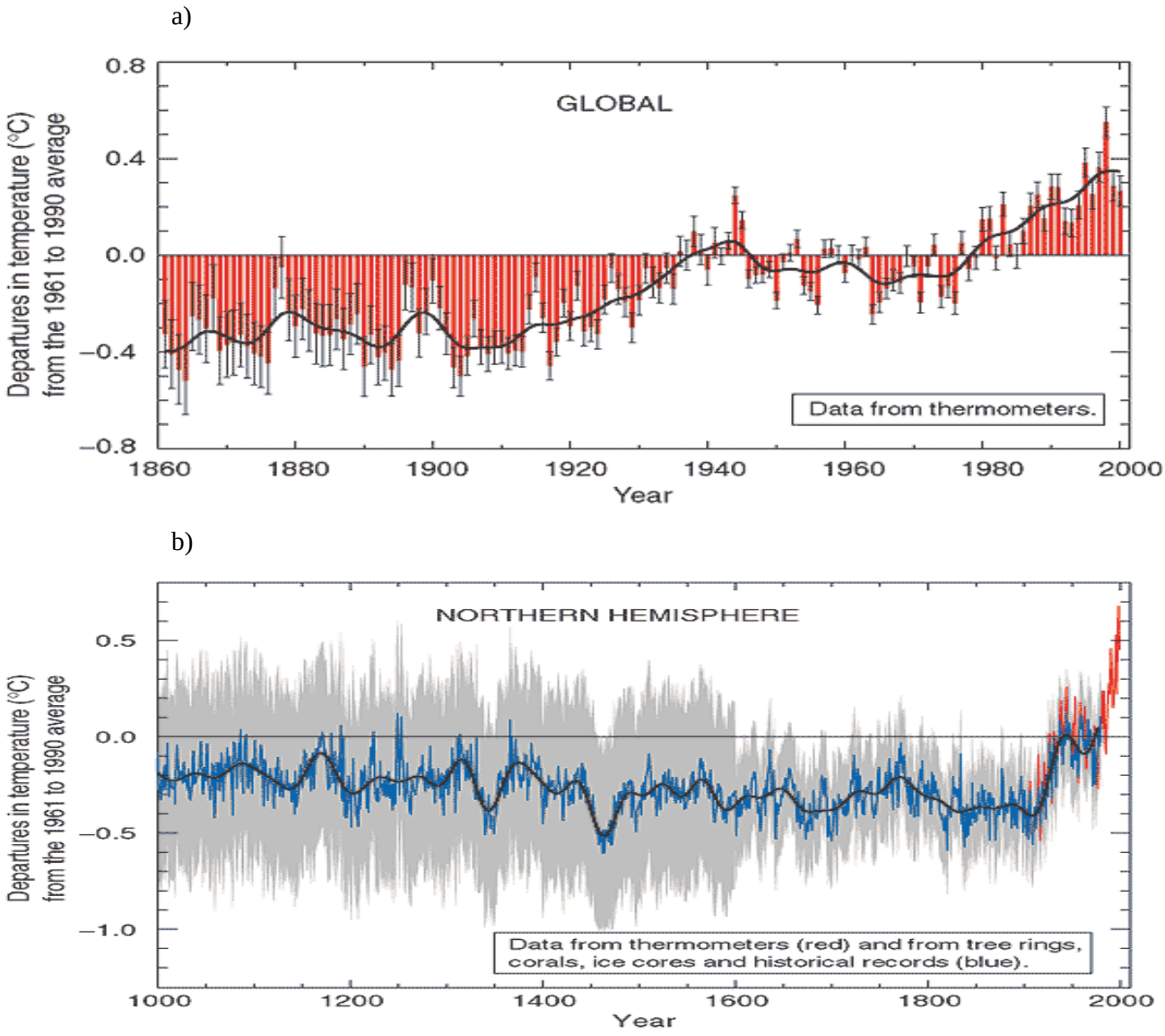

Figure 2: Variations of the Earth's Surface Temperature for (a) the Past 140 Years and (b) the Past 1.000 Years
Source: IPCC, 2001a, p. 3

Figure 1 (a), shows the global mean temperature increase since the industrial revolution. The industrial revolution is the historical event when fossil fuels, which are a major contributor to GHG emissions, took off to be the major human energy source. The red bars show the annual mean temperature with the according confidence interval. The black line represents a decadal filtered temperature development. Considering all uncertainties, global mean surface temperature increased 0.6 ± 0.2 °C in the last 140 years. Figure 1 (b) illustrates the global mean temperature development over the last millennium. The blue curve shows the

annual variations. The black curve uses a 50 year filter. In more distant times uncertainties (grey area) increase due to less reliable data sources such as tree rings, corals or ice cores.

The Earth has been warming significantly more in last century than in the previous 900 years. *"It is likely that the 1990's was the warmest decade and 1998 the warmest year"* of the century (IPCC, 2001a, p. 3). It is known that the Earth's climate has always been subject to changes. However, the *"the observed change in global mean, annually averaged temperature over the last century is unlikely to be due entirely to natural fluctuations of the climate system" (IPCC*, 2001a, p. 97). It is essential to state that global warming rates where the highest in Northern Hemisphere winter and spring, as well as *"mid and high latitude continental regions in the Northern Hemisphere"* (IPCC, 2001a, p. 129). This information is relevant concerning ski tourism in the Alps.

4.2 Climate Change in the Alps

While global temperature increase was reported 0.6 ± 0.2 °C, long term temperature observation on the Austrian mountain Sonnblick showed an increase of 1.8 °C in the last 150 years. It has to be pointed out that especially the minimum temperatures increased in that observation period (Beniston, 2005). The minimum temperate determines if precipitation occurs in the form of rain or snow. Although, the range of uncertainty is not stated for the Austrian data, an up to threefold deviation from the global mean indicates that global warming hits the Alps stronger than many other regions of the world.

Regional climate forecasts are done by downscaling GCM (Global Circulation Model) data. GCM's are rather well developed for global predictions, but they loose prediction quality for regional forecasts. Therefore, predictions for smaller regions like the Alps are still vague (Beniston, 2005). Present regional climate change is often interpreted by observing historical data. This has the drawback that high quality satellite and weather balloon data is only available for the last 30-40 years (Beniston, 2005). Before hydro electric power stations emerged in the 1920's and ski resorts boomed in the 1960's and 1970's, snow was not considered an important resource and consequently not much effort was put into examining it. Due to those reasons, older snow cover data is very inexact and long term conclusions are difficult (Latenser & Schneebeeli, 2003).

When it comes to the effects of climate change on snow Linacre (1992) describes several impact variables: Temperature, precipitation, wind, radiation and humidity. Temperate has two effects. First it determines if precipitation occurs as snow or as rain. A 1 °C increase in temperature shifts the threshold where rain precipitates as snow 150 m upwards. Second, higher temperatures enhance snow melting. The next variable

is precipitation. The most common forms of precipitation are rain or snow. More precipitation in the form of snow results in a greater snow depth. Although often believed, rain has little influence on snow melting, because of its very little energy content. The third variable, strong wind, which often accompanies rain, is more relevant as it enhances snow melting tremendously. Radiation from the sun, as the fourth variable, is also considered to have great melting potential on snow. Humidity is the last variable. Condensing water vapor releases heat and leads to melting. Therefore, more humid air increases snow melt. Prediction and observation quality differ for the different variables. The roles of radiation, wind and humidity in a future alpine climate remain to a great extent unmentioned. Only precipitation and temperature are rather well studied variables. Scientists agreed upon increased temperatures in the Alps. Temperatures are going increase more in the Alps than in the global average. The ACACIA project predicts a *"warming of 0.9 – 2.0 °C in 2020's, 1.4 – 3.7 °C in the 2050's and 1.7 – 5.7 °C in the 2080's"* for the central Alps (in Scott, 2005). Due to uncertainties, predictions vary by a factor of 3 (see 4.5). GCM models forecast that more precipitation is very likely, although increasingly happening in the form of rain (IPCC, 2001b).

A number of historical observations, which deal with alpine snow cover are available. Recent observation studies for the Austrian Alps could not be found (most recent study Fliri, 1992). Effects and impacts on the Swiss Alps are more thoroughly researched (Latenser & Schneebeli, 2003, Behringer et al. 2000, Beniston, 2005, Bürki, 2000). Wielke et al. (2003) proved that Swiss results are to a large extent valid for the Austrian case. The Swiss scientists Latenser & Schneebeli (2003) used long-term observation data from 1931-1999 to measure snow depth and the snow cover duration. Until 1980, slight increases in snow depth and snow cover duration can be observed. Since then, both variables display a significant trend in decrease until the end of the millennium. However, the trend is not entirely consistent. Winter with more snow occurred again since the millennium change. The Swiss scientists mention the recent snowy winters, but they did not include them in their research.

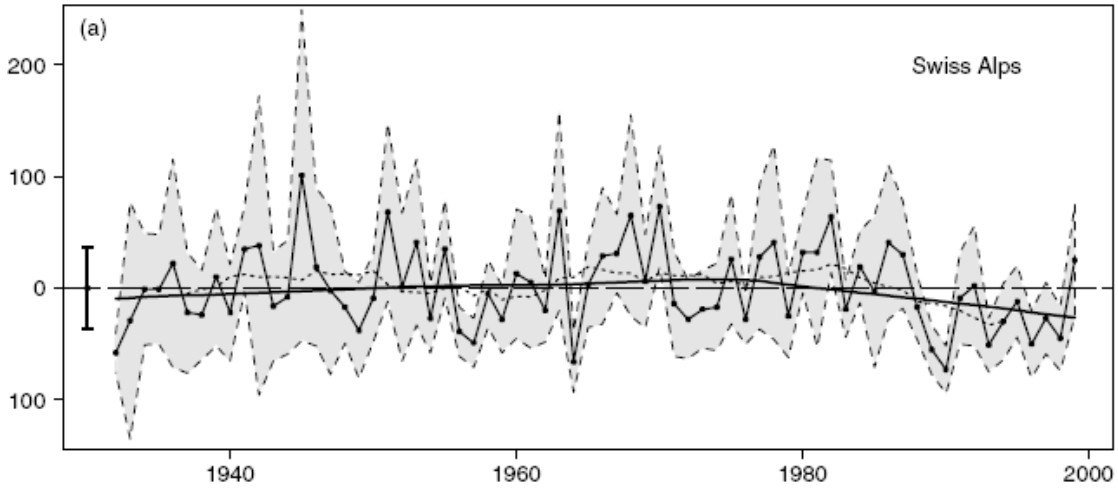

Figure 3: Snow cover variations in Switzerland from 1931-1999 -

"Relative HS [snow depth] deviation (%) of the annual winter mean (November – April) compared with the long term mean. 11-year moving average (dotted line), lowness-smoother (f=0.67, thick line) and ± 1 standard deviation (grey area, contains two thirds of all data). The vertical bar on the left stands for +- standard deviation of the whole sample (average for the entire Swiss Alps from 1932 to 1999), which is not exceeded by the long-term trend."

Source: Latenser & Schneebeli (2003)

It should be noted that temporal patterns correlate with global observations. If one compares Figure 1 (a) from the previous chapter with the observations in Figure 3, patterns are internally consistent towards the end of the century. Seasonal climates fluctuate form year to year, but by observing long term data, trends become visible. Both data sets show an increased rate of change beginning in the 1980's. This similarity could be interpreted as evidence for global warming effects in the Alps. However, this conclusion is not as easy drawn as it seems.

One phenomenon has not been mentioned yet. The dotted line in Figure 3 shows cyclic patterns. The North Atlantic Oscillation (NAO) is responsible for climatic cycles in many parts of Europe. It is determined by the opposing barometric Icelandic low pressure field and the Azores high pressure field. The differences between those two pressure fields fluctuate on times scales up to several decades. Long term cycles climate cycles are created that are determined by the negative and positive state of the NAO. Specifically, the European winter variability seems to be affected by the NAO. A negative NAO 1950 -1974 caused cold and snowy winters. This was also the period when most of the ski resorts were planned. Hence, they are originally adapted to a very snow rich phase. An extremely positive NAO was observed 1974 -1995 with peak levels towards the end of that period (Pfister, 1999, Latenser & Schneebeli, 2003).

To some extent, the reported observation in Switzerland in the 1990's can be due to the positive state of the NAO. However, the 1990 were exceptional and *"by far the least snowy decade"* and the years from 1988

until 1998 were most probably the decade with the shortest snow cover period for 315 years (Latenser & Schneebeli, 2003). Therefore, the data is hard to explain with normal cyclic oscillations. There are meteorological indications that the NAO shifted again in a negative state at the end of 1990. This could explain the recent, rather snow rich winters in the early 2000 (Pfister, 1999).

Latenser & Schneebeli observed a very significant behavior: Altitude matters. Low altitude sites are much more affected from a warming atmosphere than high elevation sites. Beniston et al. (2003) and Bürki (2000) delivered very similar conclusions. Certainly, temperature increases also occur at higher elevations, but they are still cold enough to allow snow conservation or precipitation in the form of snow. Furthermore, high altitude snow melting is compensated with heavier snowfalls on other days. Hantel et al. (2000) used snow cover data from Austria (until 1990) to conduct a sensitivity analysis. He found out that an altitude of 580 m has the greatest sensitivity to a temperature increase. An increase of 1 °C would result in winter seasons that are 4 weeks shorter in terms of snow cover at 580 m. In higher altitudes, stations become less sensitive. Although Hantel et al. defined snow cover with 5 cm, which is far too little for skiing; the low sensitivity threshold of low altitude ski resorts can be seen clearly.

4.3 Impacts of Climate Change on Skiing

Tourism in general and ski tourism in particular are sensitive to climate change because of their strong linkage to the environment (Gössling & Hall, 2005). Skiing needs a certain depth of snow cover to be operational. Bürki et al. (2003) and Bürki (2000) use the following indicators to define snow reliability. A 30 cm snow cover is regarded as sufficient for skiing, while a 50 cm snow cover is supposed to be good and a 70 cm snow cover is excellent for skiing. They also argue that 100 days of sufficient snow cover between December 1st and April 15th should be available to make skiing economically feasible. Furthermore, those 100 days should occur at least every 7 out of 10 years. The Christmas period and the Easter period are economically important portions of the season. They are located on both ends of the winter season, which makes them even more vulnerable to warming.

The best case scenario of ALACIA predicts a warming of 0.9 °C already for the year 2020. A 1 °C rise of temperature reduces the natural snow cover by 4 weeks in low altitude ski resorts (580 m). In Austria, a number of ski resorts, including famous resorts like Kitzbühel (800m) or Schladming (745m), are located just a little above this sensitive altitude (Bergfex, 2005). A reduction of the season by several weeks would have severe impacts for them. Based on this data, the future ski season might not be sufficiently long enough in many low altitude ski resorts. Certainly, only the lower region within a ski resort will be affected strongly, higher regions will hardly experience any change as the sensitivity to warming is reduced in higher altitudes.

However, many ski runs are located in the lower regions of a ski resort. Ski resorts will simply loose attractiveness when lower regions lack natural snow.

To conclude, if the predictions become true and temperatures increase their rate of change even further, impacts on skiing will increase. Low attitude ski resorts will be more affected by climate change than high altitude ski resorts. In the short run, high altitude ski resorts could even benefit from climate change as they might take over market share form the low altitude ski resorts. Two different classes of ski resorts would be generated; high altitude and low altitude ski resorts, winners and losers. However, it has to be pointed out that all alpine impact studies omit the adaptation measures like snowmaking. Snowmaking can reduce the vulnerability of low altitude ski resorts (Scott, 2005).

4.4 Snowmaking

Scott (2005) describes snowmaking as an effective means to face a lack of natural snow. Natural snow is replaced by manmade snow. Snowmaking is done by the so called “snow guns”. Different systems are used. In general, they all work with the same principle. A number of factors need to interact to transform the input resources into snow. Those input resources are water, energy in the form of air pressure and cold temperatures. The snow gun uses air pressure to spread fine water particles in the air which freeze to little ice corns. The guns distribute the snow on the ski runs. Every gun can provide a limited area of the ski runs with snow. Therefore, an entire system of guns needs to be set up to provide large areas. They work most efficiently some degrees below the freezing point and low air humidity (Rixen et al., 2003). Hence, the application of snow guns is limited by weather factors. Due to climate change, the days where they can be used in a cost effective way might be reduced.

The Austrian ski resort operator “Bergbahnen - Wilder Kaiser” uses 5 % from its annual turnover for operating the snow guns. In a warmer season, those costs increase. The 5 % are not including the high investment costs for the snowmaking system (Seilbahnen, 2001b). Energy is the main cost during operation. Seilbahnen (2001b) emphasizes that snowmaking is very expensive but necessary. In a number of countries, like the US, additives are used to improve the performance of the guns. Dead bacteria are added to the process. The bacteria form the core of the snowflake. From these means, the snow production becomes more effective, and also able to be produced in a wider temperature range. It is argued that the effects of the “potentially phytopathogenic” bacteria are not sufficiently understood (Rixen et al., 2003, p.221). These additives are prohibited in Austria, but their application is under discussion (Seilbahnen, 2005a)

Also the normal operation, without additives, is facing critique. The paper will briefly summarize the points. Snow guns need water and energy. It is argued that they use those resources extensively (Scott, 2005). 250 – 350 l of water are needed to produce 1 m^3 of snow (Seilbahnen, 2005b). To supply water to the system, very often water basins need to be built in the alpine landscape. The added water has a fertilizing effect and alters the nutrient balance of the sensitive alpine vegetation. Furthermore, it is proved that human made snow is more compact than natural snow. Consequently, it stays longer on the slopes. This can have impacts on the vegetation period of alpine flora (Rixen et al, 2003). Another negative characteristic is that snow guns emit noise. This can disturb wildlife as well as humans. Finally, one could argue that the picture of hundreds of snow guns in an alpine landscape is little appealing. The implementation of a snowmaking system is subject to several national and federal laws concerning land use, water use, forestry, etc. (Seilbahnen, 2005b).

4.5 Uncertainties about Climate Change

The previously presented global and local climate studies show clear tendencies. The global temperatures are rising, weather patterns are changing and global warming appears to be especially pronounced in the Alps. There is common agreement in the scientific world that climate is changing and that the rate of change will increase even further. Therefore, climate change appears to be a certainty, whereas the future timing and magnitude of impacts are the uncertainties (Smith, 1997).

These uncertainties form a central problem in climate research. They can be found due to different reasons. The inexactness of GCM models is one source of uncertainty. Technical, economical developments and the strength of the Kyoto protocol are uncertain variables which determine the mitigation process. Also some of the Earth's own feedback mechanisms reacting to climate change are not very well understood (IPCC, 2001a).

Climate is *"a non linear system"* due to its chaotic dynamics (e.g. NAO). Those dynamics limit the predictably of climate in general and on a regional scale in particular. The non-linearity also stands for the possibility of abrupt climate changes (IPCC, 2001a, p. 96). Such abrupt changes happened in the last glacial cycle. A *"reorganization of the thermohaline ocean circulation in the North Atlantic resulting in a more southerly flow of the Gulf Stream"* would be an example for an abrupt climate change which would most probably result in a cooling of Western Europe (IPCC, 2001a, p. 96). Those kinds of abrupt changes are possible, but due to the non linearity of climate, the predictability is very low.

Finding the right responses to climate change is difficult under such a variety of uncertainties. The next chapter will present the necessary theoretical background to understand adaptation decisions.

5 Adaptation and Perception

5.1 Adaptation

5.1.1 Definition and Relevance

"Adapt is a synonym for to make more suitable or to fit some purpose by altering or modifying" (Smit et al., 1999). Adaptation in the context of climate change developed its own definitions over time. Adaptation is *"adjustments in ecological-social-economic systems in response to actual or expected climatic stimuli, their effects or impacts"* (Smit et al., 1999). Smith (1997), on the other hand, limits adaptation to societal responses: *"Adaptation to climate change includes all adjustments in behavior or economic structure that reduce the vulnerability of society to changes in the climate system."* As this paper is focused on human adaptation, Smith's definition serves the purpose of the thesis.

Chapter 4 emphasizes that there is a broad consensus about the existence of anthropocentric climate change. At present, a stabilization of the climate is not possible because draconian measures would be needed which won't be accepted by the global community (Smith, 1997). Consequently, further and more severe impacts due to climate change are inevitable. Impact qualities will vary. While small island states fear sea level rise and consequently even their disappearance, farmers in many regions face the threat of droughts and ski resorts might have income losses to due less snow and consequently less tourists. The list of different impacts on humans is long and includes human health or economic issues. The IPCC (2001a) states that some industries will be directly affected by economical losses due to climate change. As proved in chapter 3, ski tourism is one such industry as it is especially sensitive to climate change. Therefore, adaptations will be necessary to reduce the potential impact. Adequate adaptation to climate change can minimize the cost of the inevitable.

A September 2005 cover story of *The International Herald Tribune* stated: *"Climate-change fight makes Europe adapt."* Impacts on industries, including the Austrian ski industry, and the necessity for adaptive responses were highlighted. The fact that even mass media addresses the need for adaptation to climate change demonstrates increased public awareness on that topic. Initially, the international focus was on mitigation as a response strategy to climate change (Grothmann & Patt, 2005). However, recognition of adaptation can be seen by the funding of adaptation studies by GEF (IPCC, 2001b) or UNEP (Burton, 1997). It should be noted that adaptation to climate change was already considered as an adequate response strategy to climate change in the UNFCCC established in 1992 and the resulting Kyoto Protocol in 1997:

- Article 4.1. (f) of UNFCC states that parties should *"take climate change considerations into account, to the extent feasible, in their relevant social, economic and environmental policies and actions, […], with a view to minimizing adverse effects on the economy, […] to mitigate **or adapt to climate change**."*(UNFCCC, 2005)

5.1.2 Sensitivity, Vulnerability, Adaptive Capacity

Some regions or group of people are more threatened by climate change than others. The IPCC (2001b) concludes that the most vulnerable systems are those with the greatest sensitivity to climate and the least adaptability. Vulnerability, sensitivity and adaptive capacity are key terms in adaptation theory.

"Sensitivity is the degree to which a system is affected, either adversely or beneficially, by climate related stimuli."

"Adaptive capacity is the ability of a system to adjust to climate change to moderate potential change, to take advantage of opportunity, or to cope with the consequences."

"Vulnerability is the degree to which as system is susceptible to, or unable to cope with, adverse effects of climate change […]. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity". (IPCC, 2001a, p. 6)

Both *"nature and society are adapted to the regional weather averaged over long periods"* (IPCC, 2001a, p. 92). Changes from the mean climate make nature and society vulnerable because one is not equipped for the changing environment. Eventually, the vulnerability of a system does not only depend on the sensitivity to stimuli like temperature increase but also on the adaptive capacity. The next chapter argues that perception is a relevant variable for the adaptive capacity.

5.2 Risk Perception of Climate Change

5.2.1 Definition and Relevance

This study uses the term risk perception according to O'Connor et al. (1999) who already adapted the term for climate change. Risk perception is *"the perceived likelihood of negative consequences to oneself and society from one specific environmental phenomenon: global warming."* Risk is not a new phenomenon. "*Life has always been uncertain"* (Sjöberg, 1991). Therefore, risk itself is a highly discussed issue. However, with a few exceptions, the psychology of risk for climate change has been studied little.

Grothmann & Patt's (2005) criticize that research is too much focused on *"financial, technical, or institutional constraints"* of adaptive capacity. Certainly, systems *"with limited economic resources, low levels of technology, poor information, unstable or weak institutions, and inequitable empowerment and access to resources"* are limited when it comes to adaptation (Grothmann & Patt, 2005, p. 202). However, perception decides over resource allocation. Without perceiving the risk adequately, all other determents seem meaningless. Also, Weber (in Grothmann & Patt, 2005) defines perception as a precondition for adaptation. He tested economical and technical adaptation of US farmers to climate change, and showed that perception was a dominating factor among all other kinds of other variables. Hence, a reason why risk perception should be considered as meaningful for adaptation to climate change is the direct correlation with behavior (Peters, 1997)**.**

Perception is important because a misconception of a risk has unwanted consequences. Misconceptions can lead to maladaptations, which increase the costs of climate change. While a low perception of the risk could lead to an underestimation of a risk, a high perception of a risk could maybe result in exaggerated measures (Peters, 1997, p. 105). Both extremes have negative consequences.

5.2.2 Differences in Perception between Experts and other Stakeholders

Peters (1997) points out that *"risk perception opinions very significantly within and between groups."* Several studies investigated differences in risk perception between lay people and scientific experts. Questions like the following one arise: Why is that many people fear more to die in a plan accident, while dying in car accident is feared less by many individuals? The statistical risk to die in a car accident is much higher than to die in an airplane accident. It is argued that risk perception is highly subjective and often lacks rational considerations (Sunstein, 2002).

Very few studies have specifically focused on climate change. How people perceive climate change is not necessarily what really occurs. People in Zürich (Switzerland) were asked if nowadays *"White Christmas"* occurs less often than in the past. Respondents stated that at present snow cover at Christmas time can be found less often than before. Meteorological records show a different picture as they can not show a significant reduction of *"White Christmas"* in the region. It is argued that an independent picture of climate change develops over time in the heads of people. It has to be distinguished between the mental picture of climate change and the real physical climate change (Bürki, 2000). This mental picture influences the risk perception.

Lazo et al. (2000) compared risk perception of climate change of scientists and lay people. He showed that lay people have a more catastrophic view of climate change than experts. Although Lazo's et al. research focused on the general public and not on decision makers, the clear tendencies of misconceptions between stakeholders are interesting. A review of climate risk studies concludes that there is a general misconception of risks by the general public (Stedman, 2004). The misconceptions, however, do not only originate from the lay public. Scientists also might be biased. As being human, they are also driven by beliefs and it can be hard to give up beliefs which are based on many years of an academic knowledge. Furthermore, experts are very specialized and can't assess the overall risk of a hazard (Sjöberg, 1991). However, objective science should be more reliable in predicting risk than lay people's estimates.

Studying lay people's perception is interesting, but not enough. Their perception has less influence on adaptation than the perception of decision makers. Unfortunately, decision maker's risk perception is studied very little. Studies could be found which evaluated risk perception of political decision makers (Sjöberg, 1996, Stedman, 2004), but research for non political decision makers seems lacking. It could be assumed that decision makers have a better perception of climate change impacts than the general public, because their responsibility should lead to high sensitivity towards climate change issues. In the case of this study, one could argue that decision makers of the ski industry should not be seen as lay people. Although they are not climatologists, their field of work and their exposure to climate issues provides them with knowledge. The next chapter will show how decision makers in the Austrian ski industry perceive climate change. Furthermore, current and likely adaptation strategies are presented.

6 Survey Results

6.1 Perception

6.1.1 Level of Importance and Perceived Knowledge about Climate Change

Initially, decision makers of ski resort operators were asked about what priority the issue of climate change has in their ski resort and how well they think that they are informed about climate change.

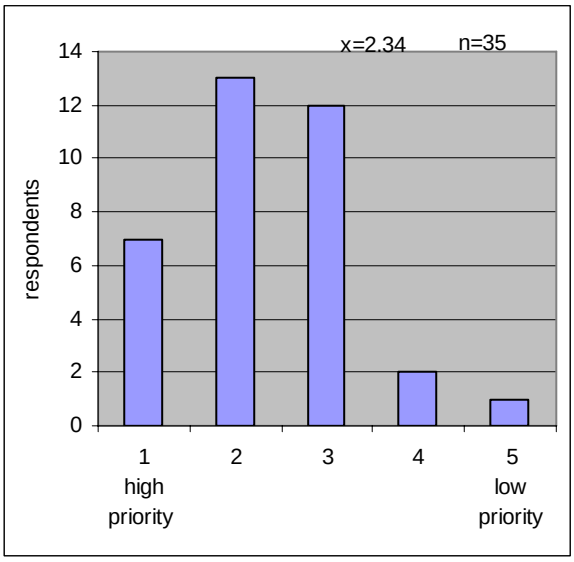

Figure 4: Priority of Climate Change

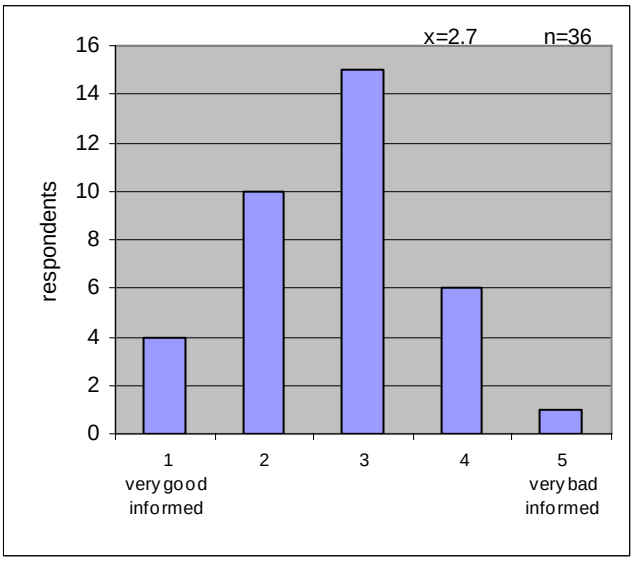

Figure 5: Perceived Level of Knowledge

x=mean value, n= number of respondents

Figure 4 shows that climate change is an important issue for ski resort decision makers. Only three respondents are located in lower end of the rating scale. Considering the sensitivity of ski resorts, this result is not surprising. Later, people were asked about their perceived level of knowledge about climate change (Figure 5). The result resembles the shape of a normal distribution. Few consider themselves as very well informed and only one person answered that he is very badly informed. Information sources about climate change are dominated by the media (89 %). Also information from official industry sources (56 %) and scientific information (39 %) are common information sources. Although the questionnaire made clear that scientific information is meant to be IPCC reports or similar documents, one can not be sure if respondents might confuse scientific articles with other information sources like mass media reports. One respondent stated that he had attended climate change conferences in Switzerland. Although the dominant information source seems to be the media, it can be shown that some single decision makers search for more sophisticated information from science.

6.1.2 Observed and Expected Climate Change

Observed changes

People were supposed to refer to climate change signs which had occurred in their resort. The perceptions vary considerably. 9 out of 31 respondents pointed out that no anomalies had been observed. Some of those denying changes attempted to submit counterarguments: *„According to precipitation records, we are still more or less on the same level like in the last 70-80 years. Winters with little snow have also occurred in the*

1920's and 1930's, and in the 1980's and 1990's." The rest of the responses can be concluded as follows. The dominant opinion was that in last 10-20 years temperatures rose and consequently the snow line was rising. This resulted in both, less snow depth and a shorter season. Several decision makers pointed out that the shorting of the season occurred due to the fact that the first considerable snowfall happened later in the season. Contrary to that, it was also mentioned that the winter season was shortened due earlier snow melting. Weather extremes like storms, flooding and long periods without snowfall were brought up by single respondents. One decision maker complained about higher temperatures, which shorten the period for snowmaking. Another respondent seemed to confuse climate change with other environmental issues. He stated that the dying of trees is a consequence of climate change. In general, wording differed. It ranged from terms like *"much less snow"* to *"it might be that"* changes happened. It can be concluded that the industry has an inconsistent perception. 9 people did not perceive any changes. The rest of the perception was located within a wide range of observations.

Expected climate change

Representatives were asked how they see the probability that a future climate would lead to the following events:

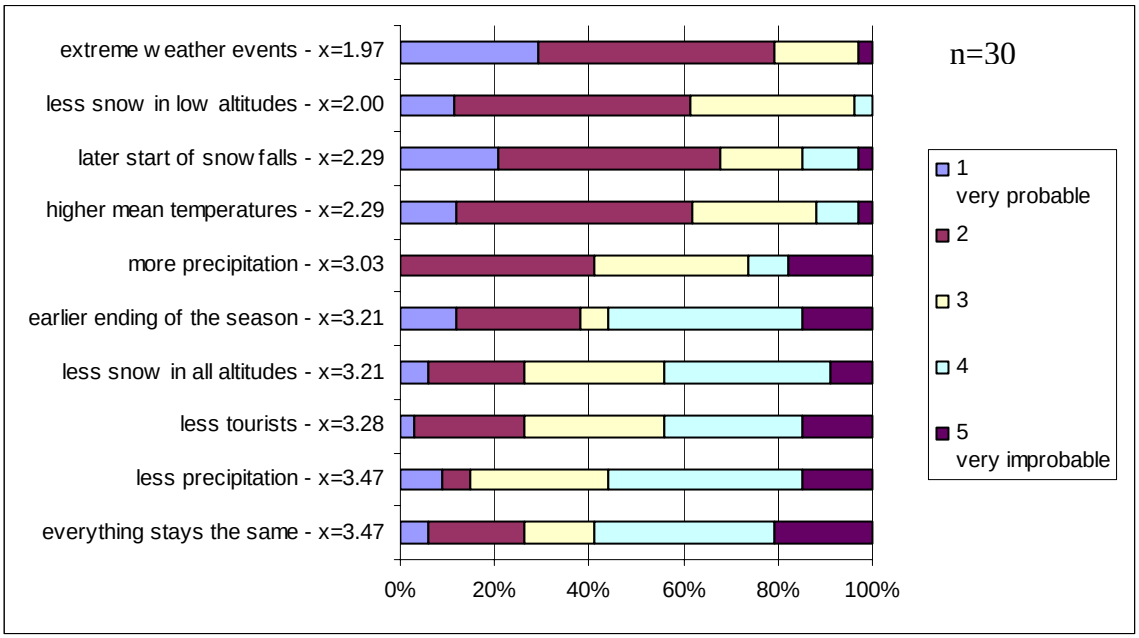

Figure 6: Probability Distribution of Single Events

The answers are ranked in an ascending order of the mean values (x). Extreme weather events are located on the top end. Extreme weather events seem to be the most expected climate change consequence in the future. Respondents ranked extreme weather events much higher than the increase of the mean temperature. This is worth a comparison with the scientific view of the issue. Due to a lack of long term data, climatologists are

rather careful when it comes to relating extreme weather events to climate change. A long term increase in mean temperature seems to be the best studied and most likely consequence of climate change.

A contradiction can be found in the perception concerning the season duration. While Latenser & Schneebeli (2003) observed that the seasons become shorter due to an earlier melting in spring, the ski industry expects a later start for winter. Fewer tourists coming to the ski resort is not regarded as very likely. Contrary to observed changes, when it comes to future impacts, a much clearer majority is convinced that climate will have impacts.

Perceived Impacts on the Business

Later people were asked about the consequences of climate change on their business. Either they stated that they had no consequences because they had snow guns, or they indicated that they had to *"increase investment in snow making facilities"*. One respondent emphasized that their turnover has not been affected yet, but the whole investment behavior is altered because investors feel insecure due to future climate scenarios. Another decision maker stated that climate change is only confusing tourists.

Remembering that Figure 4 showed a priority status of climate change, the next result might appear surprising.

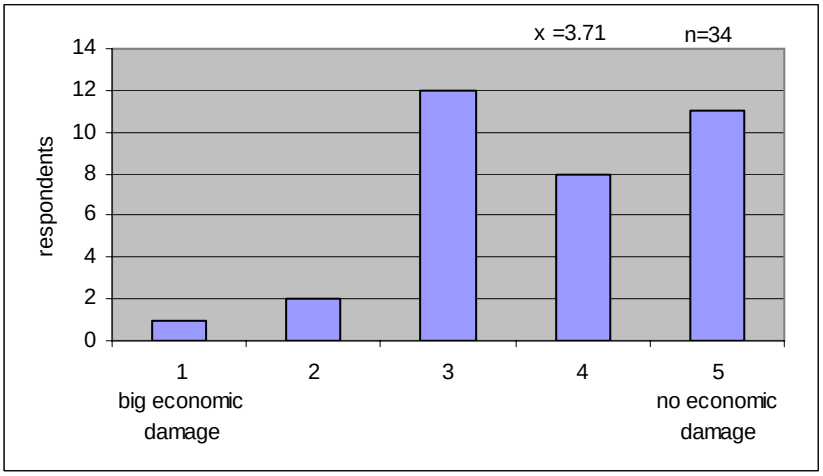

Figure 7: Perceived Economic Damage

According to the questionnaire, climate change does not cause much economical damage.11 out of 34 decision makers even indicated that no economical damage had occurred so far. Two possibilities could explain this result. First, climate change had indeed very little impacts on Austrian ski resorts. Second, the ski resorts are adapting and they are doing it successfully. Going back to an earlier part in the paper, it is

rather improbable that impacts in low altitude ski resorts were as little in the past. Consequently, present adaptation strategies appear to avoid severe economical damage.

To sum up, it was found out that climate change is of big importance for many decision makers. Why climate change has a rather high priority can not be proved by the currently perceived impacts. Impact perception does not show a clear pattern. 1/3 did not feel any climate change at all. 2/3 of the decision makers observed climate change signals, but economic damage was felt to be low and mainly due to higher expenditures on snowmaking. Hence, it appears that snowmaking is a strategy which is able to shield them from greater damage. The results give reason to believe that the status climate change has for decision makers is not caused by experienced impacts but by expected impacts. The next section will deliver results about the perceived adaptive capacity and adaptive strategies.

6.2 Adaptation

6.2.1 Perceived Adaptive Capacity

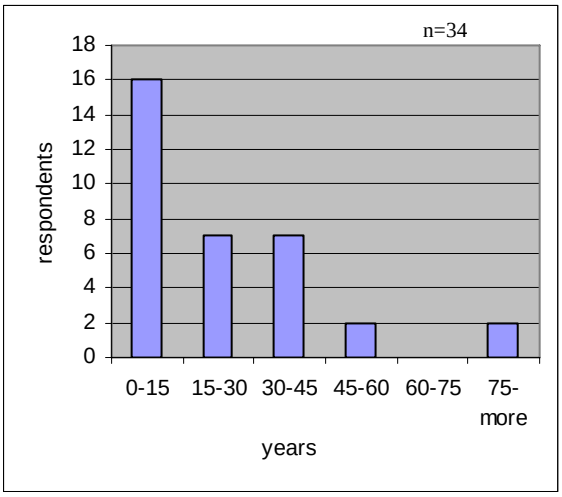

Figure 8: Perceived Economical Viability without further Adaptation

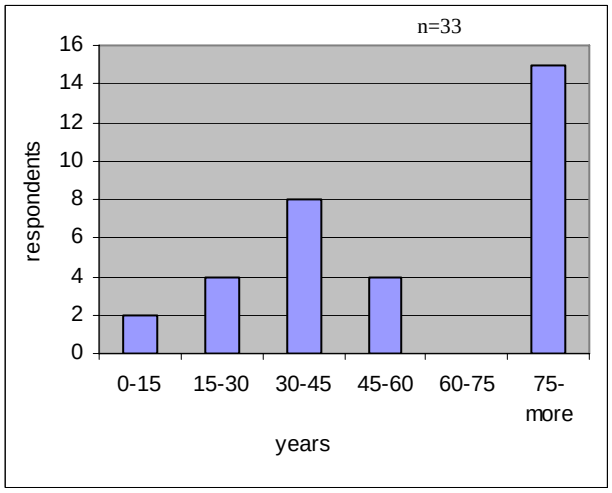

Figure 9: Perceived Economical Viability with further Adaptation

Figure 8 and 9 are able to illustrate the perceived adaptive capacity of decision makers in low altitude ski resorts. First decision makers were asked: “How long do think that you can run your ski resort in an economically viable way under the current climate trends without any further adaptation measures?” 47 % thought that they will have to give up business in the next 15 years. This result is surprising considering that rather little damage has been observed so far. This verifies the hypothesis from the previous chapter. Climate change is an issue due to expected impacts and less due to experienced impacts. A great majority believes

that skiing will not be possible longer than 45 years from now without any further adaptation. Considering the severity (see 4.3) and uncertainty (see 4.4) of impacts, this is reasonable. Figure 9 shows the results when respondents were asked the same question but now they should consider all potential adaptive strategies. A significant shift towards the other end of the scale is observable. In Figure 8, it was two respondents who believed that they could still run their ski resort in 75 years or later. In Figure 9, 15 individuals believe that this will be possible. It seems that many decision makers believe strongly in further adaptation measures. They think that those measures will help considerably to adapt to climate change. Therefore, one can conclude that the perceived adaptive capacity is high.

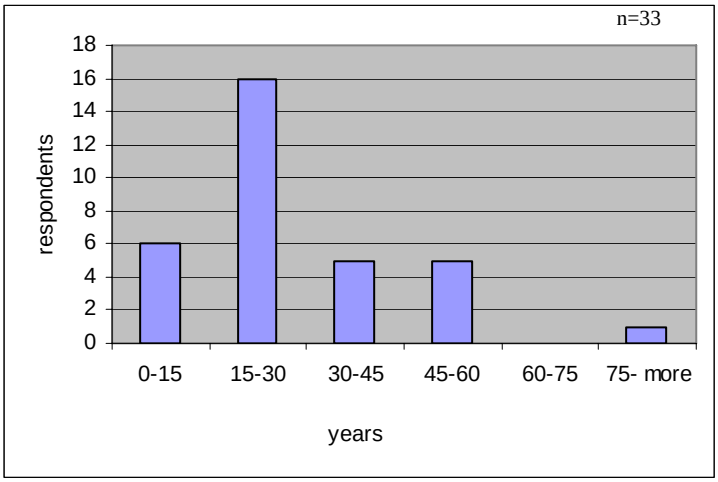

Figure 10: Time Horizon for Anticipated Adaptation

In order to get a clearer picture of adaptation decisions, it is beneficial to know about the planning period for climate change in the ski industry. They were asked how long it is meaningful to plan ahead when it comes to adaptation strategies. It is regarded as useless to plan more than 60 years ahead. Most respondents see 30 years as adequate. This results means that anticipated adaptations are only considered for the above timeframe.

6.2.2 Adaptation Strategies

There are a variety of potential strategies which could help to maintain ski tourism or at least preserve from severe economic damage. It is not the purpose of the thesis to explain all potential strategies in detail. The questionnaire used three different approaches to get the most accurate picture of the industry's adaptation strategies. First, they were confronted with a hypothetical situation. Decision makers were supposed to imagine that they knew that due to a lack of snow, the next season would be one month shorter than usual.

As a consequence, they should come up with adaptive responses. This was an open question which should not limit them in the variety of responses. Afterwards an exhaustive list of potential adaptive responses was presented to them. They had to evaluate the adequateness of the different strategies. Finally, they were asked to indicate which of the measures of the list they already apply or plan to apply. By a combination of the three approaches, one can find out about the most probable reaction if there is a need for further adaptation, the attitude towards the whole range of approaches and the current strategies.

Reaction to Season Reduction

It was discusses earlier that a season reduction is a most likely consequence of climate change. Decision makers were confronted with the hypothetical situation of a one month season reduction. Further investment in more and more modern snow guns seemed to be the most adequate solution to the majority of respondents. Also a better application of snow canons was mentioned. One stated the possibility to produce more artificial snow on stock and apply it when needed. Four persons responded that they could not react anymore because they already produce snow on a majority of the slopes. A respondent wanted to put more effort into marketing for the remaining season. Three wanted to shorten the duration of the operating season or start it later. Another one wanted to increase the lift capacity. Cutting cost was mentioned as well. Four respondents wanted to change their offer and search for alternative tourism activities. In total 8 different strategies were identified by 31 respondents.

More snowmaking	**Better application of snowmaking**	**Increase lift capacity**
Intensified marketing	**Shortening season**	**Cutting cost**
Alternative offers	**No reaction**	

Limitations

Representatives where asked about limitations to adaptation. A respondent's view can summarize the general picture: *"Financial limitation: we can not continuously raise the prices for lift tickets"*. Investment in snowmaking is costly and therefore limited. Two people stressed that limitations are also due to regulations. They did not indicate what they meant in particular but one could assume that environmental regulations concerning snowmaking were meant. They might also refer to regulations which concern the expansion in of ski resorts in higher altitudes.

Perceived Appropriateness of Adaptation Strategies

The previous section showed that the industry came up with 8 different strategies on its own. Later, a comprehensive list of potential strategies was presented to the decision makers. They were supposed to give

their opinion about the appropriateness of the strategies. The list was made after Scott (2005). He categorized responses in *"hard technological developments, soft business practices, and government and industry policy."* Those categories contain 23 different response strategies. The fact that decision makers did not come up with many of those strategies on their own could have several reasons. Maybe they do not associate them with climate change. However, those strategies can help to maintain the ski business or simply avoid financial losses. Hence, they are adaptation strategies, unintended or intended. It could also be that some strategies are not doable in some resorts.

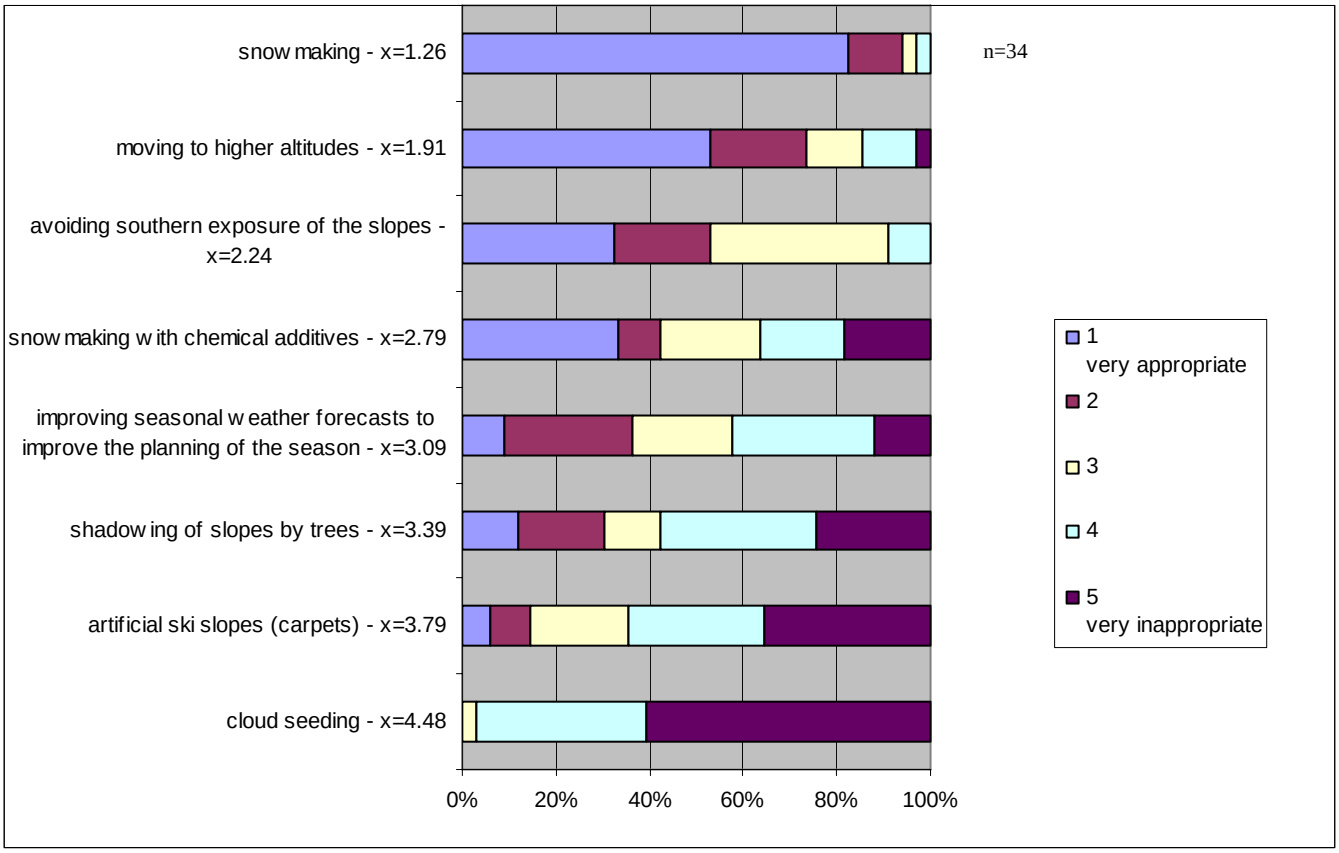

Figure 11: Attitude towards Hard Technological Adaptations

Snowmaking is considered very appropriate to face climate change in low altitude ski resorts. Also moving the ski runs to higher altitudes is regarded as appropriate. It has to be pointed out that the local geography limits this strategy considerably. Notably, only few resorts are able to move their slopes higher. This is probably the reason why respondents did not come up with that strategy in the previous section.

Shadowing slopes and avoiding southern exposure are methods to avoid radiation. The usage chemical additives for snowmaking were discussed earlier. Improved seasonal weather forecasts can facilitate

planning in terms of timing for marketing or snowmaking because better forecasts can alleviate some the climate variability.

At the bottom end of the figure, cloud seeding can be found. Cloud seeding is a weather modification technology which is used in American and Australian ski resorts. Clouds are seeded with silver iodide by plane with the intention to increase snowfall by 10 %. Scientific evidence is controversial and the operation is costly. Therefore, this technology is hardly used in general (Scott, 2005). In Austria this technology is not used at all and regarded as very inappropriate. Also artificial ski slopes which can be based on rotating carpets don't appear appropriate to the ski industry. Those small artificial ski slopes could be set up anywhere and are not dependent on mountains or snow.

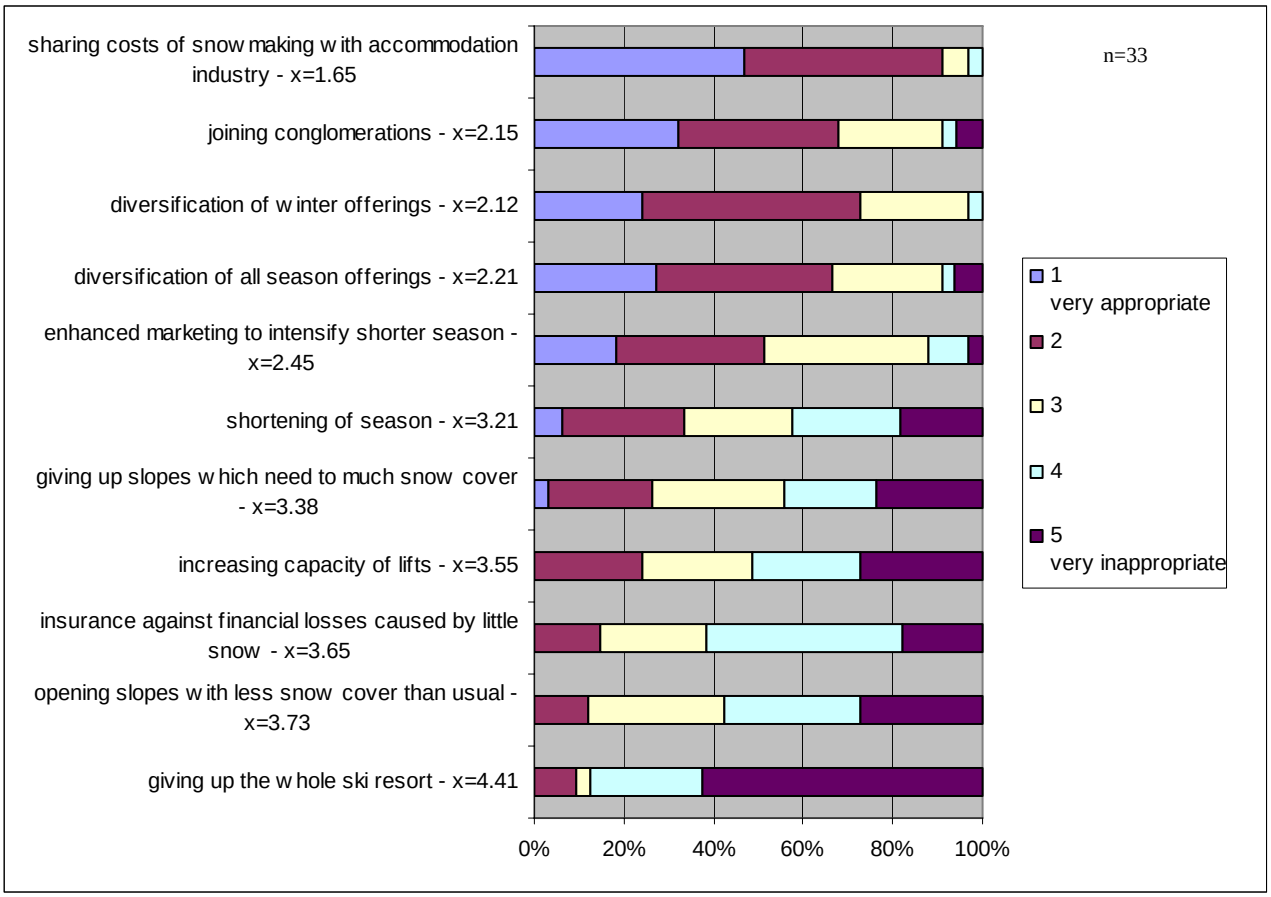

Figure 12: Attitude towards Soft Business Strategies

The highest ranking is triggered by an equity issue. Ski resort managers think that also other parts of the supply chain profit from snowmaking. Consequently, decision makers want to share the snowmaking cost with them. Ski resort conglomerations are a trend that can be observed worldwide. It can be assumed that this trend was not primarily caused by climate change considerations. However, benefits like greater access

to capital for further investments or better marketing opportunities would mitigate potential economic losses from a lack of snow (Scott, 2005). Diversification of the offering is beneficial because it makes the tourism industry less dependent on the skiing. Shortening of the operating season, giving up snow demanding slopes, or increasing lift capacity are responses with are seen as medium appropriate. Financial insurance is not regarded as appropriate. According to the decision makers, ski runs should not be opened with less snow. Nor do they think that giving up the whole ski resort would be adequate.

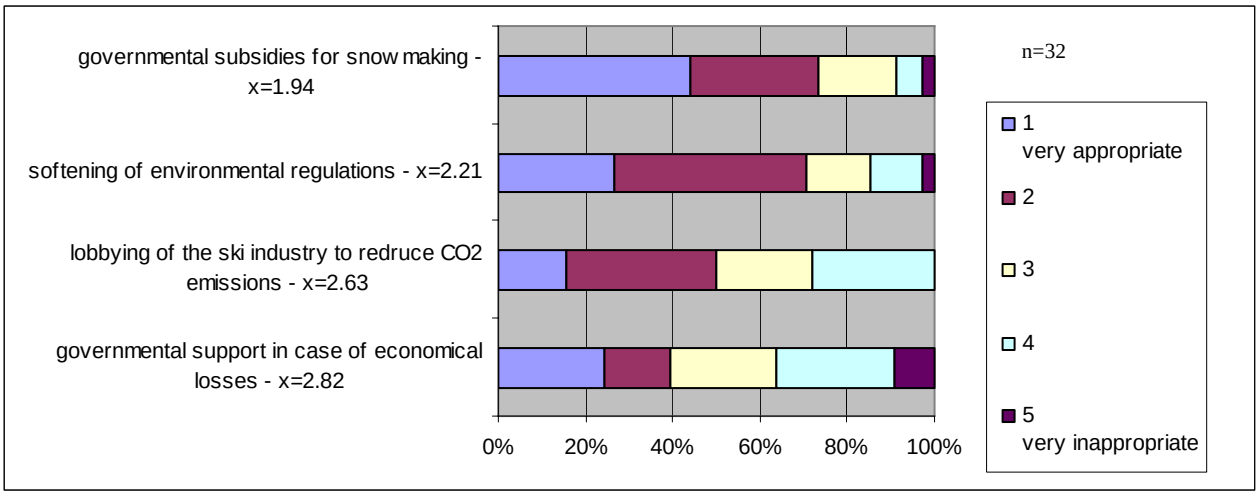

Figure 13: Attitude towards Government and Industry Responses

Policy responses are generally regarded as appropriate. Subsidies for snowmaking are wanted. Also the softening of environmental regulations for snowmaking or moving ski runs to higher altitudes would facilitate adaptation. Of interest is the option that the ski industry could lobby for climate change mitigation measures.

This chapter presented the decision makers attitudes towards a comprehensive list of adaptation measures. It is beyond the possibilities of this paper to go into detail of the single measures

Applied and planned strategies

Decision makers were asked what strategies they are currently using or planning to implement. Governmental and Industry responses were not included in the question because they are not decided by the ski resort operator. The results are compared with the perceived appropriateness of the strategy.

Adaptation Strategy	% of current usage of strategy or planned to be used	medium level of perceived appropriateness
snowmaking	100 %	1.26
joining conglomeration	79 %	2.15
diversification of all season offerings	59 %	2.21
diversification of winter offerings	59 %	2.12
moving ski runs to higher altitudes	58 %	1.91
enhanced marketing to intensify season	55 %	2.25
avoiding southern exposure of ski runs	50 %	2.24
increasing capacity of lifts	**50 %**	**3.55**
sharing costs of snowmaking with the accommodation industry	**45 %**	**1.65**
shorting the operating period of the season	38 %	3.21
opening slopes with less snow than usual	34 %	3.73
shadowing of slopes by trees	33 %	3.39
usage of seasonal weather forecasts to improve the planning of the season	19 %	3.09
giving up slopes that need too much snow cover	12 %	3.38
insurance against financial losses	6 %	3.65
giving up the whole ski resort	6 %	4.41
snowmaking with chemical additives	**0 %**	**2.79**
artificial ski slopes (e.g. carpets)	0 %	3.79

Table 1: Perceived Appropriateness and Actual Usage of Adaptation Strategies

In general, the actual usage corresponds highly with the perceived appropriateness. A comparison only makes comprehension for results where values between perceived appropriateness and the actual usage differ most. Those strategies are highlighted in Table 1. 50 % of the ski resorts have been increasing their lift capacity, but its value for appropriateness for adaptation to climate change is rather low. This means that increasing lift capacity is not done as an adaptation strategy but maybe due to economical reasons. This could also be true for many other strategies.

Only 45 % of the ski resorts share or plan to share the snowmaking costs with the accommodation industry. However, the mean level for appropriateness is very high. This could mean that ski resort operators want to

share snowmaking costs, but accommodation industry is not willing to cooperate in many ski resorts. Snowmaking with chemical additives is currently prohibited in Austria. Hence, none of the respondents are using it. However, the value for appropriateness is medium. Hence, it can be expected that some ski resorts would lobby for using chemical additives.

To conclude, this section presented the most probable strategies to fight a season reduction. It also showed that many strategies are seen as appropriate to fight the consequences of climate change. Furthermore the currently used or planned strategy where presented. For all three approaches snowmaking has the highest ranking. Therefore, a more detailed investigation in snowmaking is reasonable.

6.2.3 Snowmaking

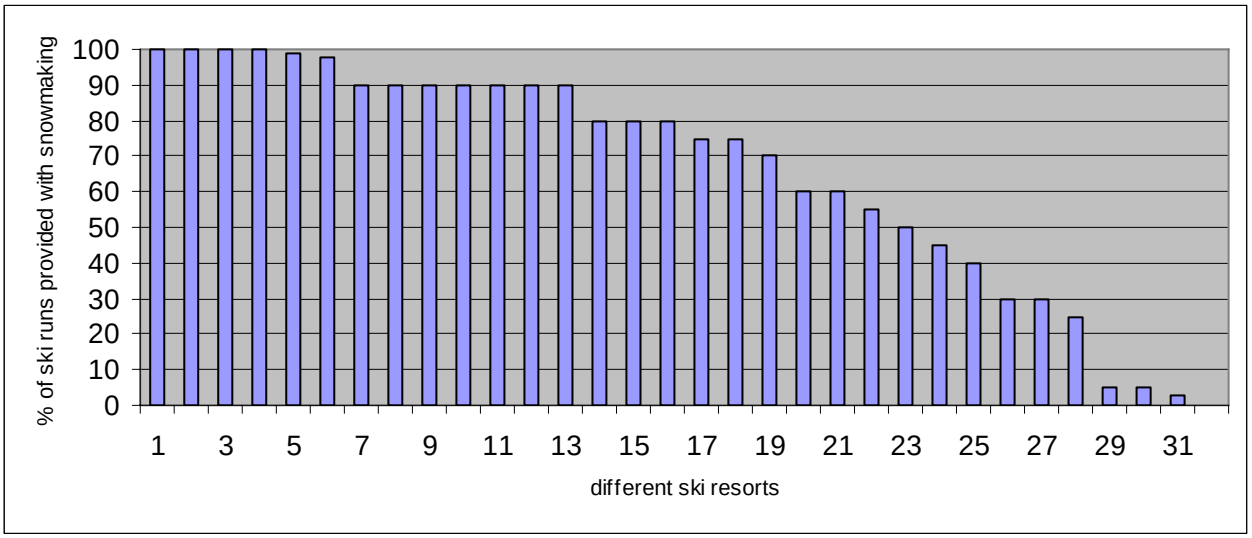

Figure 14: Relative Share of Ski Runs Provided with Snowmaking in different Ski Resorts

Figure 14 illustrates the distribution of snowmaking facilities. 50 % of the ski resorts can already provide 80 % or more of their ski slopes with snow. Only one resort does not apply snowmaking. Furthermore, decision makers were asked if they would buy more snow guns if a lack of natural snow would make it necessary. 84 % responded with yes. The ones who responded with no can already provide 90 % or more of the runs with snow. Consequently, all the ski resorts which are not already close to full coverage would invest more in snow guns.

Decision makers were confronted with the environmental problems of snowmaking. 28 out of 29 stated that they think that an intense use of snowmaking has no impacts on the environment. One respondent stated that he does "*not know about that issue.*" Another one stressed that snowmaking is not causing damage because

no chemical additives are added in Austria. Some defended the technology with counterarguments: A stable snow cover would protect vegetation from mechanical impacts (ski edges, grooming machines) or from frost damage.

To conclude, the industry uses snow canons extensively and will do even more in future. Decision makers do not perceive them as an environmental problem. However, the use of snow canons is not happening without criticism from environmentalists (see 4.4).

Basic outcome of the questionnaire:

- Climate change has a high priority in general
- Inconsistent perception of climate change signs
- Severe economical losses due to climate change have not occurred
- High expectation of future impacts
- High perceived adaptive capacity
- Snowmaking is the dominant response, but also a number of other measures are used or regarded as appropriate

7 Discussion

7.1 CLD – Explaining the Survey Results

The following model was built to explain the complexity and dynamics of perception and adaptation to climate change. It is a modification of the model used in the methodology chapter. The principle of the old model, that adaptation is based on perception, remained. This model illustrates the process of adaptation more in detail. The model described in the methodology chapter is very simplified and hides important mechanisms. The new model is presented in the form of a Causal Loop Diagram (CLD). As it has general characteristics, it can be used for all types of climate change adaptation analysis. + means a change in the same direction and – means a change in the opposite direction of the connected variables. R stands for reinforcing loop and B stands for balancing loop.

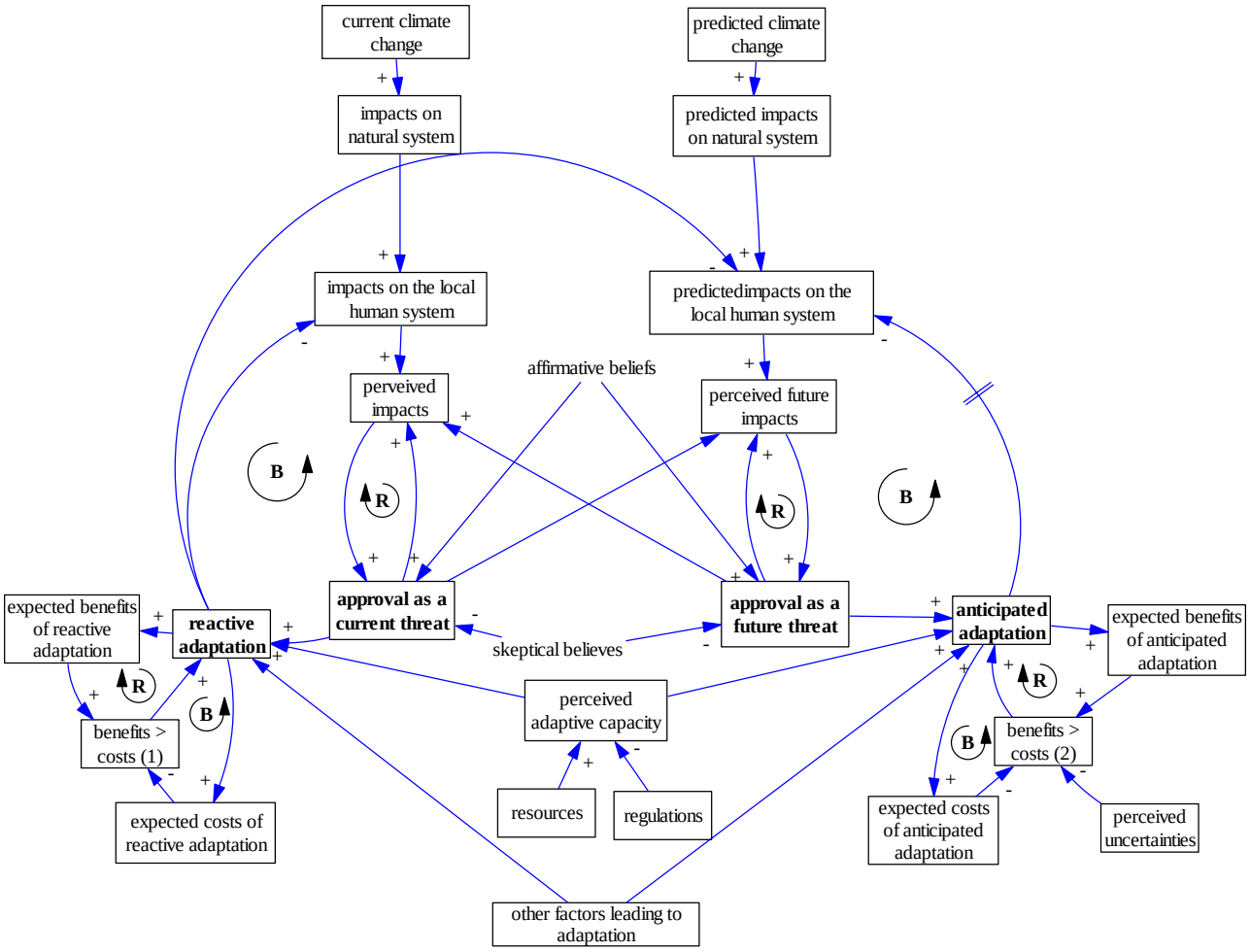

Figure 15: Causal Loop Diagram of Perception and Adaptation to Climate Change

Perception – Reinforcing Loop

Personally observed impacts of current climate change are one out of two information channels regarding climate change. The whistle blowers in media, science, etc. are the other. According to the questionnaire, personal observations of climate change signs are inconsistent. Furthermore, not much economic damage has been experienced in general. On the other hand, the perception of external warnings appears to be big. Hence, the model is based on the idea that the mental picture of climate change (renamed to “approval as a threat” in the CLD) is built up from two separated areas: Current climate change and predicted climate change.

Current climate change can be seen on the left side of the CLD. Climate change causes impacts. One has to distinguish between impacts on natural systems and impacts on human systems. Often, such as in this case study, impacts on human systems are caused by a change in the natural system (less snow). Impacts need to be perceived before one can create a mental picture of a threat.

The more that impacts occur, the more likely it is that they are perceived. It might be that natural impacts are physically more visible (higher snowline), but impacts on human systems are of more direct consequence to humans (income loss). "*Risk [and also threats] only exists when humans have a steak at outcome*" (Jaerger et al., 2001, p. 17). As soon as impacts are perceived, one will build up a mental picture which approves climate change as a threat or not. A bias called "*avoidance of cognitive dissonance"* causes a reinforcing loop (Jaeger et al., 2001). The more one is convinced about the existence of climate change, the more one will perceive climate impacts. One does not want to cause dissonance with his beliefs. In the CLD this belief is called "*approve climate change as a threat"*. On the other hand, signals that oppose the belief system will not be perceived or are downplayed (Jaeger et al., 2001). This bias leads to a selective perception of climate change signals.

Certainly, there are also external variables such as ideological beliefs which influence the mental picture of climate change. The external factors could induce a reinforcing loop in a negative direction. This depends if the beliefs are skeptical or affirmative (Jaeger et al., 2001). Those beliefs were not asked in the questionnaire as it was beyond the scope of the paper. A skeptical belief would be if somebody is convinced that mankind has little influence on life on Earth in general. Skeptical beliefs avoid believing in the existence of climate change. An affirmative belief would be if someone thinks that mankind is exploiting nature. This would facilitate believing in anthropocentric climate change. The survey showed that perception sometimes differed considerably. A number of respondents stated that there are no climate change impacts at all. This perception could be caused by the mentioned negative reinforcing loop.

The second source of climate information is somewhat different. Scientists or media create a picture of future climate change and future climate impacts (right side of the CLD). Again, those impact warnings need to be perceived in order to be approved as a future threat. Due to the previously mentioned bias, the same reinforcing mechanism is acting. It was studied that future climate change is often overestimated (Langford, 2002). The reinforcing loops in the center of the model can explain that phenomenon. High impact risks are very much discussed in the media and are therefore easily accessible. The described reinforcing loop enhances the perception of the warnings. For the ski industry, it seemed that external information was even stronger than personal experience. It is hard to assess if the risk is overestimated, but at least a high perception of the future risk could be identified. The fact that the industry perceives external information so strongly shows how easily people are to influence with external information.

The two sources of climate information are interconnected. The more one is convinced about current climate change, the more they are open to perceive future warnings and vice versa. This interconnection is also influenced by the "availability heuristic" (Sunstein, 2002). When people are not sure about the likelihood of

future events, they tend to recall examples which come easily into mind. The study was conducted short after severe flooding had hit many ski resorts in August 2005. The flooding did not affect skiing directly, but it is easily associated with climate change. It might be that respondents have recalled this event and used it for the creation of a mental picture for future climate change. People tend not to investigate in reality but they ask themselves: “Can I think of an example?” (Sunstein, 2002). This could explain why more extreme events are the most expected future climate change consequences. Another reason why decision makers refer so strongly to extreme events might be that they get their information to a large extent from the media. Media tends to focus on reporting about extreme events (Wahlberg & Sjöberg, 1997). Extreme events are events with low probability and high impacts. It was studied before that the high impact events tend to be overestimated and low impact (but high probability) events are often underestimated (Crocker in Grothmann & Patt, 2005).

The “availability heuristic” and the “avoidance of cognitive dissonance bias” influence the perception of climate change considerably. People are good in classification and the application of rules of thumb when they are confronted with complex information (Jaeger et al., 2001). Those mental shortcuts make judgment much easier, but can also lead to errors of perception. Langford (2002) concludes that psychological phenomena like biases and heuristics explain why climate change is a difficult issue for individuals and societies in terms of perception.

Adaptation – Balancing loop

As soon as one has approved climate change as a threat, one is willing to act with adaptive responses. Current threats cause reactive responses and future threats cause anticipated responses. Sometimes there might be an unclear borderline between reactive and anticipatory adaptation. An investment in a snowmaking facility might be a reactive response. However, long term risks are most likely considered when it comes to purchasing such a capital intensive technology. For anticipated strategies, a majority of respondents believe that it is useless to plan for more than 30 years ahead.

Adaptation alters the quality of impacts. Reactive adaptation alters the current impacts on the human system. It might be that snowmaking hides some of the impacts of climate change and therefore impacts are not perceived so strongly. Both, anticipated and reactive adaptations might alter the predicted future impacts on human systems because whistle blowers probably adjust their warnings to the degree of how much the ski industry has adapted to the predicted change.

Cost – Benefit Analysis

Adaptation decisions are subject to a Cost – Benefit Analysis (CBA). A CBA is driven by a simple thought: Expected benefits need to exceed or justify expected costs (Sunstein, 2002). As long as this is the case, the net benefits will drive an adaptation. The analysis can occur in different ways. In a simple approach, it only includes financial issues. Environmental considerations can also be part of the CBA. It can be based on a well sophisticated mathematical calculation or could even be done subconsciously. Eventually, every single decision is based on a CBA. Investment decisions like that of snowmaking cause immediate costs, while benefits are gathered over a longer period of time. The more distant the benefits are in the future, the more the benefits have to be discounted (IPCC, 2001a). To put it simply, long term benefits need to be high in order to consider the strategy as adequate. If the benefits are spread over a long period of time, anticipated adaptation might be less attractive than reactive adaptation.

Another reason which favors reactive measures is high perceived uncertainties. Uncertainties like time horizon and scope of impacts influence the CBA. The more uncertain an impact is, the higher the costs of adaptation are because potential opportunity costs need to be incorporated into the CBA. Future climate impacts on ski resorts are still subject to high uncertainties. The question is whether rational decisions can be made under such uncertainties? Sjöberg (1991, p. 7) argues that this is not possible: *"There is no workable definition of rationality when both probabilities and values are uncertain, as they are in the typical case"*.

Decision makers in the ski industry see their adaptation limitations in financial issues (see 6.2.2). At a certain point, adaptation will be too costly in comparison with the gathered benefits. The adaptation costs need to be incorporated in the lift ticket price. However, costs are not necessarily monetary. In the case of snow canons, environmental costs, although existent, are not perceived. This is one reason for the dominant use of snow guns. Jaeger et al. (2001) point out that all cost and benefits are based on how one values the certain costs and benefits. Every single CBA is therefore subjective. It was shown in the results that every decision maker has his preferred set of strategies.

Perceived Adaptive Capacity

It has to be stated that adaptation is not the only dependent of the approved threat, but also on the perceived adaptive capacity. Even if one perceives climate change as threat, one still needs to believe that one can adapt. The perceived adaptive capacity is determined by available resources. Those resources can be financial, technical or institutional. Also, regulations reduce the perceived adaptive capacity. Environmental regulations concerning snowmaking and moving ski runs to higher altitudes are such regulations that limit the adaptive capacity.

Unintended Adaptation

Finally, it might be that adaptation occurs unintentionally. Several other factors which are not caused by climate change can lead to adaptation. Snowmaking was used even before climate change was an issue (Seilbahnen, 2005a). It has been used to fill natural lacks of snow which have always occurred, and for extending the ski seasons. Hence, they are not necessarily used to adapt to climate change. Another example can be taken to explain unintended adaptation is that from sea level rise: Wetland protection leads to adaptation to sea level rise because people are not allowed to settle in coastal areas. However, adaptation was not motivated by climate change but by protectionism.

Snowmaking is enforcing adaptation and reducing perception of impacts. It is hard to assess if measures like snowmaking, joining conglomerations, intensifying marketing or increasing lift capacity would have been done even without climate change being an issue. It could be that already existing trends are enforced by climate change. One could argue that it does not matter if people perceive climate change signals or not, as long as adaptation reduces the vulnerability; unintended or intended. But is this also true for the long run?

7.2 What Do the Results Entail for the Ski Industry in the Long Run?

There is one positive outcome of the thesis: The results give reason to believe that the ski industry does not underestimate the future impacts of climate change. A majority of decision makers is aware of the severity of future climate change. However, climate change is not regarded as a catastrophe. Ski resorts run a number of different strategies for adaptation. A strong focus is placed on snowmaking. It is believed that the strategies are adequate to cope with impending climate changes for an extended period of time. Scott (2005) argued that many ski resorts in the USA are better adapted to climate change than European resorts due to more widespread snowmaking in the USA (Scott, 2005). The results here do not indicate that the Austrian ski industry would have a lack of snowmaking and falsify that statement for the Austrian case.

One controversial issue could be identified: Does the ski industry overestimate its adaptive capacity? Further studies will be necessary for assessment. Such an overestimation could increase the vulnerability of the industry. In case that snowmaking proves inadequate in the long run, the industry may face the climate impacts without being able to react to them. Snowmaking is dependent on low temperatures. The days which are adequate for snowmaking might be reduced by climate change. Furthermore, high investment in snowmaking will also raise costs for low altitude ski resorts. Those costs will be transferred to the lift ticket prices which the tourists will have to pay. Also, skiing on manmade snow while the rest of the mountain landscape lacks snow might me less attractive for tourists. How will the tourists react to that? It is reasonable to believe that tourists are price sensitive and that they would either ski less or ski at high altitude resorts.

High altitude resorts are less affected by climate change and natural snow will be abundant for a longer period of time. The demand for low altitude ski resorts will be reduced. Some decision makers are aware of the limitations of snowmaking, but concerning the high perceived adaptive capacity, it is questionable if the whole industry is aware of the consequences of those limitations.

Many low altitude ski resorts will not be able to compete with high altitude resorts. Intensified snowmaking will not just raise costs; it will also increase impacts on the sensitive alpine environment. Therefore, it is questionable if snowmaking is the most adequate strategy for economic and environmental sustainability. The questionnaire results tell that the industry attempts to diversify the offerings for tourists and reduce the dependency on ski tourism. However, the focus of adaptation strategies is on maintaining skier business. In the long run, it might be beneficial to shift the focus from “maintaining skiing” to “non snow dependent activities”.

In the next decades, climate change will make high altitude ski resorts more attractive. The increased demand could also have impacts on the sensitive mountain environment because there will be extended pressure to expand those ski resorts. Hence, the environment will be under pressure from two sides; snowmaking from low altitude ski resorts and ski resort expansion in high altitudes.

8 Conclusion

Ski tourism is an important employer, driver of the local economy and contributor to national income of Austria. However, due to climate change, the industry is threatened. At least, that is what science, media and political bodies have emphasized. Reduced snow cover depth and duration makes ski resorts very sensitive to climate change. In particular, low altitude ski resorts are supposed to have a low sensitivity threshold to climate change.

The thesis investigated the perception and adaptation to climate change in low altitude ski resorts in Austria. Three major findings are emphasized. The first one is a general finding about perception and adaptation to climate change. The second and third finding concerns the case study.

Finding 1: Climate change is a difficult issue when it comes to perception and adaptation. Uncertainties about future impacts make anticipated adaptation decisions irrational per se. Biases and heuristics influence perception of current impacts and future warnings. A great natural variability of climate makes perception of current change difficult for an individual. Even if the previous year was warm and had impacts on snow

cover, it does not mean that the next year will even be warmer and impacts will be worse. It is hard to distinguish climate changes signals from the "*normal pulse of a system"* (Smit et al., 2000). Hence, nobody is "*dumb or brilliant*" when it comes to adaptation to climate change, but maybe constrained in its ability to adapt or in their comprehension of changes (Tol et al., 1998). This statement could clearly be verified in the paper. Observed impacts and expected impacts are based on subjective perception. Also every adaptation strategy is based on a subjective Cost-Benefit Analysis.

Finding 2: There are no indications that the industry underestimates the severity of climate change. The industry is aware of future climate impacts. It seems that the concern about climate change originates from the external warnings and less from experienced impacts. 9 out 31 respondents did not perceive any signs of climate change. The rest perceived inconsistent signs of change. Hardly any economical impacts were felt. The inconsistency of perception can be explained with finding 1 of the thesis. However, a majority of decision makers agree with science that climate change is an important issue. The survey results show that future impacts are expected to be high. Decision makers believe that the running of the ski resorts will stop being economical within the next 15 years if no further adaptation measures are taken.

Finding 3: Despite the expected impacts, there is a strong belief that adaptation strategies will help considerably to prevent economical damage. A number of adaptive strategies are regarded as appropriate to fight the consequences of climate change. A focus is on snowmaking. Snowmaking is an accepted and widespread technology which helps to compensate a lack of natural snow. However, it is not clear if snow guns are consciously used as an adaptation strategy. They might be used anyways. Under a changing climate, snowmaking can not be increased unlimited. The costs of snowmaking will increase if mean temperatures rise. First, more natural snow needs to be compensated. Second, production is less economical with higher temperatures and stops being feasible under certain conditions. Adaptation costs entail negative consequences for competition with high altitude ski resorts. High altitude ski resorts might be the winners of climate change as they will have less adaptation costs and could win market share from low altitude resorts. Hence, low altitude ski resorts might be the losers of climate change. It is not sure if the industry is aware of those implications.

Finding the right long term strategy to mitigate damage from climate change will not be easy. Flexible strategies are needed. In the long run, a focus on other strategies than snowmaking might be beneficial as snowmaking might just be a temporary solution. Considering the uncertainties about future impacts, a fatalist attitude to give up the whole ski resort at the current stage is not a recommended strategy either. A well planed diversification of the local tourist offerings would reduce the dependency on ski tourism. For the ski

tourism industry it is essential to understand that adaptation can reduce the vulnerability but implications will be inevitable.

Further research:

It should be found out if the adaptive capacity is indeed as high as believed. Up to date, impact assessments for the alpine ski industry were done without considering the potential for adaptation. Including adaptation into an impact assessment would modify the impact estimates to net impacts estimates. This will give more objective data to evaluate the adaptive capacity of the ski industry.

A detailed Cost-Benefit Analysis of different strategies should be conducted. In particular, a CBA for snowmaking would be desirable, as it could deliver conclusions about the long term appropriateness of the strategy. This research should incorporate environmental and financial costs and it should consider that the changing climate might limit the number of days when snowmaking can be applied. If the ski industry overestimates its adaptive capacity, maladaptation or unpreparedness for future impacts can be costly outcomes for the economy and the environment.

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Appendix:

Questionnaire

1. What priority has the issue of climate change in your ski resort?
2. Where do you get your information about climate change from?
3. What do you think, how well are you informed about the impacts of climate change on the ski industry?
4. Which weather (short term)- or climate (long term) phenomena would you attribute to climate change in your ski resort?
5. Which impacts did climate change have on your business so far?
6. How high would you estimate that the financial damage caused by climate change has been so far?
7. How do you see the probability that climate change could have the following consequences?
8. How many years do you think that you can continue the ski business in an economically viable way? Considering that you do not run any further adaptive measure!
9. Lets assume that you knew that beginning with next year the ski season is one month shorter due to a lack of natural snow (very hypothetically). How would you react!
10. Where do you see the limitations to adapt to the impacts of climate change?
11. How many years do you think that you can continue the ski business in an economically viable way? Considering all possible adaptation measures!
12. What do you personally think about the following technical measures to react to a one month shortening of the season?
13. What do you personally think about the following “soft business” strategies to react to a one month shortening of the season!
14. What do you personally think about the following public or governmental to react to a one month shorting of the season!
15. Once again, some strategies are being presented to you. Please indicate if you already apply this strategy or if you plan to apply it.
16. What percentage of your ski runs can you provide with artificial snow?
17. Do you plan a future extension of your snowmaking facilities if the circumstances ask for it?
18. Do you think that an intense use of snow canons could have a negative impact on the environment? If yes, what?
19. How many years does it make sense to plan ahead when it comes to adaptation to climate change?
20. Finally, please give more information about your ski resort?

How many lifts do you have in your ski resorts under your supervision?
At what altitude is the bottom station of your ski resort?

21. If there are any comments you would like to add to the issue of climate change and adaptation to climate change, or if you want to comment on the questionnaire, please do so here!