Climate Change

"a challenge for ski resorts in the state of Washington, USA"

MSc Thesis

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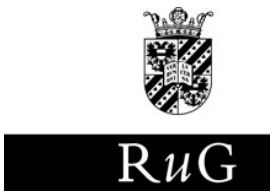
Peter Hofman
Student MSc Economic Geography
S1400355

A research in cooperation with:

University of Washington, Tacoma USA



University of Groningen, The Netherlands

Preface

To finish the Master Economic Geography at the University of Groningen, writing a thesis is indispensable. Because I went to the University of Washington in Tacoma to write this thesis, it was difficult to find a subject. Searching a subject abroad is more difficult because you do not actually know what is going on. I read some articles in the Netherlands about climate change, and how it could affect ski resorts in the Alps. I was wondering if the same effects where going on in the state of Washington ,USA. Brian Coffey, my tutor in Tacoma, send me an assessment of the University of Oregon about the economic impacts of climate change on Washington state. Key point was that snow sports areas accounting for over 40 percent of average visits to Washington ski areas during the past ten years are based at low elevations at which climate change impacts on snow cover are likely. After these facts I decided to use this subject for my thesis. I am very interested in ski resorts, because I am a fervent snowboarder myself. Economics impacts of climate change is an interest point of me too, and in view of my Master study Economic Geography significant. To get a better understanding of the impacts on the micro-scale, interviews with managers of ski resorts were indispensable. I am grateful to the managers who gave me the opportunity to talk to them. A special thanks to John Kircher, the manager of Crystal Mountain, for a free day of snowboarding, and to Bob Black for inviting me for lunch to talk about your resort Leavenworth. The interviews with Chris Bretherton and Philip Mote, researchers at the University of Washington Seattle, were very helpful for a better understanding of climate change on the regional level. And the interview with Scott Kaden, the manager of the Pacific Northwest Ski Association, gave me a better view of the economic impacts of climate change on ski resorts. I want to thank my tutors Brian Coffey and Paul van Steen for their support. And through here I want to note a special thanks to my parents and brothers for supporting me to study abroad. It was an unique experience, which I will never forget.

Peter Hofman

Summary

Since the late 19th century, the average surface temperature is increased by 0,6 to 0,2°C. The climate is very much determined by the so called 'greenhouse effect'. The concentration of CO2 (the most important greenhouse gas) in the atmosphere is defined by the carbon cycle, that is a balance between CO2 in the atmosphere and the CO2 tied up in plants, water or fossil fuels. So both natural causes and human interactions can disturb this balance, and so change the climate. Natural causes could be the Earth's tilt, the continental drift, the ocean currents, volcanic gasses, and comets and meteorites. Changes in land use pattern, deforestation, land clearing, agriculture, and other activities are examples of human interactions responsible for a raise of greenhouse gasses. Climate change could have e serious impact on icecaps and permafrost, sea level, weather circumstances, eco systems, and agriculture. While there are social and economic consequences too. One of the economic consequences is the impact on ski resorts. The melting of glaciers and higher temperatures could cause a big stir for ski resorts. Those factors could have a negative impact on the amount of visitors, the brand awareness, lodging revenues and major events. The ski industry in the state of Washington, USA is used as an example to illustrate the impacts of climate change. The 14 ski resorts of Washington are responsible for 1,8 million visitors per year. In 2002, the receipts of the ski industry in Washington state was 519 million dollar. Which makes the industry the sixth biggest of the country. Most resorts are situated in the Cascade Range, this is a mountain range running from North to South and divides the state in two different areas. The Eastern part is dry and cold, while the Western part is wet and mild (at least in the winter period). The period from 1944 to 2006 illustrates that the Snow Water Equivalent (SWE) in the Washington Cascade Range, has decreased at least 13 percent. Together with the fact that glacier volume shrank by respectively 40 and 33 percent in Washington, it makes clear that the ski industry of Washington is vulnerable to climate change. The effects are not the same for every resort. Some higher based resorts can even expect more visitors because they have more snow security. Lower based resorts and resorts situated at the rain shadow of the Cascade Range are most vulnerable. People are waiting to purchase their season tickets, and they act on information from the internet about weather forecasting. Every manager says that he is concerned about climate change, although Snoqualmie is the resort which is most concerned. Climate change has become part of their business nowadays, and climatological scientists do certainly have an impact on their opinion. Although the managers are aware of climate change, they all do not think that the ski industry will quit. Elsasser and Burki (2002) developed a four elements adaptation strategy. Ski resorts could adapt by maintaining the industry, subsidies, fatalism, and alternatives to skiing. While managers name the opportunities of night skiing, population increase, price policies, and cooperation. Resorts have to emphasize their strong points, every resort got some. And when they work on the weak points, the situation could be improved. Marketing can be a useful instrument to attract visitors outside the state. And the increasing population of the Puget Sound region could lead to generally higher revenues. A right use of marketing is essential to keep revenues.

Contents

1 Introduction

1.1 Backgrounds of the study:

Climate change is a very hot topic, it is very often subject of discussions between world leaders. Studies of the IPCC and the UN show that the Earth's climate is changing. Although it is not clear which part is caused by humans, the climate has changed seriously. The IPCC (2001) made clear that the average temperature on earth has increased 0,6 to 0,2 °C since the nineteenth century. Washington state, a territory in the North western part of the USA, is no exception in view of climate change. Scientists expect the climate in Washington to warm 0,28 °C every ten years. This is three times faster than the average rate from the 1900s to 2000. The increasing temperatures could seriously affect social-, economic-, ecological-, and political circumstances. The ski industry is one sector that is vulnerable to climate change. Several studies in the Alps showed that climate change has changed ski areas strongly. Temperatures have risen and snow pack is decreased in the Alps. The ski sector in Washington state, USA is starting to feel the impacts too. The average mountain snow-pack in the North Cascades has declined at 73 percent of mountain sites studied. And spring runoff is occurring earlier each year (ECY Washington, 2006). These factors do have an impact on the economy of the ski resorts. That is why the title of this thesis is: Climate change, a challenge for ski resorts in the state of Washington. The thesis will focus on the economic consequences of climate change for ski resorts (in Washington state).

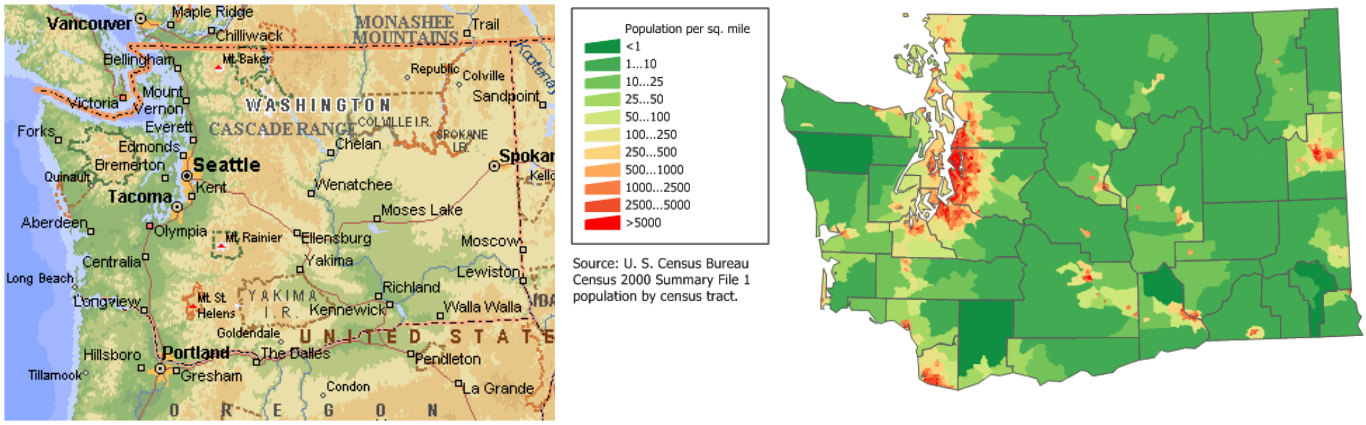


Figure 1.1: Map of Washington state (Explore Maps, 2007), and Figure 1.2: Population density per square mile in Washington state (US Census Bureau, 2006)

1.2 Research goal definition:

To define the goal of the research it is important to make a distinction between 'climate change' and 'global warming' first. The terms are often used interchangeably, as if they were the same thing (EPA, 2007). But there are differences between the meanings of the two terms. The IPCC rapport (2001) gives the definitions as follows. *"Climate change are changes in regional climate characteristics, including temperature, humidity, rainfall, wind, and severe weather elements"*. While global warming means: *"an overall warming of the planet based on average temperature over the entire surface"*. Climate change is a more all-embracing term which includes all the weather changes. The term climate change will therefore be used from now on.

In an assessment of the University of Oregon there is a small chapter related to the impact of climate change on snow sports. It shows the macro consequences of climate change, mainly the changes in temperature and snowfall. It does not show the micro-effects, how entrepreneurs think about the situation. The goal of this thesis is to identify the exact effects of climate change on the snow sport business, taking in consideration spatial variations in effects. It is helpful to know if entrepreneurs are concerned about the fact that temperatures are rising and snow pack decreases.

1.3 Research questions:

To achieve the above described goal, research questions are indispensable. Answering the research questions should give a good view of the micro-effects of climate change for ski resorts in the state of Washington. The research questions are as follows:

1. What are the expected effects of climate change for the near future?
2. In which ways can climate change effect ski resorts?
3. What is the contribution of the ski sector to the economy of the state of Washington in the USA?
4. Where are the ski resorts in this state located?
5. What are the expected effects of climate change on ski resorts in the state of Washington. Are they the same for all ski resorts in the state of Washington, or are there any spatial variations?
6. Are ski resorts in the state Washington concerned about the possible effects of climate change on their business?
7. What are the future projections for ski resorts in the state of Washington?
8. Which recommendations, if any, can be made for the marketing of ski resorts in the state of Washington in the light of the expected effects of climate change?

1.4 Research methodology:

The research is mainly based on an empirical explanation about climate change. To understand what the expected effects of climate change for the near future could be. And in which ways climate change can affect ski resorts. Secondary data is mainly collected through literature studies of IPCC and UN rapports. The third and fourth assessment of the IPCC show in great detail what the impact of climate change could be, and what the contributors to climate change are. The department of community, trade, and economic development of Washington asked the university of Oregon to make a preliminary assessment of the economic impacts of climate change for Washington. This study gives a better understanding of the economic consequences to the economy of Washington. Besides those studies, a set of other references were used to answer the research questions. Some research questions had to answered through primary data from ‘insiders’. That is why in depth interviews have been taken from managers of ski resorts, scientists, and a manager of a ski association. Those in depth interviews were indispensable in the research process. It seems logical to research chiefly the lower based elevation resorts. But climate change can although have an impact on higher based ski resorts. Maybe the higher based areas can expect more visitors. It could be the case that those ski resorts are thinking about expansion of capacity. Think about more slopes, more and higher speed lifts, and a greater variety of accommodation opportunities. So primary data of ski resorts is collected in both lower based and higher based resorts (Chapter four will discuss the methodology of the primary data collection more thoroughly). In a general sense, the

second chapter will be related to the global impact of climate change, the third chapter is about the ski sector of Washington, the fourth chapter handles the regional impacts and the opinions of ski resorts, while the fifth and sixth chapters make some future projections and solutions.

2 Effects of climate change

Climate is the composite or generally prevailing weather conditions of a region, throughout the year, averaged over a series of years (NOAA, 2007). In most countries that average series of years is ascertained on a thirty years period (KNMI, 2007). Our climate is not constant, in the Ice Age, several of ten thousands years ago, we experienced a period that was much cooler than nowadays. So climate change is not a new phenomenon, it is something that happened all the time in the past (Cox, 2002). What is new though is the rapidity of the changes that occur. Figure 2.1 shows that the average surface temperature has increased by 0.6 to 0.2 °C since the late 19th century. It is very likely that the 1990s was the warmest decade and 1998 the warmest year in the instrumental record since 1861.

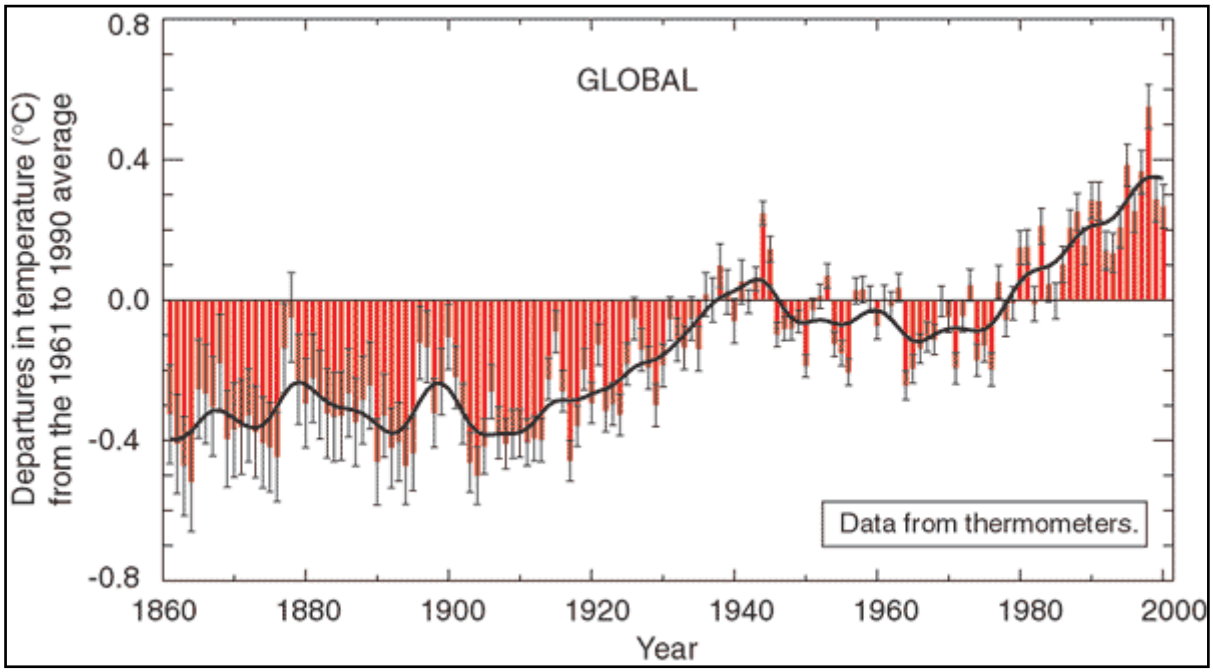


Figure 2.1: Combined annual land-surface air and sea surface temperatures (°C) from 1861 to 2000, relative to 1961 to 1990. Two standard error uncertainties are shown as bars on the annual number. (IPCC, 2001)

2.1 Global effects of climate change

As indicated in Figure 2.1, most of the increase in global temperature since the end of the 19th century has occurred in two distinct periods: 1910 to 1945 and from 1976 to now. The rate of increase of temperature for both periods is about 0.15°C per decade. Recent warming has a greater impact on land compared to oceans; the increase in sea surface temperature over the period 1950 to 1993 is about 50 percent of the mean land-surface air temperature. The high global temperature associated with the 1997 to 1998 El Niño event stands out as an extreme event, even taking into account the recent rate of warming (IPCC, 2001).

The climate is very much determined by the so called 'greenhouse effect'. This is a natural phenomenon that influences the temperature on earth. The atmosphere exists of the so called greenhouse gases, at which carbon dioxide (CO_2) is the main component (other greenhouse gases are methane (CH_4), nitrous oxide (N_2O), ozone

(O3), and carbon tetra fluoride (CF4)). The atmosphere with greenhouse gases works as a kind of a blanket around the earth, which regulates the temperature. This is because the greenhouse gases capture heat. When we did not have such a blanket it would be very cold on earth, think about an average temperature of -18°C. With this blanket the average temperature is about +15°C. If we experience more greenhouse gases in the atmosphere, the temperatures will increase. The concentration of CO2 in the atmosphere is defined by the carbon cycle, that is a balance between CO2 in the atmosphere and the CO2 tied up in plants, water or fossil fuels. So both natural causes and human interactions can disturb this balance, and so change the climate. The earth's climate is dynamic and always changing through a natural cycle. But what the world is more worried about is the fact that the changes that are occurring today have been speeded up due to human activities (Victor, 2004).

There are five main natural causes that could change the climate. The first example of a natural factor which is responsible for climate change is the earth's tilt. Every year the earth makes one orbit around the sun. The earth is tilted at an angle of 23,5 °. The northern hemisphere is tilted towards the sun in the summer period, in the winter period the northern hemisphere is tilted away from the sun. (In the southern hemisphere it's the other way around) If we did not have a tilt, we would not experience different seasons. Changes in the tilt of the earth can affect the severity of the seasons, more tilt causes warmer summers and colder winter while less tilt causes cooler summers and milder winters. The orbit of the earth is not fully round, but it is elliptical. This means that the distance between the earth and the sun varies over the course of a year. Most people think that the earth's axis is fixed, but actually it is not quite constant. The axis is not fixed, it moves with a about a half degree each century. This direction change is called precession and it can be responsible for changes in our climate (Williams, 2005).

The second example of a natural factor is the continental drift. Millions of years ago the earth was one great landmass. Ever since that period the landmass began to drift apart. So the continents as we know today did not exist in the past. This drift had an impact on the climate because it changed the physical features of the landmass, their position and the position of water surface. The separation of the landmasses changed the flow of ocean currents and winds, which affected the climate. This drift of the continents continues even today; the Himalayan mountains are rising about 1 mm every year because the Indian landmass is moving towards the Asian landmass.

Thirdly the climate could be changed by ocean currents, the oceans are very important in the world's climate system. The earth exists for about 71% of oceans and they absorb twice as much of the sun's radiation as the atmosphere (or the land surface). Ocean currents move tremendous amounts of heat over the planet, roughly the same amount as the atmosphere does. But the oceans are surrounded by landmasses, so heat transport through the water is through channels. Wind pushes against the sea surface and are so the cause of ocean current patterns. Certain parts of the world are influenced by ocean currents more than others. The coast of Peru and nearby regions are directly influenced by the Humboldt current that flows through the coastline of Peru. El Niño is also a very important determinant in the Pacific Ocean. It can affect climatic conditions all over the world. It's been caused because of a relative warming of the water temperature in the Pacific Ocean.

The North Atlantic region is also strongly influenced by ocean currents. If we compare places at the same latitude in Europe and North America the effect is immediately clear. Some parts at the Norwegian coast have an average temperature of -2°C in January and 14°C in July; while places at the same latitude on the Pacific coast of Alaska are far colder: -15°C in January and only 10°C in July. The warm current along the Norwegian coast keeps much of the Greenland/Norwegian Sea free of ice even in the winter. The rest of the Arctic Ocean, even when it is sited much further south, stays frozen. The oceans are also important for the precipitation in the world. Much of the heat from the oceans escapes in the form of water vapor. Water vapor are then important for the formation of clouds, which bring a shade over the surface and have a net cooling effect (Alley et al. 2003).

A fourth natural cause could be volcanic gases; when a volcano erupts, the atmosphere can be filled with large volumes of sulphur dioxide (SO2), water vapor, dust, and ash. Although the volcanic activity mostly does not last longer than a few days, the large volumes of gases can influence our climate for years. Enormous amounts of SO2 come into the stratosphere after a major eruption. The volcanic gases in the stratosphere often block the incoming rays of the sun, this leads to a net cooling effect. Winds in the stratosphere spread these gases (aerosols) all over the world, mostly in an easterly or westerly direction. The effect for the north and the south is much less. These aerosols could stay for several years in the stratosphere so the impact also lasts for several years. The Mount Tambora in Indonesia is often used as an example to illustrate this. After the major eruption of this volcano in 1815 the climate pattern around the world was changing. The year 1816 is often called 'the year without a summer' because the aerosols caused a tremendous cooling in the summer period in Western Europe and North America (Robock, 2000).

Comets and Meteorites to finish with, are often considered to account for the extinction of the dinosaurs 65 million years ago. The impact is not yet proven and such comets or meteorites disasters only happen once in every few millions of years (ARIC, 2007).

People can accelerate the greenhouse effect, this because humans expel extra greenhouse gases into the atmosphere. Changes in land use patterns, deforestation, land clearing, agriculture, and other activities have all led to a rise in the emission of carbon dioxide. Taking into consideration that carbon dioxide is the most important greenhouse gas. The acceleration of the greenhouse gases (especially CO2) started with the Industrial Revolution in the 19th century. The revolution caused large-scale use of fossil fuels for industrial activities. These industrial activities created jobs in the urban areas, so people moved from rural areas to urban areas. Much vegetation was removed due to urban developments. Also other natural resources are being used for industries, transport, and consumption. All those developments have a contribution to a rise in greenhouse gases in the atmosphere. We need oil to run our vehicles, we need coal and natural gas to generate energy for households and industries. All these natural resources are fossil fuels and contribute to an accelerating greenhouse effect. According to Chris Bretherton (2007), a researcher at the University of Washington, it is for 90 percent sure that humans have changed the climate over the past century. The IPCC has a measuring system which calculates what the climate change would be if there were no human life on earth. They come to the conclusion that 50 percent of the last century's climate change is due to human interaction. But Bretherton thinks the percentage is much higher. The energy sector

is the major contributor to the carbon dioxide emissions. They are responsible for about 75% of the carbon dioxide emissions, 20% of the methane emissions and a huge volume of nitrous oxide. Besides that, the energy sector produces nitrogen oxides (NOx) and carbon monoxide (CO) which are not greenhouse gases but certainly have an influence on the chemical cycles in the atmosphere (IPCC, 2001).

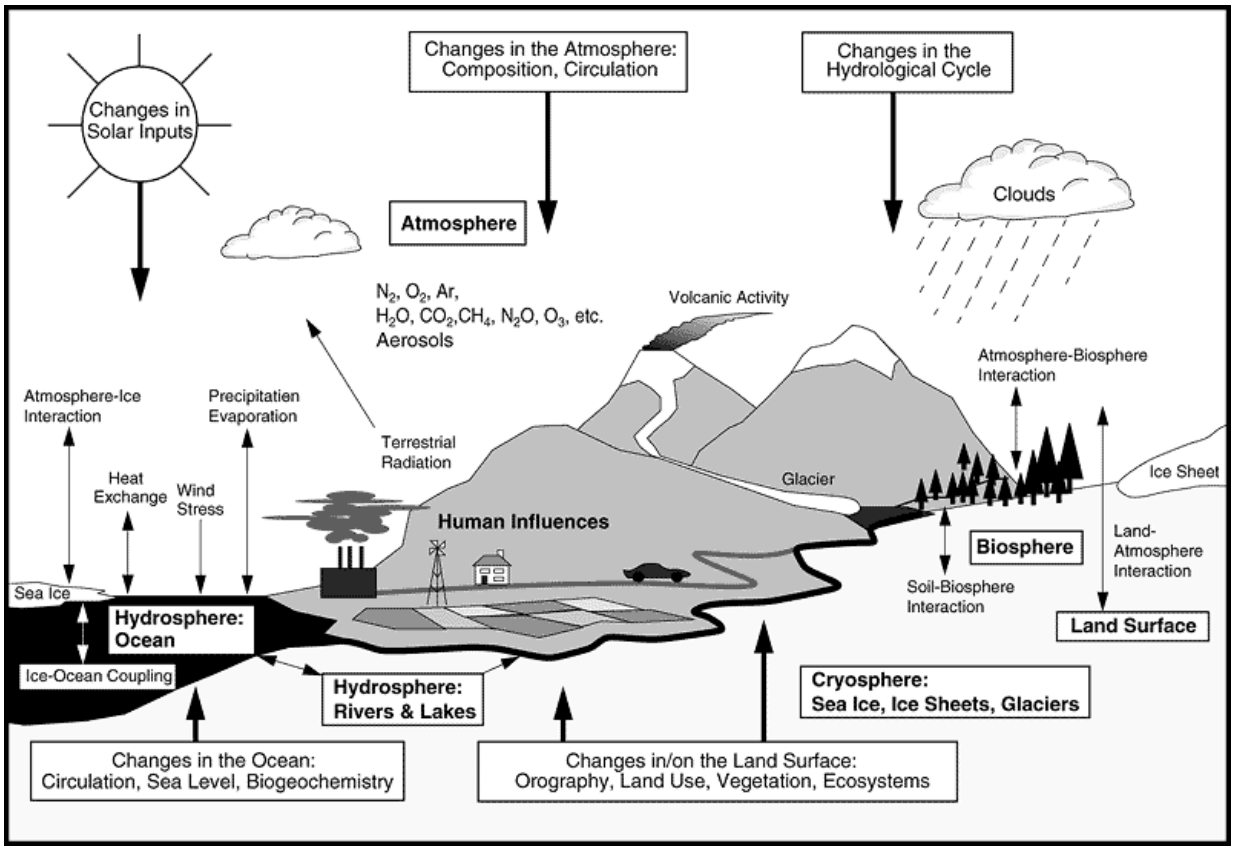


Figure 2.2: Overview of different initiators of climate change (IPCC, 2001)

The expectation, as given in the IPCC rapport in 2001, is that the average global temperature will increase by 1,4 to 5,8°C in the coming century. Compare that to the increasing in the last century, 0,7°C, and it is clear that climate change could be a serious threat. Because the blanket of greenhouse gases in the atmosphere becomes thicker, the average global temperature on earth will increase. The increasing temperatures could cause a lot of natural problems.

To start with the ice caps and permafrost; because of the increasing temperatures huge masses of ice could melt. Think about huge masses like glaciers, polar ice, and the ever frozen permafrost in tundra's. This melting process could have a tremendous effect on the local environment.

Secondly climate change could cause a rise of sea level, this has of course something to do with the melting of ice caps and permafrost. The IPCC (2001) predicts an average rise of sea level of 10 to 90 centimeters for the coming century. The fact that sea water expands as the oceans warm up is the main reason for sea level rise, the other reason is the melting process of ice caps and permafrost. Lower based areas could flow over with sea water, this especially should be a problem for third world

countries like Bangladesh. Those countries do not have the money and skills to build storm-surge defenses.

Thirdly a change of weather could come into existence because of climate change. The IPCC (2001) predicts more weather extremes for the next century, this trend is actually already going on. They expect heavier rainfall, more heat waves, and more storms (with mud flows and flooding as a result). Changes in the amount (and patterns) of precipitation could devaluate the availability and quality of water, again especially in third world countries. In the third assessment the IPCC predicts huge negative effects on the availability of fresh water in large areas in Africa. In 2050 the amount of people with a lack of fresh water is four times higher as in 1995. There are also places with a decreasing amount of precipitation, as well as places with an intermediate dry period between the heavy rain showers. A lot of places in the world have already broken dry records, this in turn is very dangerous in view of forest fires.

Fourthly climate change plays a determent role in eco systems; flora and fauna grow accustomed to the changing climate. But when the change occurs very fast it could be the case that the process of accustomizing is more difficult. The inevitable result is that some vulnerable species will not survive, think about vulnerable species like penguins, polar bears, coral reefs, butterflies, and dragonflies.

Finally, agriculture could suffer due to climate change because it is a sector which is relatively dependent on the climate. Extreme dryness or extreme precipitation make it more difficult to stay in business. The climatic circumstances could change the conditions for agriculture, some places become more efficient for agriculture (Siberia) while other places become less efficient (Africa). Biologists also expect a higher chance of insects plagues in some regions because the larva's are able to survive longer in the mild summers. Figure 2.3 shows that temperature, sea level rise, and precipitation are the main components of climate change. Changes in these elements could have an impact on the sections below. These sections are health impacts, agriculture impacts, forest impact, water resources impacts, impacts on coastal areas, and impact on species and natural areas (IPCC,2001).

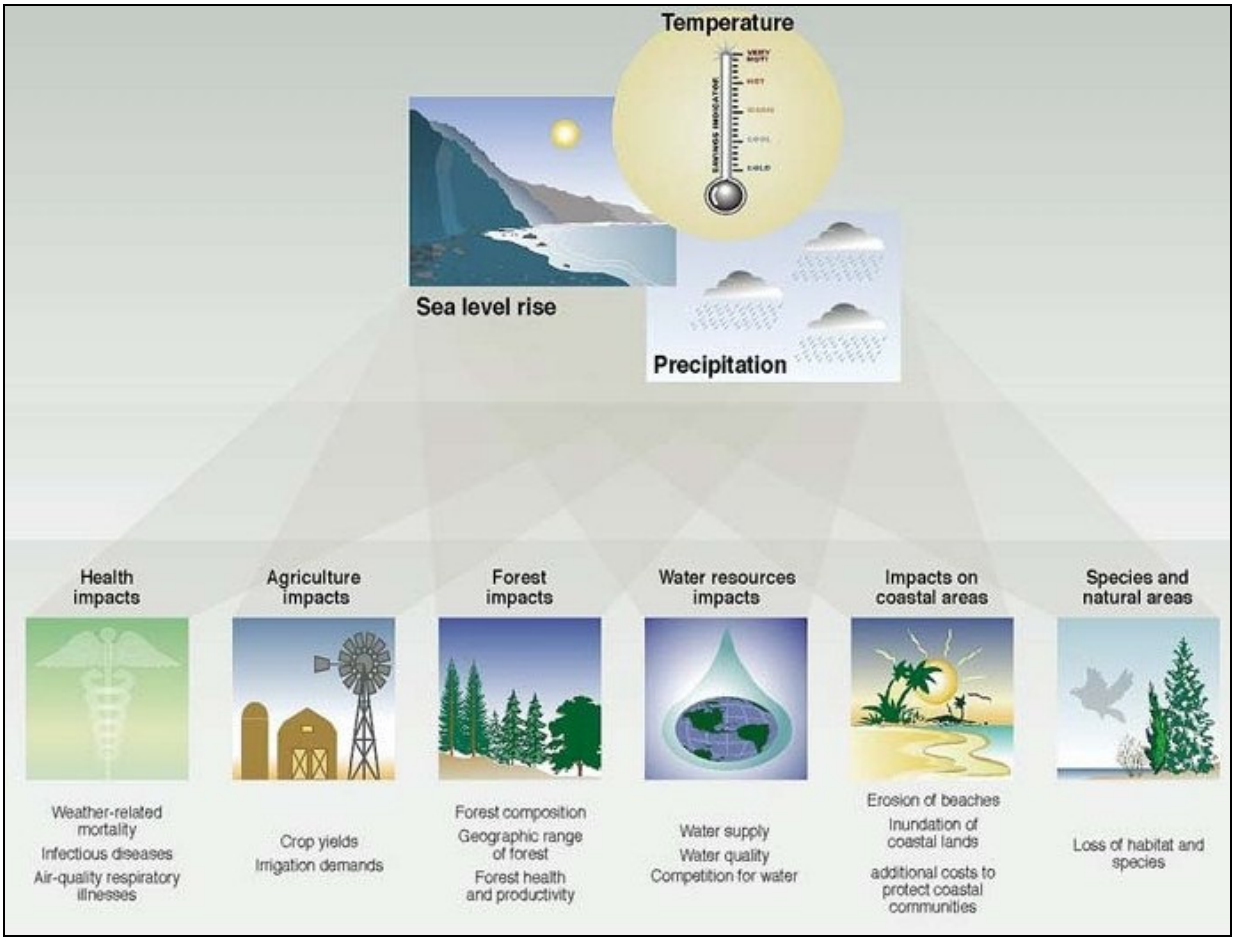


Figure 2.3: Components of climate change, how climate change can effect nature (IPCC, 2001).

Besides the natural impacts, there are also social- and economic consequences due to climate change. And you can even think about cultural and political effects (CIG, 2007). Climate change could be a serious threat to our social and economic lives. It is ironic that the third world countries encounter the heaviest impacts. It is important that climate change will be solved on a global level, because poor countries could not react adaptive on climate change (IPCC, 2001). Those countries are often for a large part dependent on agriculture, forestry, and fishery. All social and economic activities that are related to the weather could suffer from climate change. Manufacturing, retail, tourism, and agriculture are examples of sectors that have to be adaptive on climate change. The next paragraph is about the impact of climate change on tourism (winter recreation in particular).

2.2 Impacts of climate change for ski resorts

It is too simplistic to make the assumption that a warmer winter climate will lead to general disappearance of snow from the mountain areas of the world. And so threaten the future viability of snow-related recreational activities. However, the association between the duration of snow cover and winter temperature cannot be overlooked and the economic risks are real enough (Konig, 1998). As discussed in the previous paragraph climate change could be responsible to changes in temperature, sea level, and precipitation. Those changes could effect the ski resorts around the world in a dramatic way. In Austria for example, a rise in temperature by 1°C would reduce the snow season by 73 days over winter and spring (Hantel et al., 2000). Abegg (1996) suggests that the snow reliable fields at 1500 meters in Switzerland, would be reduced to 63% of current levels if the air temperature would increase by 2°C. Whetton et al. (1996) write of the total loss of the Australian skiing industry by 2020 in a worst case scenario. While in South Africa, skiing at the Drakensberg Mountains would not be possible anymore if the current rate of temperature increase continues (Perry and Illgner (2000). All those examples show that climate change could be a serious threat to the ski industry. This industry comprises, according to the US Census Bureau (2002), "*establishments engaged in (1) operating downhill, cross-country, or related skiing areas and/or (2) operating equipment, such as ski lifts and tows*". These establishments often provide food and beverage services, equipment rental services, and ski instruction services. Four season resorts without accommodations are included in this industry. In the table below there is an overview of countries that have ski resorts (at least one that is reviewed by goski, an American organization which gives resort information about ski resorts all over the world).

Country	*Country*	*Country*	*Country*	*Country*
Algeria	Chile	India	Morocco	South Korea
Andorra	China	Iran	New Zealand	Spain
Antarctica	Croatia	Israel	Norway	Sweden
Argentina	Cyprus	Italy	Pakistan	Switzerland
Armenia	Czech Republic	Japan	Poland	Tajikistan
Australia	Estonia	Kazakhstan	Portugal	Turkey
Austria	Finland	Kirghizstan	Romania	Ukraine
Belgium	France	Latvia	Russia	United States
Bolivia	Germany	Lebanon	Scotland	Uzbekistan
Bosnia	Greece	Lesotho	Slovak Republic	Venezuela
Bulgaria	Hungary	Liechtenstein	Slovenia	
Canada	Iceland	Macedonia	South Africa	

Table 2.1: All countries that have at least one ski resort that is reviewed by Goski (Goski, 2007).

Maybe not all those countries have a ski industry which is noteworthy from an economic point of view. But for some regions, especially in the Alps, North America or in South East Asia winter tourism is the most important source of income, and snow-reliability is one of the key elements of the tourist resource. Skiing and snowboarding, but also snow related activities such as cross-country skiing or snow hiking depend on there being enough snow (Hall & Higham, 2005). The winters in Switzerland with little snow at the end of the 1980s (1987/1988 to 1989/1990), for example, caused a stir over there. The big difference to earlier periods with little snow

was that the ski industry had become much more capital intense. But winters with a lack of snow are not the only problem for alpine resorts. Since 1850, Swiss glaciers (and other alpine glaciers) have lost more than a quarter of their surface. In 2030, 20% to 70% of Swiss glaciers will have disappeared. Hall & Higham (2005) say: "*This is not only a severe loss of mountain aesthetic, but also a problem for glacier skiing in both summer and winter*". Furthermore, climate change increases melting of permafrost and makes many mountain areas more vulnerable to landslides. Mountain cable stations, lift masts and other buildings on permafrost soil will become unstable and it is very expensive to stabilize them. Chapter 2.1 showed that future climate will not only be warmer, but will also change its pattern. Ski resorts have to keep in mind that there is like a big swing (in temperature and precipitation) going on which makes the future weather conditions less predictable (Kaden, 2007). In the Alps you had some great years with lots of snow altered with years with almost no winter recreation opportunities (Prick and Van der Linden, 2007).

So the disappearance of glaciers is one threat to the ski industry, it limits the opportunities for skiing and other winter activities. The other threat is the rise of temperatures, that also cause a stir when the precipitation falls in the form of rain rather than in snow. The Colorado College State of the Rockies Report Card (2006) predict that rising temperatures in the US Rockies will mean more precipitation falls as rain rather than snow, making winter sports 'no longer economically viable' by 2050. They say: "*If warm weather shortens ski seasons by a few weeks it could quickly make currently profitable resorts fall below marginal break-even season length requirements*". The IPCC (2001) has proven that the average amount of snow pack in the Northern Hemisphere has decreased since 1984.

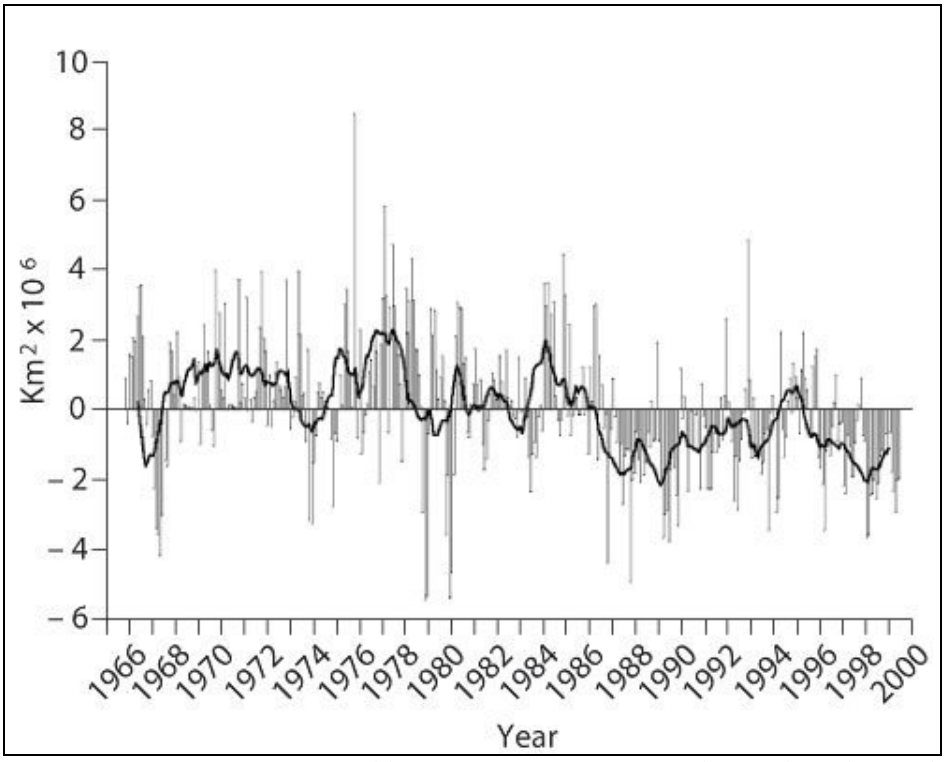


Figure 2.4: Deviations of monthly snow cover extent over the northern hemisphere lands, including Greenland, deviations are compared to a 30 year average. 12-month running means (solid curve) (IPCC, 2001).

With regard to snow cover there is the almost universal problem of shortage of data on which to base any assessment of change. It is a historian's adage that an understanding of the future can be found in the patterns of the past (Hall and Higham, 2005), but when there are no statistical records, we can not exactly predict what the future will bring. The IPCC (2001) made clear that that the average surface temperature increased by 0.6 to 0.2 °C since the late 19th century. This certainly has an impact on snow cover in the world, but the impacts on a regional (mountain) scale are not clear yet. The IPCC estimated that: "*as global warming proceeds, regions currently receiving snowfall will increasingly receive precipitation in the form of rain. For every 1 °C increase in temperature, the snowline rises by about 150 meters. As a result, less snow will accumulate at low elevations. In contrast, there could be greater snow accumulation in regions above the freezing line due to increased snowfall in some of these regions*". Satellite records indicated that the annual snow pack in the northern hemisphere has decreased by about 10% since 1966 due to higher land temperatures. This change mainly affects the snow cover in spring and summer, which has significantly decreased since the mid-1980s over both the Eurasian and American continents (IPCC,2001).

So climate change would not directly lead to general disappearance of snow from the mountain areas of the world. Some higher based areas could even get more snow cover (and visitors). The result of this is that skiers and snowboarders have to travel further to reach snow covered areas, which require further investments in the on-site infrastructure. Snowfall in lower based areas will become increasingly unpredictable and unreliable over the coming decades. As a result, almost 50% of all ski resorts in Switzerland, and even more in Germany, Austria and the Pyrenees, will face the consequences of climate change (EEA, 2004). Hall and Higham (2005) think that it is a sad situation when the ski industry disappears from the low lying resorts. The ski industry as a whole will be affected by that development, the ski industry gets its brand-awareness by the low based resorts. A lot of skiers and snowboarders want to go to ski resorts nearby, they can not effort a long trip to a more snow reliable area. Besides that, the longer trips cause even more emissions of greenhouse gases, a net loss for the climate is the result.

On the whole, climate change can cause a reduction in the number of skiers visiting the ski resorts. This measured in terms of reduced ticket sales for the ski lifts and tows. Palutikof (1999) has noted a strong correlation between lift and tow passes issued and the number of days with snow cover. Skiers and snowboarders have become more opportunistic in their behaviour, making last-minute decisions based on, for example, information from internet (web-cams, forums, and weather predictions). This has impacted directly on-service providers who have less certainty about their income. The potential visitors could also become careful when persuading a season pass, they do not know how often they are able to ski or board. Recruitment of staff shall be reduced to a level where a compromise could be reached between periods of low and high demand.(Hall and Higham, 2005). Palutikof (1999) also refers to the fact that other mechanisms may result in a very different set of changes. In Scotland, for example, the dominance of the western winds could develop the real risk that despite the presence of a snow cover, strong wind and low cloud may restrict the use of the lifts. This micro-scale climate impacts have to be researched more thoroughly to make better predictions in the future.

The accommodation providers would also have to deal with a general reduction in demand for holiday accommodation, resulting in a direct loss of income. This could cause a tremendous loss of jobs in the sector. Banks are already anticipating on this situation, in Switzerland banks refuse to lend money to resorts which are situated below 1500 meters. Some of the small resorts are already stopped being (OEDC, 2006).

When the snow cover become more unreliable, it could lead to the cancellation of some key competitive events and visits from ski clubs. The impact for low lying resorts could worsen because they miss the income from those groups and organizations. The city of Kitzbühel (Austria) had to cancel a women World Cup skiing event in 2007 because they had a lack of snow, they missed revenue of half a million euros (OECD, 2006).

Figure 2.5 shows what the optimal conditions are for the different sectors of winter recreation. Simply said, climate change could reduce the chance on the ideal circumstances. Less resorts have the luck to deal with the optimal conditions which are presented below. The fourth column presents the ideal climatic requirements for snow making, chapter 5 will handle the question how ski resorts could adapt to climate change. Snow making is one adaptation the ski industry could think of.

Environmental condition	*Nordic skiing*	*Alpine skiing*	*Snow shoeing*	*Snow-mobiling*
Snow depth (cm) – Minimum – Optimum	 20–30 60	 20–30 60	 20–30 60	 30 60
Snow density (g/cm^3)	<0.6	<0.6	0.2–0.6	0.4–0.1
Air temperature (0C)	–2 to –15	5 to –20	10 to –40	10 to –30
Snow making (0C)[1]	–3 to –15	–3 to –15	Not applicable	–3 to –15
Wind (km/h)	<20	<15	<45	<45
Wind chill ($watts/m^2$)	700	700	1600	1400

Figure 2.5: Ideal climatic requirements for winter recreation activities (Magill and Geddes, 1987).

3 Ski sector Washington state, USA

Chapter 2 showed that climate change could have serious impacts on the ski industry world wide. To get a better understanding of how climate change could effect a specific region; this chapter, and the following chapters focus on the ski industry in Washington state, USA. Washington has 14 ski resorts (which are all members of the National Ski Area Association) situated on her territory.

3.1 Contribution of ski sector to Washington's economy

Washington state is responsible for 3,14 percent of all ski resort visitors in the USA (NSAA, 2007). In chapter two the definition of the ski industry is already given. The ski resorts get their revenues from the spending patterns presented below. It is clear that most revenues from the ski resorts is earned by lift tickets and season passes. Although the restaurants and bars have a big share too. The figure shows that lodging has a share of almost 8 percent, at least in the US-NSAA bar. The Census bar represents the revenues of ski resorts that are measured by the US Census Bureau (2002), while the US-NSAA bar represents the ski resorts that are measured by the National Ski Area Association (2002). Not all ski resorts are connected through the NSAA, that is why the differences occur. Washington State's lodging revenues will not approach the 8 percent, this is because the Washington ski resorts are mainly based on daily visitors. Some of the ski resorts in Washington State do not even have the opportunity to stay over-night (Gifford, 2007).

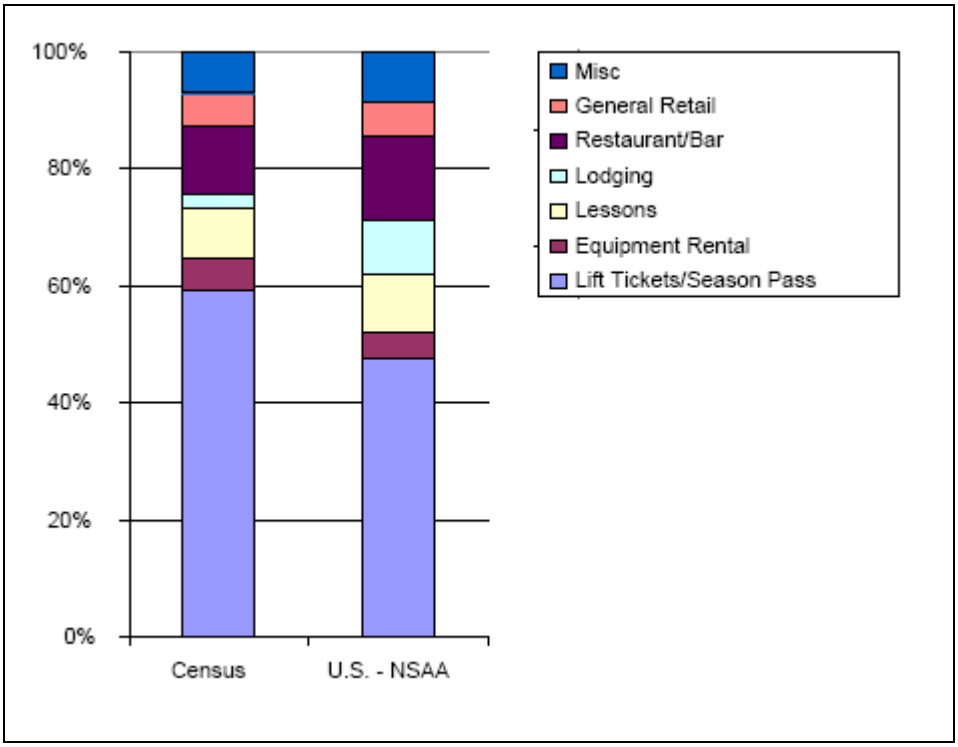


Figure 3.1: Spending patterns at ski facilities (Institute for Public Policy and Economic Analysis, 2005)

In 2002, the revenues of the ski industry in Washington state was 519 million dollar, the industry contributes 0,19 percent to the gross state product of 268,5 billion dollars. This seems a small contribution, but the industry is the sixth biggest of the country. Only Colorado, California, Vermont, Utah, and Pennsylvania have a relative

bigger ski industry (valued by total revenues). In the view of payrolls Washington has an annual payroll in the ski industry of 18,07 million dollar, earned by 3108 paid employees (US Census, 2002). After doing a economic basis analysis, the location quotient is 2,078. This means that Washington is a net exporter of the output of ski business. The location quotient describes the employment share of any sector in any region, relative to the national share of employment in the sector (Mc Cann, 2001). There have to be kept in mind that some states in the United States do not have a ski industry. After leaving the 14 states who do not have a ski industry behind, the location quotient is 1,535. So the ski industry is noteworthy in view of employment share. Per capita the annual payroll is not very high (5814 dollars) but there have to be kept in mind that most of the employees work on a temporary base. In Washington state there are almost no opportunities for year round recreation, Jon Perry (2007) says that Snoqualmie tried to develop some summer recreation like hiking and mountain biking but it was just not feasible. So most people who work in, for example, a rental shop only work there in the winter period (mostly from December till the end of April). Most of the employees work in manufacturing in the summer period. In fact almost all of the ski patrol members work as a fire fighter after the winter period (Peterson, 2007). Only the general managers and some other officials have a year round job. They are planning the coming ski season, and evaluating the previous season. The biggest sectors (in view of annual payroll) in Washington are manufacturing, information, and health care and social assistance. These sectors are mainly based on huge companies like Boeing and Microsoft (US Census, 2002).

The participation in skiing and other resort activities, measured by the number of annual visitors to all US ski resorts, increased about 10 percent the last five years, after a long period of stagnation. As the right scale of Figure 3.2 shows, from the mid 1980s to the late 1990s the number of visitors to U.S. ski areas fluctuated around 52 million annually, increasing to about 57 million visitors during the 2000-01 ski season. During this period of low growth, the number of ski areas, as shown by the left scale, fell from about 30 percent, from 720 to 490 (Institute for Public Policy and Economic Analysis, 2003). This means that fewer ski resorts caused a net increase of visitors in the period from 1984 to 2004.

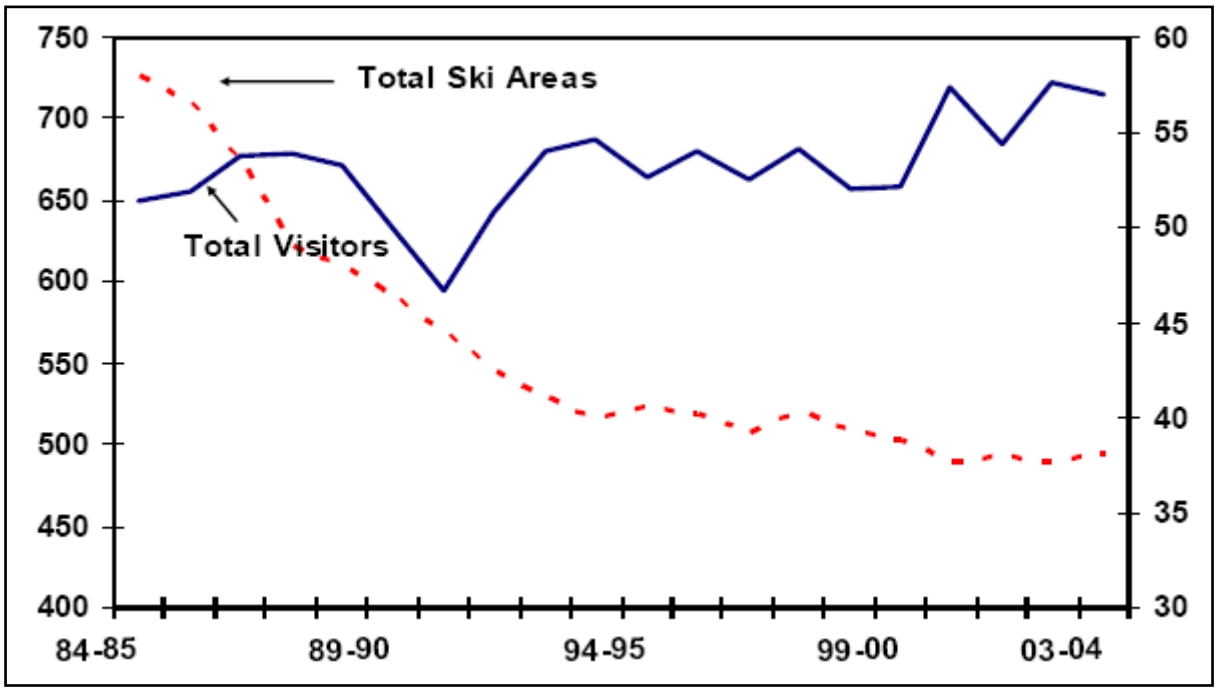


Figure 3.2: Ski Visitors and Ski Areas in US ski resorts from1984-85 to 2003-04 (Institute for Public Policy and Economic Analysis, 2005)

In Washington you also see a trend of increasing visitors after a long period of stagnation. Gifford (2007) says that the increase could be explained by the population growth, especially in the Seattle/Tacoma region. Approximately 1,8 million skiers and snow boarders visit Washington's ski areas annually. Most of those visitors come from the so called Puget Sound area, this is the urban agglomeration of Seattle and Tacoma. The agglomeration is responsible for more than half of the State's population of almost 6,4 million (US Census Bureau, 2006).

3.2 Locations of ski resorts in Washington state, USA

Washington's territory comprises 14 ski resorts, at least resorts which are member of the National Ski Area Association. Skiing is mainly possible because of the high elevated Cascade Range which divides the state in two completely different areas. The Cascade Range contains several volcanoes, which reach altitudes significantly higher than the rest of the mountains. From north to south these volcanoes are Mount Baker, Glacier Peak, Mount Rainier, Mount St. Helens, and Mount Adams. The highest point in Washington is the Mount Rainier at 4392 meters above sea level. It seems straight forward that most ski resorts are situated in the Cascade Range, although there are also other ski resorts in the state. Figure 3.3 shows a map of the different ski resorts in Washington. The places in red represent ski areas in Washington State. 49 degrees North, Mount Spokane and Ski Bluewood are resorts situated in the east of Washington. This is the place where the Rocky Mountains rise; the Washington Rockies are often called Columbia Mountains. An other ski resort, not situated in the Cascade Range, is Hurricane Ridge. This resort is sited in Olympic National Park. It is one of only two remaining lift operations in the National Parks of the United States. The figure also shows some places in black, those are areas not equipped with lifts or something. When people want to do Alpine skiing they have to walk or be dropped by a helicopter. The areas are more suitable for Nordic skiing and snowshoeing, but the facilities are minimized.

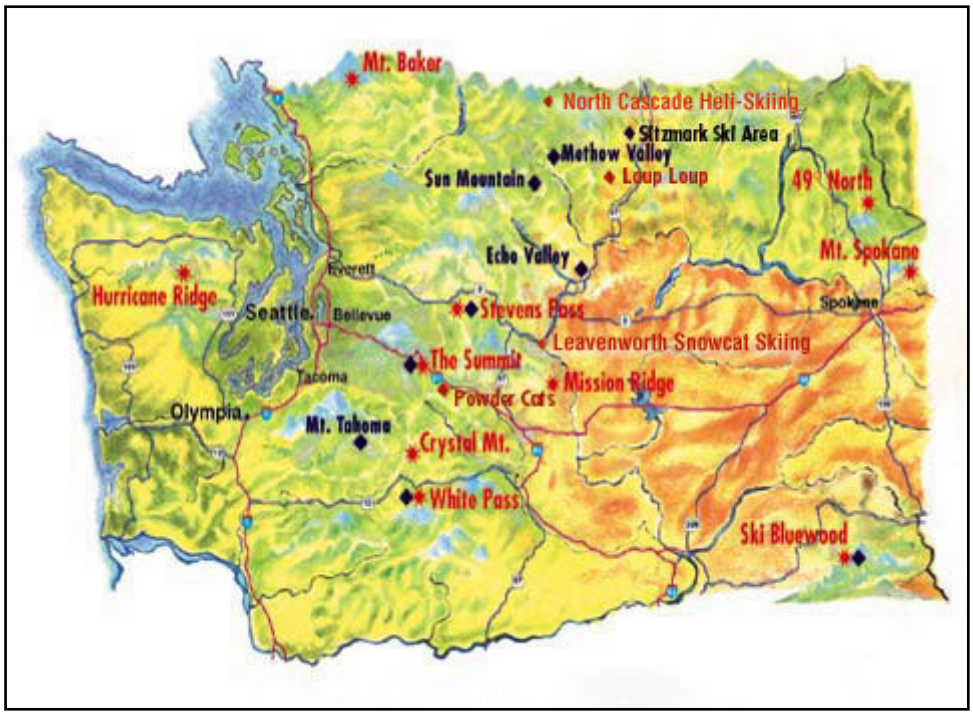


Figure 3.3: Overview of ski resorts in Washington State (Skiwashington, 2007)

Most inhabitants of Washington live in the Western part of the State. Mean reason is that Western Washington has a marine west coast climate with mild temperatures, dry summers, and wet winters. Western Washington is separated by the high mountains of the Cascade Range, running north-south, from Eastern Washington. In contrast, Eastern Washington has a dry climate with large areas of steppe and some deserts lying in the rain shadow of the Cascade Range. Western Washington supports dense forests and areas of rain forest by the way. The state is therefore often called

the evergreen state (Access Washington, 2007). All those characteristics have something to do with winter recreation opportunities.
The climate is very important in view of winter recreation opportunities. Ski resorts situated at the Western side of the Cascade Range, for instance, receive a far greater amount of precipitation than ski resorts situated in the rain shadow or in Eastern Washington. Resorts like Snoqualmie, Stevens Pass, Hurricane Ridge and Mount Baker have an average annual snowfall of more than 10 meters. Mount Baker is even the spot with a record high annual snowfall in 1999 with 28,96 meters. It has unofficially broken the world's record for season snowfall (NSAA, 2007). This is a huge contradiction with resorts like Mission Ridge, and Leavenworth which are located in the rain shadow of these mountains. Mission Ridge has an average annual snowfall of 3,43 meters for example (see table 3.1).

Ski resort	Lowest base elevation (in meters)	Highest top elevation (in meters)	Average annual snowfall (in meters)
49 Degrees North	1.196 m	1.760 m	7,65 m
Bluewood	1.385 m	1.728 m	7,62 m
Crystal Mountain	1.341 m	2.137 m	8,89 m
Hurricane Ridge	1.463 m	1.676 m	10,16 m
Leavenworth	701 m	834 m	2,34 m
Loop Loop	1.231 m	1.609 m	3,81 m
Mission Ridge	1.393 m	2.079 m	3,43 m
Mount Baker	1.311 m	1.539 m	16,43 m
Mount Spokane	1.280 m	1.795 m	7,62 m
Snoqualmie	796 m	1.652 m	11,05 m
Stevens Pass	1.238 m	1.782 m	11,43 m
White Pass	1.372 m	1.823 m	8,89 m

Table 3.1: Overview ski resort characteristics, elevation and annual snowfall (Skiwashington 2007, and NOAA 2007)

Winter temperatures in the Eastern part of Washington are significantly lower than temperatures in the West. In Seattle the average winter temperatures are around 10 degrees Celsius while in Spokane (Eastern Washington) those temperatures are around 4 degrees Celsius (RSSweather, 2007). But in spite of the lower temperatures in the Eastern part, the resorts do not receive as much precipitation as resorts in the West. It is difficult to tell whether the West or the East is more feasible for skiing and boarding. The mountains in turn cause a local climate that is difficult to describe. Chapter 3 is more about climate at the very local scale, and how climate change could effect those micro scale climates.

A closer look at the average annual visitors tells that the six biggest resorts are sited in the Cascade Range. Crystal Mountain, Mission Ridge, Mount Baker, Snoqualmie, Stevens Pass, and White Pass all have more than 100.000 visitors per year. Hurricane Ridge, Leavenworth, and Loop Loop are actually not resorts of any meaning to Washington's economy. Those resorts respectively have 5.000, 6.000, and 32.000 visitors per year. Leavenworth even is a non-profit organization promoting better health and fitness through skiing. Their income is used for improvement and maintenance of trails and facilities, and to subsidize club events and programs (SkiLeavenworth, 2007) In terms of ski able acres, Crystal Mountain is the biggest resort, but as regards to average annual visitors Snoqualmie is the biggest

with 510.000 visitors and Stevens Pass in second place with 447.816 visitors. The greater amount of visitors in the Cascade Range is mostly dependent on the Puget Sound region. The infrastructure in the Cascade Range is better as well, Snoqualmie for example is located just next to the I-90. (Skiwashington, 2007).

According to Skiwashington (2007) Mount Baker is the resort with the most lodging opportunities, but most of them are privately owned and not situated nearby lifts. Snoqualmie has 5 hotels admitted in their resort, Crystal Mountain 2, and Mission Ridge and Stevens Pass both one. So the opportunities to stay the night are not quite a lot. Even when you know that all those other resorts do not have lodging opportunities at all. Most resorts do have lodging possibilities nearby but they do not belong to the resort.

4 Regional effects of climate change for the near future

The previous chapters discussed climate change and how it could affect Washington State's ski industry. This chapter will discuss the micro-scale of climate change in Washington's ski industry. It discusses the question if ski resorts are concerned about the problems named in previous chapters. To answer this question inside information from ski resorts was needed. There has been taken several in depth interviews with both scientists at the University of Washington and managers of ski resorts. Two scientists, Chris Bretherton, and Philip Mote, gave their opinion on climate change in Washington state. Jon Pretty, John Gifford, Bob Black, John Kircher, and Kevin Mc Carty gave some inside information about their resorts. While Scott Kaden, the manager of the Pacific Northwest Ski Association, gave further information about the activities of his organization. It was sometimes difficult to contact these persons because the thesis is written in the spring quarter. This means that some managers where 'gone fishing', while others were difficult to reach because some managers have an other office after the ski season. The general opinion is however that ski resorts are concerned about the occurring climate change and that they are certainly concerned about the future projections.

4.1 Impacts of climate change for ski resorts in Washington state, USA

It is a real challenge to predict the exact impacts of climate change on ski resorts in Washington state. Bretherton (2007) says: *"the ski industry is all about there being enough snow, but estimating the total snow in a mountain range at a given time is difficult. Precipitation varies enormously with altitude, aspect, slope, and local winds interacting with vegetation and terrain cover can cause snow drifts, bare spots, and other features"*. Mount Baker, for example, often has an Eastern wind which brings cold air into the area. That is the reason why Mount Baker has no complaints about the amount of snowfall in the ski season (Bretherton, 2007). During the winter period melting events may remove snow pack, this because of streaming from the top or because of absorption in the soil. The most important measurement for snow pack is therefore the snow water equivalent (SWE). It is the amount of water contained within the snow pack. It can be thought of as the depth of water that would theoretically result if you melted the entire snow pack in one moment. Think about a swimming pool which is filled with 100 centimeters of new powdery snow at 10% snow water density. If you could turn all the snow into water (magically), you would be left with a pool of water 10 centimeters deep. In this case, the SWE of your snow pack would be 100 x 0.10 = 10 centimeters. The SWE is able to give a more precise measurement for scientist and researchers (Mote et al, 2007).

Most snow that falls in the Cascade Range tends to be higher density snow. In the Cascades, snow pack densities are around 20-30% in the winter to 30-50% in the spring. However, east of the Cascade Range, the snow pack density is much less. Typical values are 10-20% in the winter and 20-40% in the spring. Of course you could also measure the snow depth in a particular place at a certain moment. This is an old fashion method but still helpful to managers of ski resorts. The SWE is scientifically more justified though, and in the end also more helpful to managers of ski resorts. They could better predict the chances of snow drifts, bare spots, and other features then (NRCS, 2007).

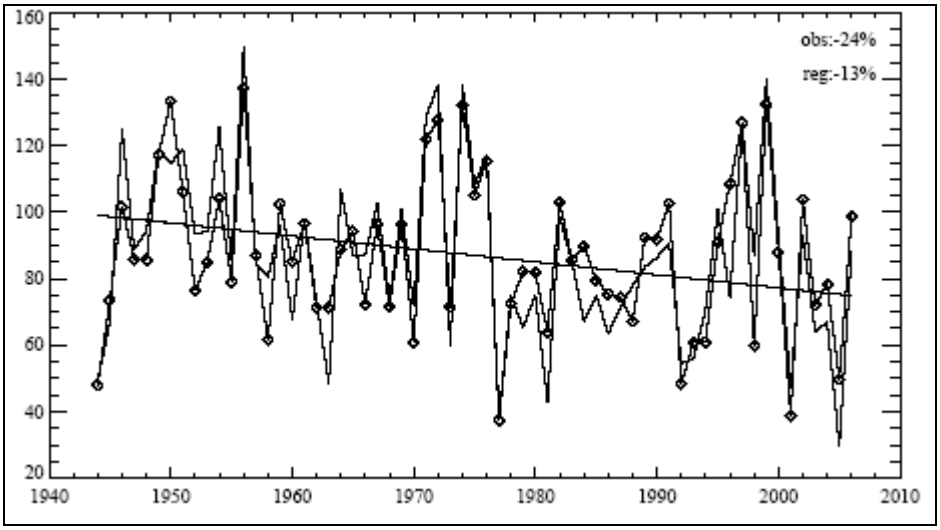


Figure 4.1: Development of SWE on April 1 from 1944 to 2006. On the vertical axis the SWE in cm, and on the horizontal axis the time period (Mote et al. 2007)

Mote et al (2007) made the upper graph after comparing the SWE of 26 "snow courses" in the Washington Cascades. They conclude a decline of 24% in the observed measurements and a 13% decline after a regression model. The decline is for a large extent caused by increasing temperatures because the amount of precipitation has increased a little bit in the period 1944/2006. This means that precipitation falls more often in the form of rain rather than snow. The April 1 SWE (showed in figure 4.1) has the greatest decline of all SWE measurements which indicates that snow pack is decreased the most in the spring. Ski resorts have to take into account that the ski season could be shortened. The revenues could be significantly lower. Chapter 2.2 already talked about the fact that if warm weather shortens ski seasons by a few weeks it could quickly make profitable resorts fall below marginal break-even season length requirements. Most of Washington's ski resorts have an open closing date for the season, it just depends on the amount of snow and visitors. In season 2005/2006 there was still enough snow to stay open after April 15, but the visitors flow was very low so they shut the facilities. The other way around has occurred more often, that ski resorts had to close earlier because a lack of snow (Pretty, 2007).

The best estimates of snow pack in the Washington Cascade Range indicate a substantial (roughly 15-35%) decline from 1944 to 2006. At lower elevations there is a larger decline than in higher elevations (Mote et al, 2007). The downward trend in overall snow pack is consistent with the observed warming. Even a conservative estimate (0,3°C per decade) of the likely warming rate for the Washington Cascades in the winter would by 2100 move the 0°C isotherm where the 3°C isotherm now lies (Leung et al. 2004) . Mote (2006) says that: "*most of the Westernmost mountains would be in the transient snow zone, in which snow accumulates and melts repeatedly during the snow season*". In other words, the more it warms, the more the warming will affect snow pack even at higher elevations. The decline in snowfall in the Northwest has been the largest in the Western United States, and it is clearly related to temperature (Mote, 2006). Although there is still little certainty that rising temperatures are caused by human interactions, climate change is happening at this very moment in Washington. Bretherton (2007) says: "*Everyone, not only ski resorts, have to react adaptive even when we don't know what the reasons for the rising temperatures exactly are*".

An other alarming development is the melting of glaciers. A study of the national environmental group recently reported that the North Cascades and Mount Rainier are among the dozen national parks most vulnerable to climate change (Blumenthal, 2006). The Mount Rainier glaciers area shrank by more than a fifth from 1913 to 1994, and the volume shrank by more than a fourth. The North Cascades and the Olympic mountains even saw their volume shrink by respectively 40 and 33 percent. Glaciers are affected by two climatic conditions: snowfall, which causes an addition of the mass during the winter, and warmer temperatures, which accelerate the melting in the summer. Both situations have a negative impact on the volume of glaciers, snowfall is declining and temperatures are rising (Mote, 2006). Hall & Higham (2005) already emphasized in chapter 2.2 that: "*glacier melting is not only a severe loss of mountain aesthetic, but also a problem for glacier skiing in both summer and winter*". Although Washington does not have opportunities for glacier skiing in the summer, glacier melting could be a serious threat to ski resorts (Mote, 2007).

Figure 4.2: Melting glacier of the Mount Rainier (Peter Hofman, 2007)

The impacts are not the same for all resorts in Washington, Mote (2007) says that some resorts can even benefit from the climate change. Resorts like Crystal Mountain and Mount Baker in Western Washington could expect more visitors in the future because they encounter a huge amount of snowfall and are situated to relative nearby urban areas. Chapter 2 already discussed the differences in precipitation and temperatures between Western Washington and Eastern Washington. Eastern Washington has the problem that the amount of snowfall is not overwhelming, temperatures are on the other hand sufficient for a feasible ski industry. Temperatures in Western Washington increase more than in the East according to Mote (2006). So the Western and the Eastern ski resorts have two opposing problems according to climate change. The West has difficulties with raising temperatures while the East has problems with a lack of snowfall.

Leavenworth, Loop Loop, and Mission Ridge have the disadvantage that they are situated in the rain shadow of the Cascade Range. Those resorts have to deal with increasing temperatures and less precipitation, it is not inconceivable that the resorts encounter the most problems according to climate change. Mission Ridge is nevertheless a higher based resort, but Loop Loop and especially Leavenworth are the first resorts who could fall below marginal break-even points. This is not a big disaster from an economic viewpoint because Leavenworth is a non-profit organization while Loop Loop has very little visitors per year. A big blow could develop when a resort like Snoqualmie is not feasible anymore. This is Washington's most visited ski resort, but they have to pay attention to climate change. It's a lower based resort and they begin to feel the consequences. In the preface, the state of Washington (2006) already pointed out that snow sports areas accounting for over 40 percent of average visits to Washington ski areas during the past ten years are based at low elevations at which climate change impacts on snow cover are likely. Chapter 4.2 discusses the consequences (for lower based resorts especially) more thoroughly.

It is a risk for entrepreneurs to go into the ski business, that is the way is has been it and will always be. Every industry which is dependent on the weather is vulnerable for an economic mishap. According to Bretherton (2007) the ski industry is more vulnerable then ever because of climate change. People are waiting to purchase their season tickets, and they act on information from the internet about weather forecasting. Ski resorts think that is disappointing because they experience some very crowded days altered with very less crowded days. On the whole the resorts did not experience a decline of visitors. Bretherton (2007) predicts a very unstable situation for the ski resorts in the future, it is a challenge for resorts to react adaptive, otherwise the revenues certainly will fall down.

4.2 Opinions of ski resorts about climate change

Snoqualmie is the resort that is most concerned about the possible effects. This is not a big surprise because chapter 3 already showed that Snoqualmie is a low based ski resort with (nowadays) a huge amount of visitors. Jon Pretty (2007), the web and PR manager, says: *"I strongly believe that climate change has an impact, but I can't predict until how far"*. Snoqualmie is the closest situated ski resort to the Puget Sound area. It is not only close to the Seattle agglomeration, it is also sited along the Interstate 90 (I90), the freeway from Seattle all the way to Massachusetts. This makes the resort very interesting for visitors.

Figure 4.3: Lifts and trails at the Summit West (Snoqualmie), on the right side the Interstate 90 is entered (Summitatsnoqualmie, 2007)

Because Snoqualmie is probably the most vulnerable resort for climate change, Pretty (2007) says: *"We are not thinking about expansion and upgrading our facilities, I don't think that the business will quit within a few years, but the concern of climate change certainly obstructs the resort to expand"*. While the hinterland of Snoqualmie is big enough to make a further growth.

Snoqualmie did put all the different resorts together in 1997, so everything is comprised since then and it is owned by Booth Creek (the fourth largest ski resort company in the United States). The resort comprises Hyak (now called Summit East), Ski Acres (now called Summit Central) Snoqualmie Summit (now called Summit West), Alpental, the Nordic Center, and the Snowflake Tubing Center (now called The Summit Tubing Center). Since purchasing the ski area, Booth Creek has invested more than $24 million in capital improvements as part of its Master Plan. So Snoqualmie is concerned about the future but the extra investments and the fact that the resort is owned by a large company will keep the resort feasible for the (near) future.

An other resort very concerned about climate change is Leavenworth. This non-profit ski resort has the lowest elevation of all resorts in Washington. Black (2007), the manager of Ski Leavenworth thought the resort was an ending story. After 4 straight years of almost no operations (from 2001 to 2005) the organization was thinking about quitting the facilities. The revenues to stay in business were very little and people moved to resorts with more snow security. But the last 2 years the resorts had tons of snow and Leavenworth has revived as never before. With the revenues of those years, the organization is able to continue operations for a few years. Nevertheless Black (2007) says: "*I don't think that the resort will exist within 20 years*". Although the resort does not have a chairlift or long trails, it is an important social organization with possibilities for Nordic skiing, Alpine skiing (by a rope), Tubing, Ski jumping, and Snowshoeing. Little resorts like Leavenworth are important for the brand-awareness of the ski industry, when those resorts disappear the industry as a whole could be affected too (Hall & Higham, 2005).

Stevens Pass, a resort owned by Harbor properties, is concerned about climate change too. John Gifford (2007), the general manager, says*: " everyone has to work harder to get the same amount of visitors. Most of the time ski season is from Thanksgiving to Easter, but the last decade Stevens Pass experienced huge fluctuations. The closing date was often before Easter and within the season the resort had to close facilities sometimes because of a lack of snow"*. Stevens Pass is a resort just situated above the 0°C isotherm says Gifford (2007), a small overall warming could shift the isotherm further uphill. The last years Stevens Pass has improved the lifts in the area, because they want at least the same amount of visitors in a relative shorter time period. So Stevens Pass did not want to expand the amount of lifts, they choose to upgrade to current lifts.

Mc Carty (2007), the general manager of White Pass, has an opposite view compared to the other resort managers. While other managers and scientists think that snow pack is decreasing, Mc Carty says: "*White Passes snow pack is constant over the last decade. Overall they did not have a decline in the amount of snowfall"*. Chapter 2 already showed that the climate is facing more fluctuations, and extremes. Mc Carty rebuts that, he just thinks that there are less extremes in our climate. "*At least White Pass did not have extremely cold periods the last decade"*, he said. This could mean that he is unintentional aware of the rising temperatures, and that the weather is changing though.

Crystal Mountain is probably the least vulnerable to climate change, they have the highest based resort and the most ski able acres of all resorts in Washington State. John Kircher (2007), the general manager of Crystal Mountain says: "*we even expect a further increase of visitors. Because other resorts have to deal with tough situations, we expect that visitors who used to go to lower based resorts are now going to Crystal Mountain. We certainly feel the consequences of climate change"*. Temperatures in Crystal Mountain are rising too, but they face more advantages than disadvantages because of climate change. Black (2007), the manager of Leavenworth ski hill, also refers to the fact that his visitors go to resorts like Crystal Mountain if they do not have sufficient snow. The average visitors number is only half of Snoqualmie's visitors number. Crystal Mountain is trying to catch up with resorts like Snoqualmie, in the season 2004/2005 the resort had the record of 430.000 visitors. But this is still 80.000 visitors below the 5 year average of Snoqualmie. Crystal Mountain tries to catch up by building the new Northway double-chairlift which

would add 1000 acres of new serviced terrain. The lift is able to serve 1200 visitors per our, it has an vertical elevation of 570 meters, and it will cost 2,5 million dollars. The 2007/2008 season will start with the opening of this new chairlift, John Kircher (2007) says: "*we will be the biggest resort in view of ski able acres and in view of annual visitors within a few years*".

Figure 4.4: Building the new 'Northway' double chairlift in Crystal Mountain (Skicrystal, 2007)

The resorts are certainly afraid about the weather projections in the future. Climate change has become part of their business nowadays. The managers, except Mc Carty of White Pass, refer to the fact that temperatures are rising and snow pack is decreasing. "*Leavenworth is the most vulnerable to climate change*", says Black (2007). It is remarkable that all the managers exactly know what climate change is, and how it could affect the ski industry. They read a lot in newspapers and journals about it, scientists do certainly have an impact on their opinion. The managers do often cooperate in research programs (Pretty, 2007). Stevens Pass and Snoqualmie had become a case study area for several research programs about climate change. Mote et al. (2007) did a research in cooperation with the Climate Impacts Group of the University of Washington in Seattle about climate change in the Cascade Range. Snoqualmie, Stevens Pass, Mount Baker and Mission Ridge are part of their case study. Opposing to scientists, public officials do not have the manager's faith. Gifford (2007) even says: "*public officials are stupid, those people are not capable enough to deal with this situation*". According to Gifford climate change is a serious threat that has to be solved on a global level. Public officials, and politicians too, have to take this as a serious problem and react on it accurately. This is a shared opinion of the managers of the resorts.

Chapter 4 showed that snow pack densities in the Cascades are around 20-30% in the winter to 30-50% in the spring. Kircher (2007) says: "*this could be a problem in view of ski pleasure. Crystal Mountain is blessed with enough snow fall, but the quality of that snow is declining. Especially in the spring, snow pack density is rising which means that it becomes diluted. Every visitor wants to experience fresh powdery snow but the last decade those circumstances did not occur very often*". Crystal Mountain is lucky though, that it is a higher based resort which increase the chances

of powdery snow. Pretty thinks that other resorts like Snoqualmie maybe have fresh powdery snow a couple of days a year. All those other days the snow in Snoqualmie is of a watery matter.

Although the managers are aware of climate change, they all do not think that the ski industry will quit. Except for Leavenworth every resort had the opportunity to recreate each year. The resorts did not encounter huge impacts of climate change already, so the measures are still tiny. There is little to do too, resorts just have to wait what the future will bring. In their business plans managers take into account the impacts of climate change. Expansions have to be well considered before the execution, visitors are more conservative with purchasing season tickets, and options like instant snow have to be well considered too. The managers are completely dependent on the ski industry so they have to deal with the situation very carefully. Chapter 5 will discuss the future projections and the solutions more further.

5 Future projections for ski resorts

"There is no doubt that the ski industry will still exist within a time period of 50 years", says Bretherton (2007). Chapter 4 showed that the climate in the (near) future could change in such a way that it is risky for ski resorts. The industry has to react adaptive on climate change, a decline in visitors and revenues could be the result. Bitpipe (2007) give an all embracing definition of enterprises who have to react adaptive on the environment. They say: "*An adaptive enterprise (or adaptive organization) is an organization in which the goods or services demand and supply are matched and synchronized at all times. Such an organization optimizes the use of its resources (including its information technology resources), always using only those it needs and paying only for what it uses, yet ensuring that the supply is adequate to meet demand"*. Ski resorts have to deal with the opportunities mother nature gives them. It is important to use the opportunities of mother nature carefully to obtain a sustainable ski industry. Workers are dependent on the ski industry, a decline in revenues could cause dismissals. Stevens Pass, to illustrate, has 950 employees working seasonal and 50 employees working year round (Gifford, 2007). A (further) decline in visitors could cause a big stir, that is why almost every manager is thinking about other ways to earn at least the same amount of money. Figure 5.1 shows different options for ski resorts to adapt on climate change. Elsasser and Burki (2002) made a distinction between maintaining the ski industry, subsidies to stay in business, fatalism, and alternatives to skiing.

To start with maintaining the ski industry. Artificial snow is one option to solve the lack of snow in Eastern Washington resorts and resorts situated in the rain shadow of the Cascade Range. Figure 2.5 already made clear that snow making requires a minimum temperature between minus 3 and minus 15°C. Temperatures in the Eastern part of Washington are lower (overall) so it could be helpful for ski resorts over there. To make snow on such a large scale could seriously damage the climate. The water used for the snow is typically taken from surface streams, artificial reservoirs and ground reserves. In the Alps, artificial snow is already used on 30 percent of all slopes. All the water needed to make instant snow for one season in the Alps, is the same amount used by a city of 1,5 million inhabitants in a year (Demetriou, 2007). Bretherton (2007) says that resorts in Washington have to deal with the same tough situation. Snoqualmie, Mission Ridge, Crystal Mountain, White Pass, Mount Baker, Mount Spokane, and 49 degrees North do have acres served by artificial snow making machines. Those resorts are thinking about expansion of the ski able acres too, but the lack of water is a limit. And also public officials are working against. Besides that, the quality of the snow is not the same as powdery snow, the SWE is very high. Bretherton (2007) thinks that man made snow in unsuitable in the Washington Cascades because of the warm weather. Eastern winds bring cold air into Washington Cascades, but this wind is very strong and so limit the opportunity to make instant snow. The machines can not operate in strong winds, and when the wind is calm they encounter higher temperatures (above minus 3°C). He is more positive about the resorts in Eastern Washington (49 degrees North, and Mount Spokane) because temperatures are much lower and water better available. Mote (2007) refer to the fact that Washington ski resorts are not big enough to make artificial snow economic feasible. Artificial snow making is very expensive while the amount of visitors is not sufficient to bring in enough money. Compared to resorts like Aspen, Colorado (3 million visitors a year) Washington ski resorts do not have enough revenues to create a great artificial snow making network.

An other maintaining option is to develop higher terrain, the higher the elevation the lower temperatures usually are. Chapter 4 already showed that Leavenworth, for example, thinks that it will shut operations within 20 years because of the low elevation. Crystal Mountain has the advantage of higher elevated slopes, when the new chairlift has opened the resort has the availability of 1000 acres of higher elevated slopes. It is difficult to achieve such expansions like Crystal Mountain. Firstly because Washington's mountains do not reach enormous altitudes, secondly because the resorts do not have enough visitors to expand spectacular, and thirdly because public officials are working against. Especially the US Forest Service is an important player in a Master plan process (Bretherton, 2007). Most resorts have a good relationship with the US Forest Service, which is part of the United States Department of Agriculture (USDA) by the way. Pretty (2007) says that Snoqualmie does not have a good relationship with the US Forest Service. According to Pretty, the US Forest Service is not very positive about Snoqualmie. Expansions are forbidden because the US Forest Service thinks that the amount of visitors will fall down in the future.

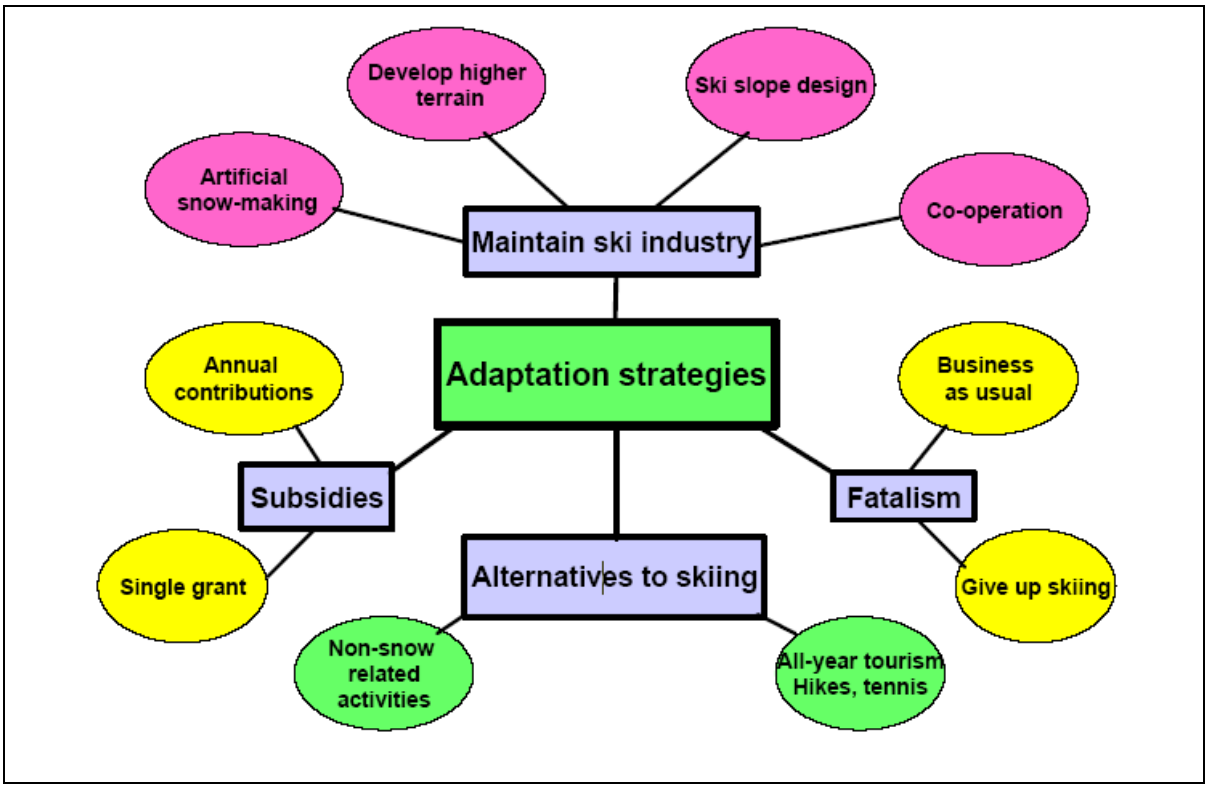


Figure 5.1: Adaptation strategies for ski resorts (Elsasser and Burki, 2002)

Changing the design of ski slopes could be helpful too. When you create slopes with very less differences in altitude, you reduce the changes of snow drifts and bare spots. This could result in a loss of expert trails but in the end you have more chances to keep running operations (Elsasser & Burki, 2002). Stevens Pass is working on this kind of options, they changed free run slopes into prepared (designed) slopes just to have more ski options. When one slope is in a bad condition, other slopes can be used to keep up revenues (Gifford, 2007).

Snoqualmie takes the lead in the co-operation process, the fourth option of maintaining strategies. Chapter 4 talked about the annexation of the different ski

areas of Snoqualmie. Booth Creek, the owner of Snoqualmie, decided that people have more job security when the resorts are under one name. It is often the case that not all different areas are open at the same time. Snoqualmie runs facilities in the area that is most feasible at that particular time. When circumstances in one area have worsened, an other area can exploit their facilities better. So they change operation days to keep revenues all the time. The employees have more job security, and the visitors are ensured that skiing is (somewhere) possible. To face climate change resorts have to work more frequently together, according to Elsasser and Burki (2002).

The second adaptation strategy is subsidies, with annual or single grant subsidies you can prevent the resorts from going bankrupt. Elsasser and Burki (2002) do not think this is a long term solution. You do not really adapt to climate change, you just postpone the consequences. Subsidies could be helpful for a resort like Leavenworth, with revenues of subsidies they can continue operations. Subsidies can give Leavenworth a more secure future, but with subsidies alone you can not face climate change (Black, 2007).

Fatalism is the third adaptation strategy, actually it is not real a strategy to face climate change. You just do not want to fight climate change. So the options are business as usual or give up skiing. Mission Ridge is an example of fatalism, they do not fight (thanks to the US Forest Service) climate change. The resort continues business as usual but it could be fatal in the end. Mission Ridge have to search for other ways of income, the amount of visitors is declining (Bretherton, 2007). Mission Ridge wants to improve the infrastructure to the resort, but the US Forest Service does not think that is desired. Highway 2, the road connecting Wenatchee with Mission Ridge, is very small and frequently closed because of snowfall. The local government and the US Forest Service are not willingly to co-operate and solve these problems. The road can not be broadened according to the US Forest Service because trees have to be cut down, and the local government can not use better technical snow clearing equipment because the road is too small (Mote, 2007). All this makes skiing very vulnerable in the future for Mission Ridge.

The last adaptation strategy is generally helpful to all ski resorts. Finding alternatives for winter recreation is dependent on the demand of visitors. Stevens Pass and Crystal Mountain have tried to develop four season recreation activities. Crystal Mountain tried to start a mountain biking trail system, but the interest was very low. Closing such activities was indispensable. Stevens Pass also tried to start mountain biking, hiking, and other summer activities but they faced the same problems as Crystal Mountain. The resorts in Washington have the overall ‘problem’ that they do not have much lodging opportunities. People spend more in a resort when they stay there for longer than one day. The target group for resorts in Washington is inhabitants of Washington, Oregon, and Idaho. It is difficult to earn a lot of money from this target group, especially when you note that Washington has 6,4 million inhabitants. Those people do not want to stay the night and go home after a day skiing. Snoqualmie has some lodging opportunities but only 2 percent stays the night, according to Pretty (2007). Maybe the resorts in Washington can focus on more lodging opportunities to attract people outside Washington (and Oregon, and Idaho). But the next paragraph will discuss more solutions, also in view of marketing.

An opportunity not mentioned in figure 5.1 is night skiing, Gifford (2007) says that Stevens Pass already has 400 acres of night skiing. They have the most ski able acres for night skiing in Washington state. Gifford thinks to get more revenues in a relatively shorter time period because of night skiing. Kaden (2007) also talks about the more efficient use of ski able acres because of night skiing. He says that you have the advantage of people having spare time in the evening, temperatures are lower (so snow making is more feasible), and circumstances are more snugly.

The population projections for the Puget Sound region are very positive, the PSRC (2005) give a projection of 990.000 new residents in 2025. The majority of new growth (58 percent) is targeted to cities. Compared to the contemporary 3,8 million inhabitants this is an increase of 26 percent. Because most visitors to Washington's ski resorts come from the Puget Sound region, the resorts (especially those near the urban area) could expect a further increase in visitors. The resorts have to be aware of this. (Kaden, 2007) thinks that the resorts can compensate climate change at least till mid twenty-first century because of the population growth in the Puget Sound region.

An other way to compensate the shorter ski seasons is to change price policies. When a resort encounters fewer ski able days in a season, it seems indispensable that prices will rise. Figure 3.1 already showed that most revenues are earned from tickets and seasonal passes. Resorts could increase prices of tickets and seasonal passes, but you do not know on forehand that this will increase your revenues. Mc Carty (2007) intends to raise prices in White Pass, although he does not know what the exact consequences will be. He thinks that visitors will pay more to ski just because the suppliers of ski services will decrease in the rest of the state. Kaden (2007) says that there has been little research on price policies to combat climate change. The PNSA will certainly study the opportunities for a researches like this, says Kaden.

The resorts have taken measures to face climate change already. Kaden (2007) says that all the resorts cooperate together in the PNSA, the Pacific Northwest Ski Association, to conquer climate change. They started a public transportation system to transport visitors from the urban areas to resorts like Snoqualmie, Crystal Mountain, Mount Baker, and Stevens Pass. The goal is to reduce greenhouse gasses and to reduce traffic problems. Crystal Mountain did start a shuttle service from the parking lot to the resort by some kind of tractor tram. The resort has finally solved the parking problems. The resorts are aware of the dangers of too much energy use. That is why most resorts started to use green energy like wind- and water powers. Kaden (2007) says that resorts want to be a good example to visitors. They hope that visitors will also reduce the expelling of greenhouse gasses. Besides those measures the resorts started a recycling system whereby waste will be separated. Every week a special truck will collect the waste separately. This is a little break through for Washington state, companies do not recycle on such a large scale ski resorts do.

6 Marketing strategies to conquer climate change

The previous chapters made clear that climate change is certainly a thing to take into account working in the ski industry. Chapter 5 showed a couple of adaptation strategies in view of climate change. This paragraph is about possible solutions, in view of marketing, to solve climate change issues. Resorts can keep at least the same flow of tourists when they use a solid marketing strategy. This is to a large extent based on the population projections of the Puget Sound region. According to Kaden (2007) the resorts could exploit the fact that the number of inhabitants is growing. A good marketing strategy is therefore essential.

The goal of (place) marketing is to create long term incentives for social and economic functions and activities. You have to try to fit the images and facts, which specific target groups have about your resort (Voogd and Ashworth, 1987). It is important to be honest about the resort characteristics, the created image has to correspond with the reality. So in the case of Snoqualmie, they do not have to hush up the fact that they are a lower based resort and therefore more vulnerable to climate change. And Leavenworth has to be honest with the fact that they will probably close first because of a lack of snow. All the resorts have to emphasize its strong points. Each resort certainly has its strong points to emphasize. Table 6.1 shows the strong and weak points of the different resorts.

Resort	Strengths	Weaknesses
49 Degrees North	- summer activities - 68 trails - great Nordic Skiing network - low prices season pass	- lack of water to produce instant snow - no snowboard opportunities
Bluewood	- much chairlifts for a small resort - ideal to beginners	- out of the way location - few possibilities to expand
Crystal Mountain	- Good parking possibilities - Highest based resort of all - Most ski able acres - Lifts in good shape - Good Nordic skiing possibilities	- access route often closed - quality of snow sometimes watery - lifts closed in times of some bad weather circumstances
Hurricane Ridge	- unique situation in Olympic National Park - fantastic views - lots of sponsors to keep running the resort	- a lot of road closures - long ride from urban areas - actually only one trail - bad snow quality
Leavenworth	- economically totally independent - large tubing park - promoting better health and fitness	- few visitors - Sited in rain shadow Cascade Range
Loop Loop	- family friendly - lodging opportunities - other activities like	- few visitors - sited in rain shadow Cascade Range

	mountain biking and hiking	
Mission Ridge	- cheap tickets - other activities like conferences, wedding, etc. - forerunner in anti climate change activities	- Bad relationship with US Forest Service - Infrastructure problems - Sited in rain shadow Cascade Range
Mount Baker	- Most snowfall of all resorts - Relative near (North) Puget Sound Region - Lots of young visitors (halfpipe, freestyle park) - A lot of lodging opportunities	- lifts not in perfect shape - high prices tickets - few opportunities for family based recreation
Mount Spokane	- non profit organisation - near Spokane, city of 88.280 inhabitants - low season pass prices - 45 trails - Low temperatures - Just opened new chairlift	- difficulties with water supply for snow making - few lodging opportunities
Snoqualmie	- lots of visitors - near interstate 90 (Puget Sound) - combined areas with different characteristics - great night skiing opportunities	- Lower based - Only 2% stays the night - Bad relationship with US Forest Service
Stevens Pass	- Most ski able night skiing acres - Easy accessible from Puget Sound region - Lots of volunteers	- Sited just above the 0°C isotherm - Infrastructure problems in busy weekends
White Pass	- family based - high based elevation - large cross country network	- few opportunities to expand - reachableness dependent on conditions Chinook Pass

Table 6.1: Overview of strengths and weaknesses of ski resorts in Washington state, Skiwashington, 2007

So every resort is unique and so competent to make an own marketing strategy. To achieve a good marketing plan, it is important to engage all the facets of the resort to create a situation that fits best with your goals. Voogd and Ashworth (1987) talk about the 'geographical marketing mix', which consists of the so called PSOF measures to achieve your marketing goal. It stands for Promotional measures, Spatial-Functional measures, Organisational measures, and Financial measures. Every element is important creating the right image to the resort. Promotion only to sell more tickets is by far not enough (Voogd and Ashworth, 1987).

So resorts have to emphasize its strong points, but at the same time they have to work on the weak points. This all in close interaction with every one working at the resort. You have to create a clear image to the outside world, that is only possible when everybody exactly knows what the intentions are. This research would be too complicated to write out a marketing strategy for every resort separately. That is why the next subsection will discuss some points of interest for all resorts.

The marketing strategy should be honest about situations concerning the resorts. You can not announce that your resort is not vulnerable to climate change, everyone is dependent on there being sufficient snow. And as everyone knows the weather is not predictable. But the marketing plan should certainly add the measurements you have made to conquer climate change. Visitors want to hear that the resort is served with instant snow machines, or at least that resorts help to reduce greenhouse gasses. Most resorts work with some kind of measurements to face climate change. You could create a 'green' image when you stimulate visitors to carpool or to use public transportation.

To keep revenues, resorts in Washington could use marketing to attract more visitors from outside the state. But to attract outside visitors resorts first have to build more lodging opportunities. Lodging is a weak point to all resorts in the state, it would not be a problem when you want day users to be the target group. Resorts like Crystal Mountain and 49 degrees North are certainly big enough to stay longer than one day. 49 degrees North has the advantage to be situated near Idaho and Spokane. A combination of visiting Spokane and staying a few days in 49 degrees North could add some extra visitors. Kircher (2007) says: "*Crystal Mountain is working together with the city council of Seattle to start a combination trip Seattle/Crystal Mountain*". Visitors could stay 3 days in Seattle and then travel by public transport to Crystal Mountain for a 3 day skiing trip for example. More resorts close to the Puget Sound region could think of a combination like that. People could always decide to stay in Seattle when the weather circumstances obstruct the opportunities to ski. Visitors will not be very disappointed when you create some extra activities in periods of closings. Maybe you can offer a trip to an other resort when one resort is closed. A closer collaboration between resorts in the Western Cascade Range could make those intentions more feasible.

Improving lifts is also a development every resort should be thinking of. Improved lifts could be more efficient (more transported people per hour). You could transport more visitors, and in view of shortened seasons such improvement help to keep revenues. Next to the fact that visitors would appreciate a quick shrunk of the row, waiting for the lifts. 49 degrees North just opened a new chairlift, Crystal Mountain will do this in 2008, and other resorts are thinking of installations like these resorts. Stevens Pass replaced some lifts a couple of years ago, the visitors increased after this development, although the ski able acres declined. It makes clear that such developments work more cost efficient.

The resorts have to improve the infrastructure too, situations like Mission Ridge (see chapter 5) are not necessary. Many resorts complain about the fact that they are dependent to the state government in view of infrastructure improvements. Hurricane Ridge is an example of a resort often closed because of bad road conditions. Because they are a small resort, the consequences are not enormous, but to a resort like Stevens Pass a road closure or traffic jams could cause a big stir in view of income.

You can use good infrastructure accessibility as a marketing strategy, Snoqualmie is already advertising with its location next to the Interstate 90. The most important reason why Snoqualmie encounters the most visitors of all resorts is because of its location, says Kaden (2007). Other resorts have better ski facilities, have more ski able acres, better snow, more lodging opportunities, and more night skiing acres but Snoqualmie still have the most visitors per year. When seasons become shorter, it is important to welcome all the possible visitors without infrastructure problems. Otherwise people go to an other resort next time.

Gifford (2007) says that all resorts work with an all embracing marketing campaign too. The 12 resorts in table 6.1 are working together with resorts in Oregon and Idaho in the Pacific Northwest Ski Association (PNSA), with the main purpose to create an overall marketing campaign. The region does not have a winter recreation image like Colorado or Utah, says Kaden (2007). The organization is trying to improve this image, mainly through marketing. They try to bring in some huge skiing events for example. Besides that, the organization lobbies for extra federal money to improve ski infrastructure. The resorts independently do have faith in the job PNSA is doing, according to Pretty (2007). It is important to resorts to not forget guiding a marketing strategy by themselves. The PNSA could bring in some extra visitors from outside the state, but you have to convince visitors to visit your resort in contradiction to other resorts. Creating more lodging opportunities seems important to satisfy those visitors.

To finish, resorts have to emphasize its strong points (described in table 6.1), this all in a strategy that is based on the famous 4 marketing “p’s”. Namely product, price, promotion, and place (Gold and Ward, 1994). Resorts have to work on a decent product, they have to price sharply, promote right, and emphasize that their place is the best. Climate change is an issue to deal with carefully, you have to create the image that you are working on climate change. Maybe not only to create a ‘green’ image, but maybe to help the environment too. Although it is not fur sure climate change is caused by humans at all.

7 Conclusions

The research goal was to identify the exact effects of climate change on the snow sport business, taking in consideration spatial variations in effects. The thesis showed that there are a lot of important factors in view of climate change. The climate can change due to natural or human interactions. The fact is that temperatures are rising on earth, and this has an impact on ski resorts in the state of Washington. It has a negative impact on the amount of visitors, the brand awareness, lodging revenues and major events. Some higher based resorts can expect more visitors because they have more snow security. Lower based resorts and resorts situated in the rain shadow of the Cascade Range are most vulnerable. People are waiting to purchase their season tickets, and they act on information from the internet about weather forecasting. All the resorts are concerned about climate change, but the solutions are difficult to find. Resorts could think of snow making, developing of higher terrain, cooperation, change of ski slope design, subsidies, fatalism, or alternatives to skiing. Resorts refer to opportunities like night skiing, and price policies by themselves.
A right marketing strategy, with a focus at more lodging opportunities, could certainly help the resorts to conquer climate change too. The resorts have to keep in mind that the strategy inhauls the PSOF measures, named in chapter 6.

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Interviews

- Mr. Scott Kaden, general manager of the Pacific Northwest Ski Association (PNSA), Hood River, Oregon
- Mr. Chris Bretherton, researcher at the Atmospheric Science Department of the University of Washington, Seattle
- Mr. Philip Mote, State Climatologist JISAO/SMA Climate Impacts Group at the University of Washington, Seattle
- Mr. Kevin Mc Carty, general manager of White Pass, Washington
- Mr. Jon Pretty, web and PR manager of Snoqualmie, Washington
- Mr. John Gifford, general manager of Stevens Pass, Washington
- Mr. Bob Black, manager of Leavenworth ski hill, Washington
- Mr. John Kircher, general manager Crystal Mountain, Washington
- Mr. Jack Peterson, member of the ski patrol in Crystal Mountain, Washington