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The adaptation of European Alpine tourism to climate change

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<p>The changing environment poses challenges for the tourism industry in the Alps. Especially winter sports tourism is under threat due to the expected declination of snow conditions. The present thesis examines relevant literature to form an understanding of expected future climatic conditions, how the conditions effect the Alpine environment and thus the operating environment for Alpine tourism, and of the adaptation measures suggested by the literature. Using the Austrian state of Vorarlberg as an example region, the thesis estimates and highlights the potential effects of the implementation of a sustainable and a non-sustainable set of adaptation strategies by the relevant tourism actors. It can be estimated that the implementation of technological adaptation strategies to support the viability of ski areas should only be considered in regions that are snow-reliable currently and in the future to avoid misplaced investments. The climatic conditions of the summer season will improve in the Alps and the region should focus on touristic offers that are sustainable in the long term and that can benefit from the existing infrastructure in the region. Adaptation measures can be estimated to be the most viable when based on the existing strengths of a region.</p>	
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1 Introduction

The climate change is a fact proven by scientists the world over. In the 25-year period leading to 2007, the annual mean temperature in the European Alps increased by 1.2 °C – a rate of increase unprecedented in a 250-year instrumental period (EEA, 2009). The period of 1983-2012 was likely the warmest 30-year period of the last 1400 years, and each of the years 2014-2016 has consecutively been the warmest on record (IPCC, 2013; WMO, 2017). The European Environment Agency (EEA) (2009) predicts an increase in the annual mean temperature in Europe of 3.3 °C to occur by the end of the 21st century, and expects the increase to be 3.9 °C in the Alps and a higher-yet 4.2 °C in Alpine areas above 1500 m of elevation. Precipitation patterns are also projected to change, namely to decrease in Southern Europe and in the South of the Alps, and to increase in parts of Northern Europe and in the North of the Alps. Summer time precipitation is predicted to decrease, while precipitation during the winter is expected to increase. Under the warmer ambient temperatures however, an increasing share of the increased winter precipitation will fall as rain instead of snow in the Alps (OECD, 2007; EEA, 2009; Gobiet *et al.*, 2013). Water run-off from melting snow and glaciers will peak in the winter instead of spring under future conditions, and the overall run-off will decline, meaning decreasing water resources for a large part of Europe (EEA, 2009).

The changing environment poses challenges for the tourism industry in the Alps. Especially winter sports tourism is under threat due to the declination of the snow conditions. AlpNet (2016) considers winter tourism to be of existential importance for the economically and socially sustainable development of Alpine tourism, and notes that at least two thirds of tourism income occurs in the winter for many regions in Austria and Switzerland. To avoid the declination of the economic development of the Alpine region, adaptation measures will need to be implemented. Adaptation strategies are split into technological and behavioral adaptation measures (OECD, 2007). Technological adaptation strategies to support winter tourism have been the preferred choice of tourism managers, but there are signs of an increasing understanding among stakeholders about the increasing importance of summer tourism (Pütz *et al.*, 2011).

The topic of this thesis is *the adaptation of European Alpine tourism to climate change*. An extensive review of literature in the fields of climate change in the Alps and adaptation strategies has been conducted to form an understanding of the status of the adap-

tation efforts. The literature was found to document changes in the climate extensively and to present a range of adaptation strategies. However, the literature was found to lack an estimation of the consequences of implementing a particular set of adaptation strategies. To contribute to the literature, this paper forms two estimations of the consequences of different adaptation strategies in the Austrian state of Vorarlberg. The adaptation strategies in the estimations have been included based on their ability to consider the effects of the climate change on the natural and economic environment, the location of the region, the dependency of the region on tourism, and the type of tourism the region is dependent on.

The aim of the thesis is to facilitate the critical assessment of the currently known adaptation strategies, and to encourage the active evaluation of the long-term viability of a particular adaptation strategy. Maladaptation, or action taken to reduce vulnerability against the climate change while impacting adversely on other systems (ESPON, 2011a), is a serious risk in the Alpine region and should be eliminated to the best possible extent. Maladaptation risks wasting time and resources that could have been spent in building genuine climate resilience and the long-term sustainability of the touristic offer of a region.

This paper will provide a literature review of the relevant material in the second chapter, followed in the third by the conceptual model that explains the evaluation of the value of adaptive strategies. The fourth chapter on the methodology explains the data gathering process and the aims of the thesis. The fifth chapter presents findings about the climate change, the effects it poses, the current state of tourism in the Alps, and the adaptation measures suggested by the literature, while the sixth chapter contains an estimation of the consequences of two different sets of adaptation strategies in the Austrian state of Vorarlberg. Chapter seven concludes the thesis with an overview of the main findings.

2 Literature review

2.1 Research issue

This thesis is a study about the effects of the climate change on Alpine tourism in Europe. More specifically it will focus on the Alps located in Central Europe. Seven countries share the area of the Alps and include Austria, France, Germany, Italy, Liechtenstein, Slovenia and Switzerland. Of those seven countries Austria, France, Italy and Switzerland will be the primary focus areas due to the varied and highly important tourism sectors active in the Alpine regions of said countries, while Germany, Liechtenstein and Slovenia may be mentioned but will not be the focus.

Climate change has long been a commonly accepted scientific fact with undeniable, yet uncertain, effects on tourism. The changes are interesting because they will alter the habitat of the Alps' 15 million inhabitants and the conditions for tourism Europe's second most popular destination after the Mediterranean coast (OECD, 2007; ESPON, 2011b; Davoudi *et al.*, 2012). Tourism accounts for an estimated 15 % of the labor market in the Alps, including both directly and indirectly linked jobs. However, the Alpine Convention (2013) states that "the economy of only 10 % of the municipalities, representing 8 % of the Alpine population, is based on tourism, and 46 % of the beds are concentrated in 5 % of the municipalities." The share of jobs provided in the region by the tourism sector is considerable, however, and the Organization for Economic Cooperation and Development (OECD) (2007) claims that tourism generates around EUR 50 billion annually, and enables the economic growth of some of the most rural areas. Furthermore, OECD states that 4.5 % of the Austrian GNP is generated by winter tourism alone, forming half of all tourism based income. More up-to-date figures suggest that tourism contributed 4.8 % directly and 13.5 % in total to the Austrian GDP in 2014 (WTTC, 2015).

Changes in the operating conditions of the tourism sector are inevitable and pose a direct threat to the livelihood of over 2 million people and the economic development of many regions. Many authors and resorts have started planning adaptation strategies, although most are focusing on trying to keep the winter tourism sector alive. The importance of non-snow related activities will become more and more important (OECD, 2007; Carraro *et al.*, 2008; Alpine Convention, 2013; AlpNet, 2015), yet the high share of income brought in by winter sports tourism likely cannot be substituted with other

offerings (OECD, 2007; Carraro *et al.*, 2008; Fehringer, 2014). The prevalent adaptation strategy for winter sport resorts currently is artificial snow-making and the technology continues to see important research and development funding to enable snow-making in ever warmer conditions in the future (The Economist, 2017). Artificial snow-making can be expected to rise in the near term as an adaptation strategy, but due to the technology's temperature limitations and consumption of energy and water, it is not expected to be a sustainable strategy (OECD, 2007; EEA, 2009; Rixen *et al.*, 2011; Fehringer, 2014; Kovats *et al.*, 2014).

The Alpine region needs sustainable adaptation models to counter the climate change's adverse effects on its economy. The sooner feasible adaptation strategies can be developed, the lesser the impact on the economic development of the region will be. Existing literature has suggested some concrete technological and behavioral adaptation strategies (OECD, 2007; Rixen *et al.*, 2011; Alpine Convention, 2013; Fehringer, 2014; Vanat, 2016), but does little to estimate the impacts and effects to tourism in the Alps under any specific chosen array of adaptation strategies. Thereby to contribute to the literature the thesis will describe the expected outcomes of two different implementations of adaptive measures, while the main research question of the thesis is, "what does the climate change mean for tourism in the Alps and how should the region adapt?"

2.2 Literature streams

The climate change and its effects on health, landscape, industry, tourism and most other sectors have been extensively studied by academics, experts from the different sectors, governmental institutions and non-governmental organizations (NGOs). The Intergovernmental Panel on Climate Change (IPCC), the Organization for Economic Cooperation and Development (OECD), the European Environment Agency (EEA), the Swiss Federal Institute for Forest, Snow and Landscape Research (WSL), the UN World Meteorological Organization (WMO), the Worldwide Fund for Nature (WWF), the organization of the seven Alpine countries and the EU, the Alpine Convention, and the European Spatial Planning Observation Network (ESPON), to list some organizational researchers, have looked at what the climate change will cause and how the effects will translate on to different sectors of the economy.

The literature examined for this thesis has been split into three literature streams: the first one on climate change data and information on what the climatic changes mean now and how will they affect tourism in the future; the second on the state of Alpine tourism now, which includes economic figures, current practices, and the overall importance of the sector; and the third one on adaptation literature, discussing more what is currently being done to adapt to the projected climatic changes and what is suggested for the future.

The first stream on climate change information presents what the literature knows of past, present and future climatic changes. The stream shows past weather patterns and climate projections for the Alpine region for the future, including changes in the temperature and precipitation levels. The effects on nature and thereby on infrastructure, population and the operating environment of the tourism sector are explained on the basis of climatic facts.

The stream on the state of Alpine tourism examines the current conditions of tourism in the Alps. The activities, seasons, locations and types of tourism are of interest here, as well as the income figures for different regions, the importance of tourism for different regions and the dependency of regional economies on tourism and its different types. This second stream establishes the importance of tourism for the Alps.

The third stream is about adaptation literature and presents what the literature currently suggests as both technological and behavioral adaptation practices. It presents what is currently being done to adapt to climatic changes and what the literature believes should be done to better prepare Alpine tourism for changes in the conditions it operates in.

All authors agree that the climate change is happening and that signs of it are being experienced already. In fact, authors almost unanimously agree on the projected changes in the climate and future temperature levels. Some variations are due mostly to newer, more developed climate models used by scientists, that can give higher resolution information of the Alpine weather, which is characterized by many micro-climates in the mountain valleys. Some differences of opinion exist about projected future precipitation levels, more precisely when and where will precipitation fall. Authors mostly agree on the factors affecting the nature, population and economy of the Alps to include more pronounced extreme weather events, less snow, increased flood risks,

changing water run-off cycles, increased land and rock instability, glacier melt, increased temperature and changing eco-systems.

The number of suggested technological adaptation strategies is limited, as is the expected sustainability of such measures. Most of the literature understands that artificial snow-making is being invested in and will be used as a technological adaptation measure in the near term, but most of the literature also does not support further investment in it, because increasing temperatures will only make an already water and energy-inefficient measure more so. Some authors show support to resorts increasing investment in artificial snow-making however, basing their arguments on mitigating the direct economic losses of losing tourists. Authors mostly agree on the currently known technological adaptation strategies only being feasible in the short term. Instead, support is shown for behavioral adaptation options to include national policy frameworks, improved education and access to information for decision-makers, tourists and the population, and broadening the touristic product on offer.

2.3 Overview of the literature

2.3.1 Climate change information

One of the older publications studied in this thesis, Abegg *et al.* (1997) discussed the effects of climate change on winter tourism in the Swiss Alps in their report *Impacts of Climate Change on Winter Tourism in the Swiss Alps*. The authors suggest that the snowline will go up in altitude by 300 m due to an expected 2 °C temperature increase by the middle of the 21st century, resulting in resorts at lower altitudes with worsened natural snow reliability to die out. The authors claim the result will be a threatened regionally balanced economic growth, elimination of small businesses essential to the diversity of the Swiss touristic offer, and increase stress on the ecosystems surrounding the still-snow reliable high alpine resorts.

Blackett (2016) agrees that the warming climate may displace lower altitude resorts in his text *Is climate change ruining skiing in the Alps?* He argues that 2014 was the warmest ever year on record in Europe with 2015 coming second, and 2007 being third. He accepts this as a sign of the climate warming and argues that artificial snow-making, that is using electronically operated snow-cannons to turn water into snow

during favorable, slightly below freezing temperature, was the method many resorts had to resort to in the face of the poor start to the 2016 season.

The International Commission for the Protection of the Alps (CIPRA) (2017) argues on their web page *Climate change: why the Alps are particularly affected* that, “the Alps consume around 10 % more energy per capita than the European average.” They maintain that heating accounts for the biggest share. CIPRA also states that motorized road traffic accounts for 93 % of greenhouse gas (GHG) emissions caused by traffic in the Alps, and that 84 % of holiday travels in the Alps are done by car.

The EEA report *Regional climate change and adaptation: The Alps facing the challenge of changing water resources* (2009) has very detailed climate data and projections of future changes in a high resolution adapted for the Alpine space. The report concludes that Europe and especially mountainous areas have warmed more than the global average in the last 250 years and at an unprecedented rate of 1.2 °C for the 25-year period preceding the report. EEA projects that on average the annual temperature in Europe will increase by 3.3 °C by the end of the 21st century, by 3.9 °C in the Alps and by 4.2 °C in elevations higher than 1500 m. The report recognizes the Alps as the second most favored holiday destination in Europe after the Mediterranean coast and continues to state that increasingly high temperatures at the Mediterranean may drive tourists to the increased, yet milder temperatures of the Alps during summer. At the same time, diminishing water resources from less snow and melting glaciers are seen as a potential strain, and glacier retreat and alteration of the landscape due to melting permafrost are considered to decrease the touristic attractiveness. Hydro and thermal power production are presented as threatened, and together higher temperatures, more limited water resources and strained energy production are presented as reasons for artificial snow-making adding to the stress on the Alpine environment.

EEA (2010) claims in their report *Alps – The impacts of climate change in Europe today*, that 40 % of Europe’s fresh water originates from the Alps, and that the mountains act as water towers, supplying fresh water to tens of millions of Europeans in lowland areas. The report states that especially Southern Europe will likely face droughts more frequently in the future due to higher ambient temperatures and decreased precipitation, and that decreasing water flows from the Alps combined with increasing water demand due to agriculture irrigation and tourist influxes will lead to conflicts between the Alpine region and elsewhere. EEA lists households, agriculture, energy production,

forestry, tourism and river navigation as sectors that will suffer from the situation and also end in a conflict of interests between each other.

ESPON (2011a) offers further information on climatic changes in their report *ESPON Climate: Climate Change and Territorial Effects on Regions and Local Economies*. ESPON projects that the mean annual temperature in the Alps will increase by over 4 °C by the end of the 21st century, leading to a decrease in the annual number of snow days by 40 to 50 days, depending on the region. ESPON claims the economic sensitivity of the Alps to the climate change to be high, as the region relies heavily on tourism income, which is highly dependent on specific climatic conditions. The energy sector is also presented as being very sensitive, as power plants need water for cooling. The environment is presented as highly sensitive, due to an increased risk of forest fires, floods, permafrost melting and changing precipitation patterns. ESPON expected winter tourism to decrease in attractiveness due to fewer days with snow cover shortening the season and the increasing occurrence of natural hazards. Summer tourism is expected to benefit due to temperatures in the high alpine areas and the number of summer days increasing, and the increasing attractiveness of lake regions in lower, rural mountain areas. City tourism in the Alps is also expected to benefit.

Farinotti *et al.* (2016) study the possibility of storing run-off water from the Alps by building dams at the sites of some current glaciers. To point out the importance of glacial run-off to major European rivers, the authors estimate the share of summer (annual) run-off from presently glacierized surfaces to be 53 % (15 %) for the Rhône measured at Chancy and 6 % (2 %) for the Rhine measured at Basel. The authors claim that 65 % of expected decreases in summer run-off could be mitigated by through active water management. Furthermore, Farinotti *et al.* claim that the equivalent of 80 % of contemporary Swiss fresh water consumption may be missing in the Alps between 2070 and 2099.

Gobiet *et al.* (2013) argue that precipitation will increase during winter and decrease during summer, and that the changing patterns will become more pronounced after mid-21st century. The authors project that the snow albedo feedback will decrease due to higher temperatures melting more snow faster, and exposing ground that absorbs heat faster, creating a cycle and helping the authors to support a claim that snow-abundant winters will become a 1-in-30 year's event, compared to eight in the 1961-1990 reference period. The authors highlight the increasing risk of floods due to the

increased risk of alpine lake outbursts triggered by ice avalanches or rockfalls, and warn that the Alpine climate may warm faster than indicated in popular climate models, as the 0.5 °C increase per decade during the past three decades is well above projected rates of change.

IPCC (2013) states in their report, *Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, that “1983-2012 was likely the warmest 30-year period of the last 1400 years.” IPCC goes on to claim that each of the three decades was successively warmer than any preceding decade since 1850. The report states that Northern Hemisphere snow cover extent decreased by 1.6 % per decade for March and April, and by 11.7 % per decade for June during the period 1967-2012.

Kovats *et al.* (2014), in their report *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change*, support the notion of tourism in mountainous areas benefiting from warmer climatic conditions in summer, yet recognize the adverse effects on natural snow reliability and ski season length, and state that low-lying areas are the most vulnerable. The report lists demographic changes, namely ageing populations in ski tourist source countries, as potentially having a higher impact than climatic changes up to 2050. The report recognizes that artificial snow-making has physical and economic limitations and concludes that technical adaptation measures and year-round tourism may not fully compensate the lost income of the diminishing winter sports tourism. Damage to cultural buildings and landscapes due to increased soil instability is projected to increase, potentially harming tourists' perceptions of the Alps as a traditional destination.

The OECD report *Climate Change in the European Alps: Adapting winter tourism and natural hazards management* (2007) is one of the most thorough and referenced reports. The report states that losses in winter tourism and the increased exposure of settlements and infrastructure to natural hazards are the primary vulnerabilities to climate change in the Alps. OECD claims that tourism provides 10-12 % of the jobs, but that tourism activities are concentrated in only 10 % of the Alpine municipalities. The report found there to be 666 ski resorts in the Alps, of which 91 % were naturally snow-reliable. OECD claims that a 1 °C warming in the environment will increase the snow-line by 150 m, and at already a 1 °C increase the number of snow-reliable resorts

would fall to 75%, at 2 °C to 61 % and at 4 °C to 30 %. OECD predicts Austria to be particularly affected due to winter sports tourism's importance and due to the low altitude of many Austrian resorts, while Switzerland is predicted to suffer the least due to many of its resorts at high altitudes. The report points out four technological adaptation strategies: landscaping and slope development, a move to higher altitudes and north facing slopes, glacier skiing, and artificial snow-making. OECD supports forming large ski conglomerates that would have a reduced vulnerability against climate change through the diversification of business locations. The report believes in summer tourism benefiting from warmer and less rainy conditions, and that hotels and restaurants will benefit more from year-round tourism than cableway operators, but states that the income brought in by winter sports tourism likely cannot be substituted by a more diversified offering.

Stocker (2012) states in his keynote speech at the award ceremony of the National Latsis Prize 2011 in Bern, that climate warming occurs with a delay from when GHG emissions occur. Stocker insists that GHG emissions be immediately reduced to decrease global warming.

WMO (2017) states that 2016 is the new record warmest year in *WMO Statement on the State of the Global Climate in 2016*. WMO claims that 2015 CO₂ emissions were higher than in 2014 due to an increased occurrence of forest fires and a decreased uptake of CO₂ by vegetation in drought affected areas. Fossil-fuel based emissions remained similar.

YLE (2017) reports, based on WMO (2017), that 2016 is the new record warmest year surpassing 2015, and thus making 2014-2016 the warmest consecutive period on record.

2.3.2 The state of Alpine tourism

The Alpine Convention (2013) report *Sustainable Tourism in the Alps – Report on the State of the Alps* estimates 464 million overnight stays in the Alps in 2011 and states that figure does not include one-day trips that are popular in the Alps from bordering cities, in Switzerland estimated to bring in one third of tourism related sales. The report claims that overnight stays in hotels had stagnated in France, Germany and Liechtenstein, and increased in Austria, Italy, Slovenia and Switzerland, with the winter season

being more popular than summer. 15 % of jobs in the Alps are claimed to be directly and indirectly linked to tourism, and the economies of 10 % of the municipalities are claimed to be based on tourism, representing 5 % of the Alpine population. The report portrays the approximately 20-year rent periods of ski lifts to be a common reason behind Alpine resorts not always considering climate change as their main challenge and for many resorts' willingness to invest in artificial snow-making.

AlpNet (2015) counted the overnight stays per year in the Alps to be 375 million in their publication *Alpine tourism gathers its strength*. The organization for tourism partners from Austria, France, Italy and Switzerland states that Alpine region is stagnating in the international tourist destination competition. AlpNet calls for focus in planning the future of winter sports, innovating new Alpine summer attractions, improving sustainability and added value and finding new markets for holidays in the Alps.

AlpNet (2016) discussed existing conditions in the Alps in their report *theALPS Symposium 2016: Alpine Tourism impresses on competitiveness*. A key statement of the report is that winter tourism is of "existential importance" to the economic and social development of Alpine tourism. The report claims that two thirds of tourism income occurs in winter in Austrian Tyrol, Salzburg and Vorarlberg and in Swiss Graubünden and Valais. The above-average turnover is claimed to be a driving force for investment for both the businesses and the destinations, and that income is secured in peripheral regions by tourism and its supply.

Carraro *et al.* (2008) studied the economic impact of climate change in Italy and its effects on tourism in *Climate Change Impacts and Adaptation Strategies in Italy. An Economic Assessment*. The Authors project income from winter tourism to decrease by 10.2 % by 2030, calculated as an average of IPCC A1, A2, B1 and B2 climate warming scenarios. The authors explain the widespread adoption of artificial snow-making equipment and migration of infrastructure to higher altitudes in the Italian South Tyrol by the severe threats faced by winter tourism and the high turnover brought by the sector. Snow-making equipment operation and maintenance costs are claimed to be 8.5 % of profits. Carraro *et al.* state that diversifying the tourism product is important and that one third of the tourists in the Italian Alps visit for something else than winter sports, but as winter sports represent the largest source of income in the Alps, the expected reduction of income likely cannot be substituted.

Davoudi *et al.* (2012) suggest in their paper *Climate change and winter tourism – A Pan-European perspective* that the sensitivity of the Alpine regions to climate change depends on the regions' dependency on winter tourism.

Eurostat (2017) provides yearly statistics about tourism trends, the number of hotels and the number of bed places on a European-wide and regional level on their *Data-base* page on tourism. Eurostat also documents annual data on EU residents' trips, annual and quarterly enterprise data for tourism industries on a European-wide level.

Fahy (2014) discussed employment in the tourism industry in Switzerland in *Why working in tourism is no holiday for the Swiss*. The article states that 40.7 % of the workers in the Swiss hospitality sector are foreign. The article maintains that the irregular hours and comparatively low wages decrease Swiss interest in working in the field, rather finding non-customer service oriented work. Fahy interviews the head of the tourism department at the Feusi business school in Bern, who admits that attracting young talent towards the tourism sector is hard.

Macchiavelli (2009) discusses the ageing demographic of skiers, forcing industry managers to consider new target groups outside of traditional markets. The author also considers the increased competition by other tourist destinations due globalization, the changing wants of tourists, and the nature of the Alpine population and businesses.

OECD (2012) reveals economic figures related to the tourism industry in its report *OECD Tourism Trends and Policies 2012*. The report tells of an Austrian initiative to strengthen summer and off-season tourism, to develop and renovate existing Alpine infrastructure including mountain huts instead of building more, and to increase public transport mobility to, from and within tourism regions. OECD states that the Swiss tourism sector is not capitalizing on its full potential and that the sector needs to create more value-added in its regions. The report also shows data on the absolute and relative employment created by tourism, as well as tourism's contribution to the national GDP in 51 countries, including all OECD and EU member states.

Pütz *et al.* (2011) argue in their report *Winter Tourism, Climate Change, and Snowmaking in the Swiss Alps: Tourists' Attitudes and Regional Economic Impacts*, that cable-way companies are the "motor" of destinations, enabling the entire winter tourism sector, but that the diversification of the touristic offer will probably be crucial for successful

competition between destinations. The authors base their statements on expert interviews, and further argue that up to 10 % of climate change induced winter sports tourism losses for Swiss Davos may be prevented by artificial snow-making. The authors claim the cableway companies, hotels and restaurants would benefit the most from the method.

SWI swissinfo.ch (2016) claims in its web article *Tourism today*, that the strong Swiss franc is putting pressure on the Swiss tourism industry, and Switzerland Tourism is increasingly trying to attract visitors from countries like China and India, with increasing numbers of prosperous people.

Vanat (2016) examines the current state of mountain tourism in *2016 International Report on Snow & Mountain Tourism*. He claims that the Alps are the most visited ski destination, hosting 43 % of all skier visits, while producing only 15 % of all skiers, accepting the figures as a sign of a high proportion of outsider visitors. Vanat discusses Austria as an example, claiming 66 % of all skier visits in the country are by foreign people, and that the ratio of skier visits per inhabitant and per foreign visitors is the highest of the study together with Andorra. The author claims skier visits in France, Italy and Switzerland have been stagnating since 2005, and that the process of learning to ski needs to be made easier to attract a new generation of skiers in place of the world's ageing skiing population.

Die Wirtschaftskammer Österreich (WKÖ) (2016) publishes key economic figures of Austria and its federal states. The Austrian chamber of commerce provides data on e.g. the number and duration of overnight stays, the number of employed by sector and the sector's share of all employed, and the degree of utilization of the available accommodation.

The World Travel & Tourism Council (2015, 2016) publishes annual, country-specific tourism outlooks, *Travel & Tourism Economic Impact 2015: Austria, Italy, Switzerland*, and *Travel & Tourism Economic Impact 2016: France*. The reports show the direct and total GDP contribution of the tourism industry in the country in focus, and the direct and total employment impact in the country for the previous year. The reports also show the percentage and absolute figure of tourism investment out of total investment and the expected trends.

WWF (2005) states in its report *Ecoregion Conservation Plan for the Alps*, that “most people in the Alps live in cities (58 %) where the majority of jobs are found (66 %).” WWF explains that the cities in the Alps are located in broad Alpine valleys that are well connected to large outside cities, and that Alpine cities are set to become suburbanized to larger cities outside the Alps. WWF claims that since the 1970s European and global economic cycles have replaced regional Alpine economic cycles, and that mass tourism that replaced the more varied economic cycles is stagnating in the face of competition from non-Alpine destinations. The report maintains that traditional decentralized tourism is being replaced by highly concentrated tourism centers.

2.3.3 Adaptation literature

The Economist (2017) discusses the costs of artificial snow-making in the article *Snow-making companies in a warming world*. The article claims that the cost for covering 1 km² with artificial snow is roughly EUR 1m, and that many resorts in Northern Italy are already equipped for covering slopes even fully with artificial snow, while resorts in Austria have invested around EUR 1bn in the equipment over the past decade. The article points out that around 5 % of profits from snow-making equipment are going into research and development on enabling snow-making even in 0 °C temperature.

ESPO (2011b) adds to ESPO 2011a in a case study focused specifically on the Alps in *ESPO Climate: Climate Change and Territorial Effects on Regions and Local Economies. Annex 1 – Case Study Alpine Space*. The report assumes that regions with wide array of natural and cultural assets have a higher potential for diversifying their touristic offer for all-year tourism. The report claims that regions already investing in research and development in long-term adaptation tourism and large tourist organizations with multiple big sections that are already cooperating with local authorities have a high adaptive capacity to climate change. ESPO also suggests that a high contribution of winter tourism to the added value of a region diminishes its adaptive capacity. The report claims, based on an expert survey it conducted, that the tourism operators’ knowledge and awareness is very low in large parts of Switzerland, and that in Italy tourist actors refuse to accept long-term adaptation activities, but cling on to winter tourism. The surveyed experts state that increased awareness among tourism actors, including the tourism industry, the guests and the local population, is needed. The report concludes that region specific climate data and vulnerability assessments are needed.

Farinotti *et al.* (2016) were covered already in stream one on their study about building dams to save fresh water. Active water management as suggested by the authors could mitigate an estimated 65 % of expected fresh water run-off decreases.

Fehringer (2014) claims in *Skiing, climatic changes and the environment: A study into the perception of tourists in Austria*, that one third of every euro spent by a tourist in Austria can be traced to winter sport tourism. The author conducted a survey of highly active skiers in Austria to find out about skiers' knowledge and awareness of climate change. The survey concludes that missing snow cannot be replaced by special activities when choosing a destination, that 64 % of respondents believe artificial snow-making to be an effective adaptation strategy and that respondents are unwilling to pay more for snow-making, and that no respondent would stop skiing to save the environment. 30 % of the respondents would support some restrictive measures, e.g. limiting the number of skiing slopes or the skiers on the slopes. It is concluded that protective measures are only accepted if no personal sacrifice is related. The report concludes that current technological adaptation and mitigation measures are not viable in the long-term. However, the author proposes for ski resorts to develop more sustainable adaptation measures to ensure the well-being of the skiing industry.

Rixen *et al.* (2011) recommend tourist destinations to determine their regional strengths to identify potential high-quality winter and summer tourism activities in their report *Winter Tourism and Climate Change in the Alps: An Assessment of Resource Consumption, Snow Reliability, and Future Snowmaking Potential*. The authors support the notion of potential snow-making days decreasing due to increasing temperatures, with potential days possibly falling by 50 % in Parsenn in Davos, Switzerland.

The Swiss Federal Institute for Forest, Snow and Landscape Research WSL (2016) presents information on active water management in the Alps, referring to Farinotti *et al.* 2016. WSL expands that approximately 1 km³ of water would need to be stored for mitigating two thirds of expected decreases in available water supply. The available volume is claimed to be ten times higher, and the main problem is centralizing, or distributing depending on the implementation, the stored water across the Alps.

2.4 Gaps in the literature

The research question “*what does the climate change mean for tourism in the Alps and how should the region adapt?*” is to quite some extent discussed in the existing literature. The existing literature documents the expected climate warming and the resulting effects on ecosystems and the industry in detail. The literature then forms a solid base for understanding the environment chosen in the research question. Existing literature also provides ideas of adaptation strategies, but outside of the limited range of technological adaptation options, the recommended adaptation strategies are mostly rather theoretical, leading to few concrete recommendations with estimations of consequences to the Alpine touristic actors. To contribute to the literature, this thesis will document the suggested adaptation measures and build examples of two different adaptational scenes.

3 The conceptual model

3.1 The variables

The dependent variable in the research is the adaptation strategies of the tourism sector to the climate change, based on the research question *what does the climate change mean for tourism in the Alps and how should the region adapt?* The value of an adaptation strategy for a region may be assessed by the completeness of the adaptation strategy for the region – the degree the adaptation strategy is able to support the economic development and mitigate negative impacts on tourism in the region. The requirements for an adaptation strategy are dictated by the independent variables that affect and enable a region’s tourism industry.

The independent variables are the effects of the climate change on the natural and economic environment of a region, the location of the region, the region’s dependency on tourism, and the type of tourism a region is dependent on.

The effects of the climate change on the natural and economic environment of a region are extensively researched in the literature this thesis draws on. The indicators are mainly based on current scientific understanding and research, but some future chang-

es can only be assessed through estimation, such as the pace and magnitude of changes in the environment.

The mean annual temperature is projected to be higher in the future and precipitation levels are expected to change. Water availability will therefore change due to less rain in parts of the Alps and more rain in others, and due to more precipitation falling as rain instead of snow, the snow cover arriving later and melting earlier, and the glaciers melting more leading to a decrease in summer run-off. The result will be an increased risk of droughts and floods, respectively, a weakened energy sector due to a diminished water supply, and increased energy demand due to cooling equipment. A warmer climate will also threaten 60 % of the plant species of the fragile Alpine ecosystems with extinction by 2100 (EEA 2009), accelerate glacier melt, accelerate permafrost melt leading to soil instability and an increased risk of landslides, rock avalanches, alpine lake outbursts and weakened bases for structures in the high alpine areas. The increased risk of natural hazards and threat to the cultural landscape and structures may decrease tourist demand, although the warmer and sunnier climate is also suggested to attract more summer and year-round tourists in the high alpine as well as low-lying mountain lake regions.

The second variable, location of the region is of high importance, as it will dictate the magnitude of changes in precipitation and temperature imposed by the climate change. The location also dictates the diversity of cultural buildings and landscapes and the possible touristic offer in the surrounding environment, as well as the exposure to natural hazards.

The dependency of the region on income from tourism, both directly and in total, and the type of tourism a region is dependent on dictate its vulnerability to climate change. A region with a tourism sector focused on summer and year-round tourism may benefit from the projected effects of the climate change, but a region focused on winter sports tourism, depending on its location and altitude, is likely to experience adverse effects to its operating conditions. The dependency of a region on tourism can be assessed based on commercial accommodation beds in the region, as suggested by Davoudi *et al.* (2012). The number of beds compared with the size of the population can also be used as an indicator, but the population of tourism-heavy regions differs so the resulting ratios will be somewhat incomparable. A region's dependency on winter tourism can be estimated with the presence, or lack, of major winter sports tourism resorts.

3.2 Hypothesis on the connection of the variables

Adaptation strategies probably can be designed on a broad level to include the entire Alpine region, some parts of it, or to cover a specific sector and then be implemented in a similar fashion across regions. Presumably a more effective, and to tourist destinations more appealing, method would be to design an array of adaptive measures and then implement a selection of appropriate measures in a specific region. The tourism industry's adaptation strategy would thereby be designed to suit the surrounding region and the regional strengths, as suggested by Rixen *et al.* (2011).

The climate change's effects on a region must be taken into consideration in designing an adaptive strategy. Expected changes in the region must be used as a guide in evaluating what will be possible and safe under future conditions. Adaptation strategies should be planned to be sustainable to prevent short-lived investments, e.g. building on glaciers, and to give the tourism destination a solid base for updating its offer and image. Although the tourism industry is a big employer in the Alps and enables the economic growth of peripheral regions, it cannot adopt adaptation strategies limiting for example the water supply of the population outside of the Alps. For the national economies of Austria, France, Italy and Switzerland the tourism industry, and Alpine tourism in particular, is important, but an adaptation strategy to counter decreasing incomes in the Alps resulting in exacerbated decreases in water and energy supply for the surrounding metropolitan areas, like Milan and Vienna, is unacceptable.

The physical location of a region must be considered in designing and evaluating suitable adaptation strategies. The altitude of the location has a big impact on the expected natural snow-reliability and thus the ability to host snow sports. The presence of cultural buildings and landscapes, and the overall attractiveness and diversity of the region's landscape will be important for tourists when choosing a destination. The accessibility of the region together with the type of the attraction will also be crucial: can the tourist destination be easily visited by public transport, and is the destination close enough to big tourism source cities for a day trip, or is the region more peripheral and visiting requires more time and effort? The location of the destination will have an impact on future precipitation, meaning some regions will become more and some less rainy.

The region's dependency on tourism for economic growth essentially dictates the need for adaptation strategies. If the region is not dependent on tourism, it may of course start developing tourism preferentially through sustainable strategies, but it does not stand to suffer from the climate change. However, if a region is dependent on winter tourism especially, depending on its physical location, it will need a strong strategy of adaptation to climatic changes to counter its economy being crippled by a weakened tourism industry.

The resulting hypothesis is that adaptation strategies need to be built according to the local physical conditions and the importance of the tourism sector, and in addition to mitigating potential economic losses, the strategies need to be sustainable and should not exacerbate developments in the Alps or in the surrounding lowland regions. The value of an adaptive measure to a region can be found through analyzing the measure's ability to consider the future climatic conditions, the physical location of the region and the current status of the tourism sector in the region. The research question, *what does climate change mean for tourism in the Alps and how should the region adapt*, can be answered as such with limitations to the focus of the adaptive strategies, but for a comprehensive answer the tourism regions in the Alps need to be considered individually. The question *how should the region adapt* can best be answered with adaptive strategies that have been considered based on the conditions characterizing a particular region.

4 Methodology

The type of this thesis is that of a problem-centered one. The research question, *what does the climate change mean for tourism in the Alps and how should the region adapt*, is a closed research question and the purpose of this thesis is to compile the suggestions of different authors to highlight the necessity of innovating and implementing adaptation strategies, and to build example cases of the possible effects of two different strategies. The existing literature on climate change and tourism in the European Alps does present possible adaptation strategies, but very few works give direct recommendations or consider the effectiveness of a strategy in a particular region. Instead many authors prefer to extensively document the expected climatic changes and conclude by calling for local authorities and tourism actors to innovate. This thesis attempts to build

a case for more sustainability in the implementation of adaptation measures. The feasibility of adaptation strategies will be evaluated based on an assessment of the importance of tourism to a region based on the number of commercial bed places, and by identifying the importance of winter sports tourism to a region by the presence of large winter sports resorts.

The topic and the literature review are based on a literature review done by the author in April 2015, itself based on a preliminary thesis topic proposal. Data gathering for this thesis has been guided by the search for information on the climate change and its implications in the European Alps, and information about the current state of the tourism industry in the Alps. The research question and the plan to answer the question has become clearer during the data collection but more so during planning and writing the thesis. The topic of climate change and its implications in the Alps is of great interest to the national governments of the Alpine countries, the EU, as well as the municipalities situated in the region and to NGOs driving economic growth, such as the OECD, Alpine Convention and AlpNet. Many academics are interested in applying their knowledge especially into projecting future climatic conditions. The availability of information is good, but a large part of the studied, relevant information is now some years old. Newer literature may have more and perhaps more refined adaptation strategies, but the basic understanding of future climatic changes is largely homogenous in the researched literature and can be expected to remain so, although with possible changes occurring in climate modelling.

The reviewed literature can be deemed dependable based on many of the authors being NGOs and the reports being well-coordinated and funded studies based on solid scientific research. Some independent academic publications are included in the bibliography and deliver a great deal of information, yet some of the surveys the authors have conducted could be seen as being limited in scope. The authors agree on the underlying climatic science, which legitimizes the scientific base.

5 Findings

The findings from the literature have been structured according to the literature streams, and further split into subsections covering essential aspects of information in a particular stream. Information about the climate change and its effects will be presented first, followed by detailing the current state of Alpine tourism and showing important numbers. Last the adaptation strategies suggested in the literature will be shown.

5.1 Climate change information

5.1.1 Past temperature data and future projections

EEA (2009) shows that the overall mean annual temperature in the Alpine region has increased by roughly 2 °C between the late 19th century and early 21st century. The temperature increase has been the most pronounced during the 25-year period leading to 2007, amounting to 1.2 °C in 25 years, which EEA states is unprecedented in a 250-year instrumental period. IPCC (2013) supports the finding on a global scale by concluding that “each of the last three decades has been successively warmer at the Earth’s surface than any preceding decade since 1850,” continuing to state that “1983-2012 was likely the warmest 30-year period of the last 1400 years.” More recent data holds that each of the years 2014-2016 has consecutively been the warmest on record (Blackett 2016, WMO 2017).

The global mean land temperature increase since pre-industrial times has been 1.0 °C and for Europe 1.2 °C. The higher warming in the Alpine region is due to subtropical high air pressure bands systematically shifting northward, leading to extended periods of sunshine in the Alps. Wind speeds in general have decreased in Central Europe during the 20th century (EEA 2009). Human caused GHG emissions presumably became comparable in magnitude to natural forces causing climate variability in the mid-20th century, and pre-1950 climate curves were almost exclusively due to natural variability (Ibid.).

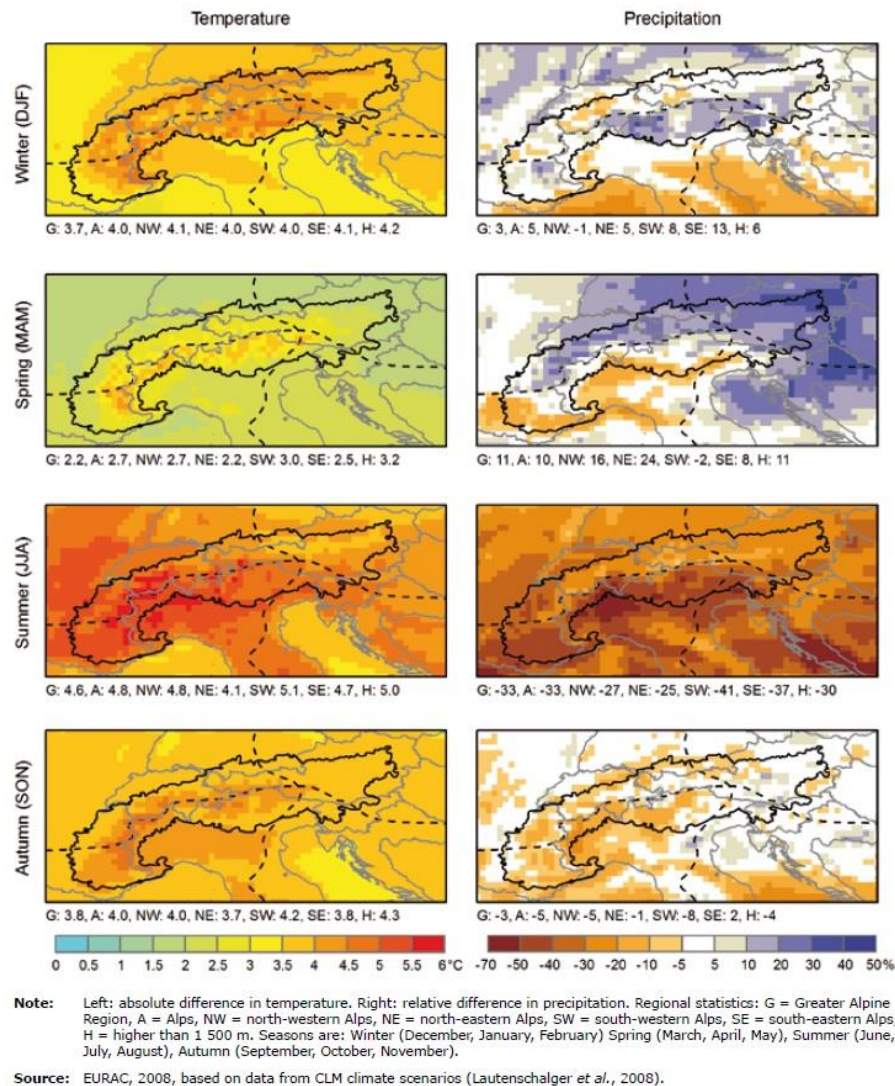


Figure 1: Projected changes in annual mean temperature and precipitation (EEA, 2009).

Abegg *et al.* (1997) assumed a 2 °C warming in the Alpine space by 2050 relative to 1990 already in 20 years ago. OECD (2007) coarsely estimated temperatures to increase by 1-5 °C in summer and by 1-3 °C in winter relative to 1990. Based on the IPCC A1B climate scenario of moderate GHG concentration increases in the atmosphere, the EEA (2009) expects a 3.3 °C annual mean warming in Europe, with a 3.9 °C warming for the Alps and a 4.2 °C warming for Alpine areas higher than 1500 m of elevation, relative to 1960-2000 average temperatures. Warming is expected to be milder (1.4 °C) until 2050 and more pronounced (2.1 °C) thereafter. ESPON (2011a) predicts annual mean temperatures to increase by roughly 4 °C in the Alpine region by the end of the 21st century relative to 1961-1990 average values. Gobiet *et al.* (2013) note that the projected rates of climate warming are below the observations of the past few decades of roughly 0.5 °C per decade, warning of a possibility of faster than projected warming.

5.1.2 Precipitation changes

Summer precipitation is expected to decrease in Southern Europe especially, while winter precipitation in Northern Europe is expected to increase. The Alps are situated in between the changing zones in an area called the European Climate change Oscillation (ECO), that makes predicting future conditions difficult (Gobiet *et al.* 2013). Gobiet *et al.* however project changes in the Alps to be in the range of -4.1 % in summer and + 3.6 % in winter until 2050, and -20.4 % in summer and + 10.4 % in winter until the end of the 21st century. OECD (2007) projected precipitation to increase by 5-25 % in winter and to decrease by 5-40 % in summer by 2050. EEA (2009) projected summer decreases to be more profound, between -25 % in the North-East section of the Alps and -41 % in the South-West section by the end of the 21st century. EEA also predicts the number of dry periods, meaning five consecutive days without rain, to increase by 36 % in summer, with the relatively highest changes in the North-West and North-East sections by +73 % and +52 % respectively. IPCC (2013) states that the “contrast in precipitation between wet and dry regions and between wet and dry seasons will increase.” Kovats *et al.* (2014) state that the increased winter precipitation will increasingly fall as rain instead of snow. Heavy precipitation events are predicted to increase throughout the Alps (EEA 2009, ESPON 2011b, Kovats *et al.* 2014).

5.1.3 Changes in the environment

The projected changes in temperature and precipitation will impact soil, glaciers, snow extent and water run-off cycles in the Alps. The increasing level of precipitation in the winter, together with the frozen soil's decreased water permeability, is likely to cause floods in the lowlands (OECD 2007). The warmer temperature will melt more snow in the winter instead of spring, and more of the increasing winter precipitation falling as rain instead of water will increase snow melt and thus water run-off during winter by an estimated +19 %, while spring and summer run-off is estimated to decrease by -17 % and -55 % respectively (EEA 2009). The expected increase in extreme precipitation events in all regions and seasons is expected to increase downstream flooding, soil erosion, sedimentation, reduced water quality and the degradation of rivers, and to increase the frequency of landslides and mudflows (Ibid.). The expected decreases in summer precipitation and run-off, together with projected increases in water demand from agriculture irrigation and tourism influxes are deemed likely to hurt the Alpine ecosystem and economic sectors, including tourism, energy and industry, and to exacer-

bate droughts expected to occur more frequently in Southern Europe (EEA 2010). Farinotti *et al.* (2016) support the notion of warmer temperatures reducing the duration and spatial extent of snow cover, especially in the spring, and accelerated retreat of glaciers, leading to increases in water discharge in winter and spring and decreases in summer and fall. The glacier recession is estimated to increase water discharge in the short-term, but to considerably decrease long-term water availability in the Alps (Ibid.). Water run-off from Glaciers in the Alps will decrease by an amount estimated equal to 80 % of freshwater consumption in Switzerland today (WSL 2016).

Changes in Natural Hazards	Confidence in projected changes	Most affected regions	Economic importance
<u>Permafrost related hazards:</u>			
Increase in frequency of rockfalls and magnitude of debris flows	Very high	High mountain range, tourism areas	Low
<u>GLOFs:</u> Increasing incidence of Glacial Lake Outburst Floods	Very high	High mountain range, tourism areas	Low
<u>Other Glacier related hazards:</u>			
Increasing frequency and magnitude	High	High mountain range, tourism areas	Low
<u>Winter floods:</u> Greater intensity and frequency	Medium	Lower mountain range, densely populated areas	Very high
<u>Storms:</u> Greater intensity and frequency	Medium	Alpine arc, densely populated areas	Very high
<u>Rockfalls:</u> Increasing frequency	Medium	Lower to medium mountain range	Medium
<u>Forest fires:</u> Increasing number of events in the Southern Alps	Medium	Lower mountain range of Southern Alps	Medium
<u>Landslides and debris flows:</u>			
Increasing frequency and magnitude	Medium/Low	Lower to medium mountain range	Medium
<u>Avalanches:</u> Increasing frequency and magnitude at high altitudes	Low	High mountain range, tourism areas	Medium

Table 1: *Impacts of the climate change on natural hazards in the Alpine Arc* (OECD, 2007).

OECD (2007) estimated that 30-50 % of glaciers globally may disappear by 2100 under a mean annual warming of +2-4 °C, and that nearly all Swiss glaciers would disappear by 2100 under a warming of 5 °C. EEA (2009) estimated that the glacier area in the Alps will decrease by -50-90 % by 2050 relative to the 1971-1990 reference period, resulting in the Alps becoming less attractive for tourists.

Based on the so-called 100-day rule, the altitude of natural snow-reliability is roughly 1050 m for Eastern Austria, 1200 m for Western Austria and Switzerland, and around 1500 m for Alpine areas more influenced by the warmer Mediterranean climate. The 100-day rule holds that an area is naturally snow-reliable if it has at least 30 cm of snow for 100 days per season, in seven out of ten consecutive seasons. OECD (2007) considered 609 or 91 % of Alpine ski areas to be naturally snow-reliable. The altitude for natural snow-reliability is estimated to increase by 150 m for a 1 °C temperature increase (OECD 2007, Gobiet *et al.* 2013). Under a 1 °C warming, OECD (2007) estimates 500 or 75 % of the ski areas to remain snow-reliable, while the figures would fall to 404 or 61 % with a 2 °C and to 202 or 30 % under a 4 °C warming. EEA (2009) estimated that snowfall would decrease by -70 % in the South-East and by -40 % in the North-West of the Alps by 2100. The South-East part would be left with 11 snow days, of which four would occur during spring, and the North West with 40 snow days in winter and 28 in spring. Overall snowfall is estimated to decrease by -36 %, and by -20 % at altitudes above 1500 m (*Ibid.*). ESPON (2011a) calls the Alps a hotspot due to the expected decrease of snow cover and because of the importance of tourism to the region. Gobiet *et al.* (2013) expect the snow cover extent to decrease dramatically below 1500-2000 m by 2100. Snow-abundant winters are estimated to become a 1-in-30 year's event by 2100 versus 8-in-30 in the 1961-1990 reference period.

Warmer temperatures will increase permafrost melt, which leads to an increased occurrence of mass movements and reduced slope stability. The effects include more pebble and rock falls; more intense debris flows; glacier lake outburst floods (GLOFs) due to ice avalanches, rock falls; and debulking effects on rock slopes, resulting in the decreased structural stability of cableway stations, lift masts and other buildings in high Alpine areas and threatening humans and structures below mountain faces (OECD 2007, EEA 2009, Gobiet *et al.* 2013, Farinotti *et al.* 2016). Kovats *et al.* (2014) project the loss of cultural landscapes and damage to cultural buildings to increase by 2050.

The melting and re-freezing of the permafrost causes the rock to crumble, making pathways in the high Alpine areas dangerous (EEA 2010). The erosion of the soil and soil water saturation may increase the occurrence of mass movements, and the inflation-retreat of clay in the soil due to an increased occurrence of droughts may damage building foundations (OECD 2007). Many Alpine ski areas are building water reservoirs for collecting run-off water from snow for re-use in artificial snow-making to reduce stress on the local water management (EEA 2009). The increased soil erosion and instability and rock falls expected to threaten glacier lakes, resulting in flash floods below, may cause an outburst of such a run-off water reservoir, leading to a flash flood in a village below.

5.1.4 Implications to the industry

Tourism and the energy sector are two particularly vulnerable industries in the face of the climate change (OECD 2007, Carraro *et al.* 2008, EEA 2009, ESPON 2011a, Kovats *et al.* 2014). Water shortages in the Alps are predicted to increase in frequency, while water demand from agriculture irrigation, tourism influxes in the summer and energy production is predicted to increase. Conflicts are thus predicted to rise between drinking water supply, energy production, agriculture and artificial snow-making. Hydro power and thermal power have a higher water demand than other industries in the Alpine region, with thermal power plant cooling accounting for 64 % of all abstracted water in Germany, 69 % in the Rhone basin area, and 13 % in Northern Italy. The manufacturing and services industry otherwise accounts for 6 % of water abstraction in the Rhone basin and 20 % in Northern Italy. Hydro power and thermal power production are predicted to decrease due to arising conflicts (EEA 2009, EEA 2010, ESPON 2011a, Kovats *et al.* 2014).

Country	Number of ski areas	Snow-reliable under current conditions	+1 °C	+2 °C	+4 °C
Austria	228	199	153	115	47
Switzerland	164	159	142	129	78
Germany	39	27	11	5	1
France	148	143	123	96	55
Italy	87	81	71	59	21
Total	666	609	500	404	202

Table 2: *The number of naturally snow-reliable ski areas by country (OECD, 2007).*

Winter sports tourism is predicted to be adversely affected. According to a prevailing future temperature projection, the number of naturally snow-reliable ski areas in the

Alps will decrease to 202 or 30 % of today's figure by 2100. The line of natural snow-reliability will move up to 1600-2000 m of altitude, depending on the region, leaving many ski areas in a difficult position and have especially adverse effects on low-lying resorts at altitudes up to 1600 m (OECD 2007, EEA 2009). The decrease of snow-reliability, the overall lesser number of days with snow cover meaning a shorter season, and the increased risk of natural hazards, to include avalanches, will likely decrease the attractiveness of Alpine winter tourism considerably (Abegg *et al.* 1997, ESPON 2011a, Kovats *et al.* 2014). In its current state, winter sports tourism is the most important source of income for some Swiss alpine regions, it contributes two thirds of annual tourism income in Salzburg, Tirol and Vorarlberg in Austria and in Graubünden and Valais in Switzerland, and it creates the largest share of income in the Italian Alps (OECD 2007, Carraro *et al.* 2008, AlpNet 2016). AlpNet (*ibid.*) considers winter sports tourism to be “of existential importance for the sustainable development, both economically and socially,” of the Alps. The increased demand of energy of artificial snow-making, currently the most favored adaptation measure, will likely increase its costs disproportionately in a warmer ambient temperature and render it obsolete (OECD, 2007; Fehring, 2014).

Summer tourism is predicted to benefit from the increasing number of summer days, decreasing summer precipitation and mean temperatures in the Alpine area (OECD, 2007; ESPON, 2011a; Kovats *et al.*, 2014). Due to the Alpine climate becoming more stable and being fresher compared to the warming and drying Mediterranean conditions, summer tourism in the high Alpine areas, in the rural, low-lying lake regions of the Alps, and city tourism in the Alpine lowlands is expected to become more attractive (ESPON, 2011a). Some of the improved climatic conditions may be countered by the increased risk of natural hazards and soil instability. The increased risk of rock falls, the weakened integrity of structures in the high Alpine areas due to permafrost melt, ice bridges on glaciers disappearing, high Alpine pathways becoming dangerous may decrease touristic attractiveness, and the increased risk of loss and damage to cultural buildings and landscapes may decrease touristic attractiveness (OECD, 2007; EEA, 2009; EEA, 2010; Kovats *et al.*, 2014).

5.2 The current state of tourism in the Alps

The Alps are the second most popular tourism destination after the Mediterranean coast in Europe, with 60 million annual overnight guests, amounting to four times the local population (Davoudi *et al.*, 2012). AlpNet (2015) counted for roughly 375 million overnight stays per year, while the Alpine Convention (2013) found that day trips with no overnight stay accounted for one third of all tourism related sales in Switzerland in 2011. A minimum of 7 % of jobs in the Alps were found to be within the hotel and restaurant sectors, while a total of roughly 15 % of jobs were estimated to be directly and indirectly linked to tourism (*ibid.*). The economy of 10 % of Alpine municipalities is based on tourism, which account of 8 % of the Alpine population, around 1.2 million people, and 5 % of Alpine municipalities account for 46 % of accommodation beds (Alpine Convention, 2013). 58 % of the Alpine population lives in cities where 66 % of the jobs are found. The situation forces many people to commute and also to bigger cities outside of the Alps (WWF, 2005). The tourism industry provides employment through small, family-run businesses like hotels, restaurants, shops, and other services, through big companies in cableway operation, transportation, maintenance, accommodation, etc., and especially winter tourism enables the regional economic growth of even rural areas, often being the most important share of income (OECD, 2007; Macchiavelli, 2009; AlpNet, 2016). Fahy (2014) found that 40.7 % of workers in the hospitality sector in Switzerland were non-Swiss.

AlpNet (2016) states that both economically and socially, winter tourism is of existential importance to the sustainable development of the Alps, accounting for two thirds of all tourism income in Austria in Salzburg, Tirol and Vorarlberg, and in the Swiss cantons Graubünden and Valais. For measure, Tirol accounts for 49 % of the annual over 50 million skier visits in Austria (Vanat, 2016). One third of every euro spent by a tourist in Austria can be traced to winter tourism (Fehringer, 2014). Winter tourism is a driving force for investment from both businesses and destinations in the Alps (AlpNet, 2016). Pütz *et al.* (2011) state that cableway operators can be considered as the “motor” of destinations that enable winter sports and the large winter tourism sector. Carraro *et al.* (2008) conclude that winter tourism is the largest share of income in the Italian Alps, and that the threats posed by climate change on the high profits from winter tourism have led Italian resorts to adopt artificial snow-making equipment, and to using and migrating structures into higher altitudes more. If 2006 had experienced the climatic conditions projected for 2030 in average by IPCC climate projections A1, A2, B1 and

B2, the Italian Veneto region would have lost EUR 2.4m or 0.3% of its direct income from Alpine tourism, while Trentino Alto Adige would have lost EUR 587m or 14.1 % of its own income or 9.4 % of all Alpine tourism income in Italy in the year (Carraro *et al.*, 2008).

Indeed, 77 % of ski resorts in Italy have artificial snow-making equipment, which costs 8.5 % of profits to operate, and to cover a hectare of land with 30 cm of snow, requires 1000-1200 m³ of water (Carraro *et al.*, 2008). Resorts in Austria have invested around EUR 7bn in infrastructure since 2000, which is more than 50 % of revenues on several years. 60 % of slopes can be covered with artificial snow – an investment that has required a yearly average of EUR 130m since 2008 (Vanat, 2016). The Alps are the internationally most visited ski destination, hosting 43 % of all skier visits, while they produce only 15 % of the world's estimated 125 million skiers. The Alps have 35 % of the world's ski resorts, and 37, or 84 %, of ski resorts with over 1 million annual visitors. In Austria, foreigners account for around 66 % of all skier visits and the highest ratio of skier visits per inhabitant and per foreign visitor. Germany is the skier source country with the most skiers, while the UK comes second, with the four biggest tourist flows being Germans to Austria, British to France, and Germans to Italy and Switzerland (*ibid.*). The Bavarian Alps in Germany are one example of a region where summer tourism is more important however, and in winter health and recreation tourism, together with conferences and events, are more important than winter sports tourism (Alpine Convention, 2013).

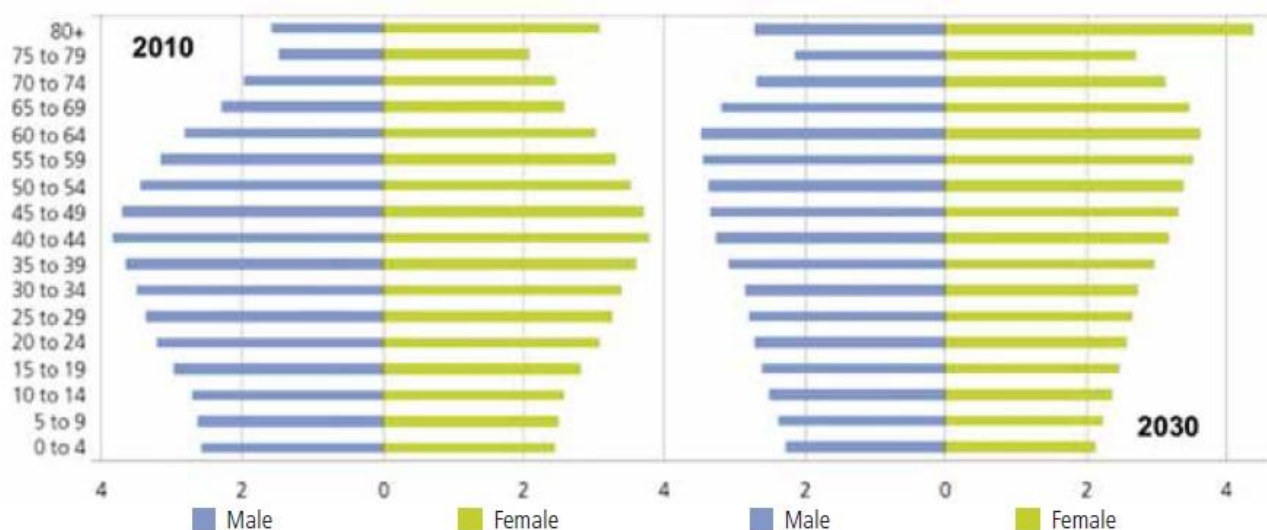


Figure 2: Ageing in the EU27 until 2030, assuming the total population remains constant (Alpine Convention, 2013).

Alpine tourism has met some headwinds, however. The Alpine Convention (2013) stated that the number of stays was decreasing in Germany and Liechtenstein, stagnating in France and increasing in Austria, Italy, Slovenia and Switzerland. In a newer study, Vanat (2016) states that skier visits in Austria, Italy, France and Switzerland have been stagnating since 2005, and the figures show a decrease since 2012. The Alps are stagnating in the competition between international tourist destinations (AlpNet, 2015). Globalization and the ease of reaching more varied holiday destinations appeals to consumers, placing stress on the mature offer of skiing in the Alps, which is losing competitiveness in costs and in the exclusivity which helped make ski tourism successful (Macchiavelli, 2009). The trend towards shorter, if more frequent stays is decreasing the number of overnight stays, and the ageing of the baby-boomers' generation is decreasing the number of skiers and forcing resort managers to consider new target groups and new infrastructure. The changes in the skier demographic are suggested to have a more adverse impact on winter sports tourism until 2050 than effects from climate change (Macchiavelli, 2009; Kovats *et al.*, 2014; Vanat, 2016). Tourists are increasingly interested in products promoting personal well-being, health and relaxation, that are less effort-heavy and demanding sports (Macchiavelli, 2009). In Switzerland, the strong franc is putting pressure on the industry, as tourists perceive the country as expensive (SWI 2016).

Strengths	Weaknesses
<ul style="list-style-type: none"> + central location in Europe with more than 400 million overnight stays/year + strong emotional binding of Europeans to the Alps as symbol of pure nature and high quality of life + landscapes of high ecological and aesthetical importance + cultural identity, recognition value + high purchasing power and high travel intensity in source markets + good to very good accessibility by either road, train or air + positive and international image + multifarious tourism relevant attractions based on unique nature and culture + some highly competitive destinations with modern infra- and supra-structure as flagships + well functioning spatial and territorial planning systems avoid overdevelopment + long-lasting experiences in tourism led to comparably high professional standards (at least in tourism centres) 	<ul style="list-style-type: none"> - low distribution power by atomised structure of suppliers and marketing services - low economic attractiveness for leading European tour operators to cooperate with destinations - very limited development options in attractive destinations because of constraints of space and high prices - topography leads to bottlenecks in transport system during high season - high vulnerability due to natural hazards - high vulnerability due to tourist activities - high vulnerability to climate change impacts - high costs for suppliers (investments, staff, energy) - in general low innovation rate of suppliers - poor working conditions for employees (low incomes, long and irregular "family unfriendly" working hours) - tendency to use uniform standardization of infrastructure and services - nature and landscape only as scenery for sports and leisure and not as a valuable asset in itself

Table 3: *The strengths and weaknesses of Alpine tourism* (Alpine Convention, 2013).

Davoudi *et al.* (2012) state that the economic sensitivity of regions to climate change depends on their dependency on winter tourism. Pütz *et al.* (2011) record tourism stakeholders in Switzerland concluding that summer tourism will become more important economically and a source of differentiation and competitive advantage in the competition for tourists. The motors enabling winter tourism, cableway operators, who generate 5 % of the total aggregate income in Davos (Pütz *et al.*, 2011), will likely suffer from a move to summer tourism, due to summer tourists spending 7.9 % of their daily budget on transportation services versus 22.9 % of the daily budget of winter tourists (OECD, 2007). Swiss Federal tourism policy requires the attractiveness of the tourism supply to be constantly improved, with responsibility lying with enterprises (OECD, 2012). However, Alpine residents are observed to be less amenable to change, creating a cultural brake on the need to innovate. The large number of small, family-run business in the Alps add to the intimacy of the experience, but prevent economies of scale being born and the reduction of costs and prices. The small size of the firms may instead add to the management costs, and the high number of stakeholders needed to agree upon and to implement policy changes may slow down the implementation of policies (Macchiavelli, 2009).

Austria has the largest hotel accommodation offer in Europe. The many small, family-run hotels have little marketing, but loyal clients keep returning. Resorts in Austria have tried joint marketing efforts, which have allowed for higher pricing despite an inability sometimes to ski between the participating resorts. Tourism contributed EUR 15.9bn (4.8 %) of the Austrian GDP directly and EUR 44.5bn (13.5 %) in total in 2014, while 2014 tourism related investment was EUR 3.1bn or 4.2 % of total investment (WTTC, 2015; Vanat, 2016).

Some large French resorts are heavily focused on winter tourism and were purpose-built from scratch in the 1960s and 1970s. The resulting high proportion of apartment housing in the French Alps limits the number of beds available for marketing. 77.5 % of winter sports related overnight stays and 73.9 % of winter sports holidays in France occur in the Alps. Most skiers in France are French, while the British account for around a quarter of the roughly 2 million annual foreign skiers. Tourism contributed EUR 80.4bn (3.7 %) of the French GDP directly and EUR 199.3bn (9.1 %) in total in 2015, while 2015 tourism related investment was EUR 29.8bn or 6.4 % of total investment (OECD, 2007; Vanat, 2016; WTTC, 2016).

Italy has the lowest rate of foreign visitors of the major Alpine countries and relies heavily on domestic tourists. Skier visits have been declining in Italy for a decade, despite renewal of lifts and investment in artificial snow-making equipment. Tourism contributed EUR 66.0bn (4.1 %) of the Italian GDP directly and EUR 162.7bn (10.1 %) in total in 2014, while 2014 tourism related investment was EUR 9.2bn or 3.2 % of total investment (WTTC, 2015; Vanat, 2016).

Today less than 50 % of skiers in Switzerland are foreign, as the number of foreign tourists from Germany, the UK, France, Italy and the Netherlands has fallen by 1.5 million overnight stays over the last decade. The ageing visitor demographic is causing the ski visitor figure in Switzerland to decline in the long-term. Tourism contributed CHF 13.6bn (2.1 %) of the Swiss GDP directly and CHF 48.0bn (7.4 %) in total in 2014, while 2014 tourism related investment was CHF 2.9bn or 1.9 % of total investment (WTTC, 2015; Vanat, 2016).

5.3 Adaptation measures

Adaptation measures for tourism against the climate change are split into two categories: technological and behavioral adaptation strategies. The technological adaptation strategies concern mostly only winter tourism, because it is the sector that is under most threat from climate change and needs to adapt, whereas summer tourism will receive improved conditions as is. The technological adaptation strategies include landscaping and slope development; a move to higher altitudes and north facing slopes; glacier skiing; and artificial snow-making (OECD, 2007; EEA, 2009).

Landscaping means altering the state of the natural shapes on slopes with the use of heavy machinery, with the aim of creating shades and features that demand less snow to remain skiable. Moving to higher altitudes holds moving existing infrastructure and building new at higher areas, where natural snow-reliability is higher, and building ski runs on North facing slopes aims to ease the maintenance of ski runs due to less sun. Glacier skiing means to suggest building and utilizing more ski infrastructure on glaciers to allow for longer seasons and also summer skiing. Artificial snow-making has the purpose of guaranteeing snow-reliability when natural snowfall is weak (OECD, 2007). OECD (Ibid.) and Carraro *et al.* (2008) found ski area managers to prefer technological adaptation measures to ensure the continuity of the high profits, while The Economist (2017) found out that Austrian resorts have spent around EUR 1bn in artificial snow-

making equipment over the last decade. However, the currently considered technological adaptation strategies do not have potential to be viable in the long term (OECD, 2007; Fehring, 2014; Kovats *et al.*, 2014), and serve to increase the dependency of tourism on skiing instead of decreasing it (Alpine Convention, 2013). Rixen *et al.* (2011) suggest that those regions currently, and expectedly also in the future, enjoying high natural snow-reliability could boost their regional strength by artificial snow-making.

	Summer tourism	Winter tourism
City tourism	Increasing attractiveness due to more summer days, prolonging season	none
Rural tourism	Increasing attractiveness of lake regions	Decreasing attractiveness due to lack of snow cover
High alpine tourism	Increasing attractiveness due to freshness of summer resorts	Decreasing attractiveness due to lack of snow cover, shorter season, natural hazards

Table 4: *The expected effects of climate change on seasons* (ESPON, 2011b).

The behavioral adaptation strategies can be found in the realms of business strategy and policy frameworks. OECD (2007) introduced five options of adaptation based on business strategy, namely sharing the costs of snow-making with the accommodation sector; businesses joining together to form ski conglomerates; diversification of winter tourism products; diversification of the tourism product throughout the year; and enhanced marketing efforts. Four policy options were introduced also, shown in order of preference among ski area managers: governmental subsidies for snow-making, reviewing environmental regulations, climate change mitigation through lobbying to reduce emissions, and governmental support in case of economic losses. The Alpine Convention (2013) supports improved marketing efforts and suggests a focus on conveying the identity of a destination, showing flexibility in the tourism offer, and showing innovation. It counters some of the introduced adaptation strategies however, instead calling for tourism-related public funding and decision-making to be based on climate resilience and long-term sustainability.

The Alpine Convention (2013) lists six policy instruments for the sustainable development of tourism: new legislation promoting sustainable tourism to avoid negative environmental and socio-cultural impacts, and to serve as a requirement to access public funding; improving existing legislation to better serve the notion of sustainability; state

or region-issued incentive programs for tourism actors developing sustainable adaptation measures; facilitating public participation in policy-making processes; communication and awareness-raising for tourists; and incentives for sustainable behavior among tourists. OECD (2007) suggests that the state should oversee the adaptation process, and perhaps facilitate transition for the regions at the “losing” end due to climate change induced limitations on the operating environment. Especially low-lying, winter sports dependent resorts could start actively planning withdrawal from ski tourism to exit the market in a controlled manner, instead of being eventually forced by the prevailing climatic conditions.

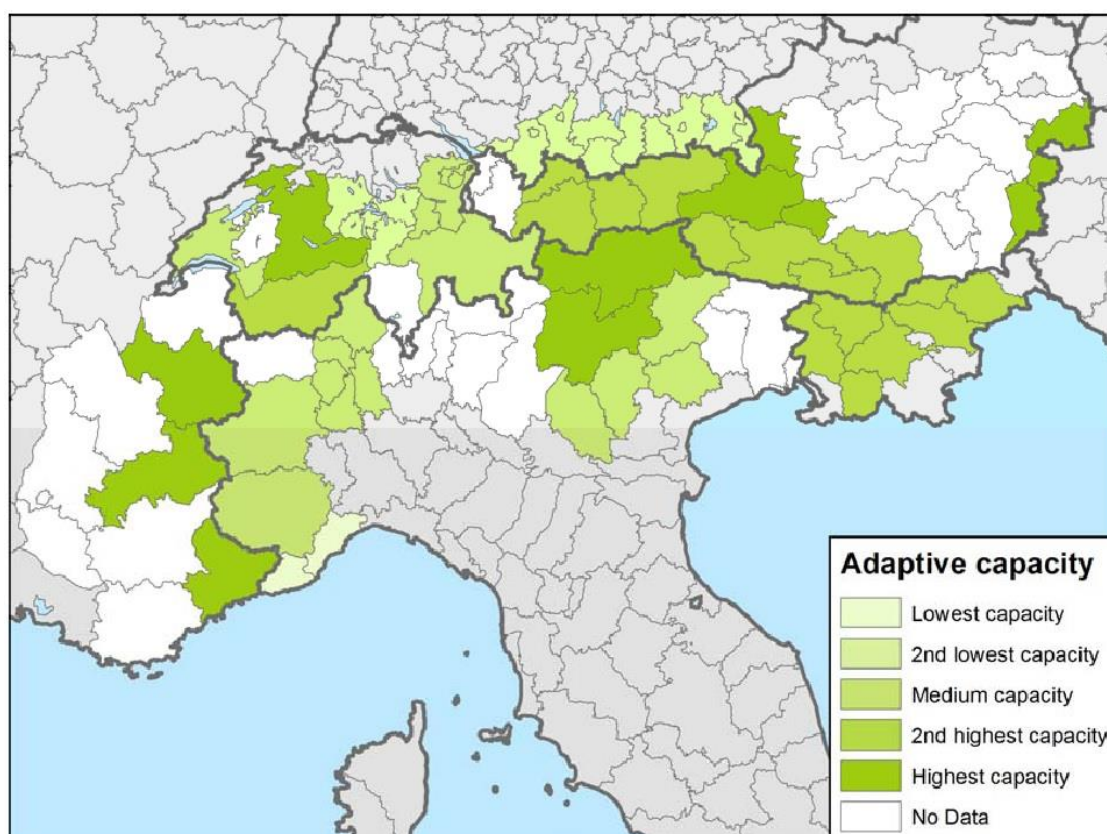


Figure 3: *The adaptive capacity of the Alpine regions* (ESPON, 2011b).

ESPON (2011a, 2011b) calls for further raising awareness of climate change impacts among the tourism industry, tourists and the local population. Furthermore, to better allow for the development of long-term adaptation strategies, region specific climate data and vulnerability assessments need to be made available to the decision-makers in the tourism sector (Ibid.). The Alpine Convention (2013) recognizes the high share of SMEs and the fragmented structure of Alpine tourism to slow down systemic innovation in the development of sustainable tourism, and suggests that “destinations could establish partnerships between operators to share products (e.g. soft mobility) or system

production methods (water systems and waste management). Increased economic cooperation between destinations and even mergers could allow for increased diversification of the offered tourism product, reduce vulnerability to climatic changes through regional diversification, and provide greater access to capital, enhancing the adaptive capacity of destination (OECD, 2007; ESPON, 2011b).

The ageing “baby-boomers” generation forms the majority of participants in the ski market, which itself is mature and facing the general problem of the ageing Western demographic. The generation is progressively quitting the sport and is not adequately replaced by younger generations (Macchiavelli, 2009; Alpine Convention, 2013; Vanat, 2016). Kovats *et al.* (2014) suggest that up to 2050, demographic changes may have a higher impact on Alpine tourism than climate change. The demand for health care and cures, disease prevention, and revitalization services will increase, and service providers should increasingly adopt low-barrier hardware, making use and mobility for the elderly easier. A worthwhile target group to focus on could be the so called “lifestyle of health and sustainability (LOHAS)”; middle aged people who look to improve personal wellness in the face of work life continuing until age 65 (Macchiavelli, 2009; Alpine Convention, 2013). Vanat (2016) considers it essential for customer retention, that destinations provide convenience and exceptional customer experiences to visitors, with improved, easier to approach ski instruction forming an important part.

Adaptation options for Alpine Tourism	
Promoting innovation and diversification of tourism offers	<ul style="list-style-type: none"> • Creation of new summer attractions • Development of Spa programs and promotion of health specific aspects
Further developing and securing of snow sports activities	<ul style="list-style-type: none"> • Extension of existing ski areas to higher elevations • Building of new high-altitude ski areas • Cooperation or merger of cableway companies • Securing snow-reliability by using additional snow making equipment • Construction of reservoirs for water supply of artificial snowmaking • Promotion of glacier skiing
Promoting all year tourism	<ul style="list-style-type: none"> • Withdrawal from ski tourism in ski areas at lower elevations • Development of all year tourism offers that are climate and weather independent • Increasing the attractiveness of the region by emphasising regional specialties • Improving of learning opportunities and cultural offers • Inform tourists about climate change impacts
Other adaptation options	<ul style="list-style-type: none"> • Use of insurance instruments • Improving natural hazards Management • Monitoring the impacts of climate change on the tourism sector • Promoting research and development projects in order to actively participate in climate change adaptation of tourism

Table 5: *Adaptation options for Alpine tourism* (ESPON, 2011b).

The tourism product is suggested to be diversified through new activities. OECD (2007) estimated that non-skiers formed 25 % of winter tourists in France and 48 % in Italy. Winter hiking, tobogganing and snow-shoeing may be complementary winter offers, and in some destinations facing limits to their operation due to climate change, could be marketed as replacements to skiing (Ibid.). Freeride skiing and ski mountaineering, both as a hobby and in competitions, could also function as niche winter offers, as they are dependent on natural snow conditions are human labor intensive, instead of being capital-heavy (Alpine Convention, 2013). An offer of spas, health clubs, festivals and events, indoor sports like tennis, etc., may aid in persuading tourists to choose a destination, but likely will not be able to attract considerable amounts of visitors alone (OECD, 2007; Fehringer, 2014). Summer demand may be stimulated by improving the already existing services to mountain bikers and paragliders, and by investing in gastronomy, themed walks, improved hiking routes, adventure parks and summer toboggan runs (OECD, 2007; Alpine Convention, 2013). The Alpine Convention (Ibid.) suggests establishing and marketing activities directly linked to mountain farming. Vanat (2016) gives as an example the *Mille8* development in Les Arcs in France: a year-round on and off-slope entertainment hub, that has a freestyle ski course for all levels, a spa, entertainment from children's teatime with the resort mascot through hot tubs to a golf simulator, events and fitness classes, restaurants, etc.

In addition to the already suggested marketing and service improvement efforts, the offered accommodation and restaurant products need to be of high standard to attract tourists, both in the high alpine areas and in the low-lying regions looking to attract summer tourists. Destinations should better learn to utilize the internet and social media to market their touristic offer to win tourists over internationally (Vanat, 2016). To decrease the soil consumption in the Alpine region and to improve and the perception of authentic Alpine destinations, the existing dwellings should be rehabilitated and developed further, instead of new building projects (OECD, 2012; Alpine Convention, 2013). Accessibility and public transportation options should be developed further to make the Alps seem an easier and closer choice for consumers to make gains in the international competition for tourist inflows. Connections between destinations and long-distance trains and public transportation options within destinations need to be improved, as well as the collaboration between tourism service providers and local transportation providers (Ibid.).

6 Adaptation discussion

This chapter will estimate the likely outcomes of two different series of adaptation strategies based on the findings presented in Chapter 5. The Austrian federal state of Vorarlberg was chosen to serve as an example region. Vorarlberg borders the Austrian state of Tirol to the East, Germany to the North, and Liechtenstein and Switzerland to the West. The state is almost entirely mountainous and has regions of different altitudes within. Vorarlberg has two of the world's 44 ski resorts with over 1 million annual visits, Silvretta Montafon and Stuben am Arlberg, which is connected to the neighboring and much larger system of St. Anton in Tirol (Vanat, 2016). Besides a wide offering of downhill skiing, Vorarlberg also has plentiful opportunities for cross country skiing, freeride skiing and ski touring, ice skating, sled dog rides and tobogganing in the winter, and hiking, mountain biking and trail running in the mountains in the summer. The summer season also enjoys of the beautiful Lake Constance in the North-West, with the possibilities for swimming, boating and day trips to the nature, and of the annual Bregenz music festival in the state capitol Bregenz at Lake Constance.

The state has a population of 388 711, of which over 111 000 live in the three biggest cities, Bregenz, Dornbirn and Feldkirch, on the Western border of the state. WKÖ (2016) counted 156 415 employed in Vorarlberg in 2015, of which 10 815, or 6.9 %, were employed by the accommodation sector. 8 554 852 overnight stays were recorded in 2015, accounting for 6.3 % of all overnight stays in Austria. Around 3.7 million of the overnight stays were recorded for the summer season, compared to almost 5 million in the winter season. The average length of a stay was 3.7 days, while the utilization of the accommodation capacity was 45.3 % (WKÖ, 2016). Eurostat (2017) counted for 58 285 accommodation beds in Vorarlberg in 2015, but the degree of utilization calculated by WKÖ, based on the formula of overnight stays times 100, divided by the amount of beds times the number of days, suggests a count lower by some thousands. The Eurostat (Ibid.) indicated 58 285 beds would mean a ratio of 0.15 beds per inhabitant, while Tirol for comparison has a ratio of 0.37 beds per inhabitant with its 270 897 accommodation beds.

Based on the share of overnight stays occurring during the winter season and the amount of ski resorts present in the state, some of which are presented in table 3, supported by the findings by AlpNet (2016), that "in areas such as - - Vorarlberg, - - at least two thirds of the income from tourism occurs in winter", and of Fehringer (2014), that in

Austria “one third of every euro spent by a tourist can be traced back to winter sport tourism”, it may be deducted that winter sports tourism is essential to the economy of Vorarlberg. Furthermore, based on the statement by Davoudi *et al.* (2012), that the economic sensitivity of a region to climate change is related to its dependency on winter tourism, and the findings by OECD (2007) and EEA (2009) that the altitude for natural snow-reliability in Western Austria is currently 1200 m and under climate warming will rise to 1800 m by the end of the century, it can be said that the tourism sector in Vorarlberg is under serious threat, considering most of the prepared ski area is below 2000 m of altitude (OECD, 2007).

Resort	Altitude range	Over 1 million annual visitors	Naturally snow-reliable under current 1200 m snowline	Naturally snow-reliable under projected 1800 m snowline	Possible to ski down to the valley under 1800 m snowline
Brandnertal	890 - 1900 m		X		
Damüls	1431 - 2009 m		X		
Diedamskopf	820 - 2060 m		X		
Gargellen	1423 - 2150 m		X	X	Maybe
Golm	1000 - 2124 m		X	X	
Laterns	1040 - 1785 m		X		
Lech Zürs am Arlberg	1450 - 2450 m		X	X	Zürs, Oberlech
Oberstdorf-Kleinwalsertal	1086 - 1996 m		X		
Silvretta Montafon	700 - 2430 m	X	X	X	
Sonnenkopf	963 - 2300 m		X	X	
Stuben am Arlberg	1407 - 2400 m	X	X	X	Maybe
Warth-Schröcken	1269 - 2050 m		X	X	Maybe

Table 6: A number of ski areas in Vorarlberg and their status of snow-reliability. Snow-reliability is estimated based on the resort's ability to offer skiing at a snow-reliable altitude.

The following two sections are estimations of the consequences of different levels of adaptation in Vorarlberg. The first will estimate the conditions under a business-as-usual setting, where the ski resorts are enhanced to their maximum potential, without necessarily considering sustainable economic and environmental development. The second assumes conditions where long-term strategic planning is given priority and sustainability is the basis for development.

6.1 Business as usual

Technological adaptation strategies will remain as the preferred method of ensuring the continuity of the high profits of the winter sports sector, as suggested by Carraro *et al.* (2008). As resorts cannot move higher up or on glaciers due the limitations of the terrain, slopes will increasingly be developed on North-facing aspects, and especially the larger resorts with higher turnover will continue to invest in more and improved artificial snow-making capacity, as documented by The Economist (2017). Due to the decreasing snow-conditions in many low-lying destinations, the larger resorts situated higher up the mountains and with better snow-making capability will cannibalize a large share of the visitors, and due to increasing inconvenience of not being able to ski down the hill to the valley in many destinations, visitors may further opt for resorts in other regions altogether. Enterprises succeed in persuading regional policies to continue the support of ski destinations through subsidies, loans and even by acquiring a share of the businesses or contributing to their expansion (OECD, 2007). Cooperation between nearby resorts will increase and mergers will occur to bring down the costs of the ski system operators. The intensifying cooperation will lead to new lift systems that link the resorts together being built to offer visitors more variability within a resort, despite most of the skiable area lying at decreasingly snow-reliable altitudes.

	– 4 °C	– 7 °C	– 10 °C
Snow capacity per snow gun	23 m ³ /h	34 m ³ /h	45 m ³ /h
Water use per snow gun	11 m ³ /h	15 m ³ /h	18 m ³ /h
Operating time	120 h	81 h	61 h
Total water consumption	5 261 m ³	4 853 m ³	4 400 m ³

Table 7: *Water consumption of artificial snow-making in Garmish-Partenkirchen, Germany (EEA, 2009). Electricity consumption for 1 m³ of snow is around 1.5 kWh (Rixen et al., 2011).*

Resorts will increase their marketing efforts to make the continued investments in ski resort infrastructure seen. New activities with low capital-intensity will be offered, like winter hiking, tobogganing and snow-shoeing, while spas, health clubs, event venues and on-and-off-slope entertainment hubs in the footprints of *Mille8* in Les Arcs will be built, and (OECD, 2007; Vanat, 2016). The new developments will be set up in new buildings to offer the increasingly international visitors first-class services and facilities. Extensive investments will also be made in improving the public transport network and the road network to improve the convenience of reaching the destinations (OECD, 2012). Resorts will try to compensate the increasing cost of electricity, due to the diminishing capacity to produce hydro and thermal power, and the disproportionately in-

creasing cost of producing artificial snow, due to more snow needed to be made under warmer conditions, by increasing ticket prices. As the water resources are diminishing and the run-off periods are changing, it too will become a more expensive commodity and to avoid conflicts between the drinking water supply and snow-making, more reservoirs will need to be built on the mountain sides. Due to the increasing ticket prices, some visitors will stay out (OECD, 2007; Fehringer, 2014).

The continued alteration of the Alpine landscape to better suit the needs of the winter sports sector will decrease the attractiveness of the region in the eyes of many summer tourists interested in hiking, health tourism, trail-running and traditional Alpine experiences. Mountain bikers and paragliders will benefit from the improved lift infrastructure and the added services in resorts. The few lakes in the Southern tip of Vorarlberg and the area around Lake Constance will become more popular in the more favorable Alpine summer weather, and especially Bregenz will draw more city tourism. The lake areas to the South of the state have very limited existing infrastructure and will likely remain as day trip destinations due to their isolation.

The perception among tourists will slowly start to turn more negative against the high consumption of natural resources, including in the choices of travel destinations and activities, due to the increasing level of awareness of the climate change. This will work against ski areas, but even more so the ageing of the majority of participants in skiing will decrease the number of visitors, while younger generations cannot be attracted to the sport due to the hard, time-consuming, and increasingly expensive learning process (Alpine Convention, 2013; Vanat, 2016).

The diminishing visitors and higher costs together with the high investments made by ski areas to ensure operation even under conditions of warming temperatures will serve to decrease the profitability of the businesses and likely lead to some areas closing their operation. The already decreasing trend of visitors will have put pressure on employment in SMEs and the closing down of the motor of a destination, the ski system operator, will leave many directly and indirectly affected unemployed. Due to the high focus on winter sports activities and the lack thereof on the summer season, many potential summer tourists will not find the possibilities in Vorarlberg, while others may even be pushed away by the continued efforts to ensure ski area operation and the resulting effects on the environment.

6.2 Sustainable adaptation

A sustainable strategy for the development of the tourism industry needs to consider future conditions regarding the climate, the demography of the visitors and the developing wants of tourists and tourism offers globally. To make adaptation more structured and organized, the state could oversee the development and implementation of adaptation measures, as suggested by OECD (2007). The Alpine Convention (2013) lists some policy instruments to support sustainable development, namely new legislation to avoid negative environmental and socio-cultural impacts and to guide the flows of public funding; improved and reviewed implementation of existing legislation; incentive programs for sustainable initiatives; activating stakeholders by facilitating public participation to policy making processes, although in a controlled manner to reduce the required time; communication and awareness raising for tourists; and incentivizing sustainable behavior on the tourists' side. Awareness raising within the tourism sector needs to occur constantly and to aid the decision-making processes of the tourism managers, local and regional information on climate change scenarios vulnerability assessments should be provided (ESPON, 2011b).

The winter sports sector is currently of high importance to the tourism industry in Vorarlberg and will continue to be for some time. Skiing and snow-making infrastructure should be maintained where the climatic conditions are favorable, and where conditions can be expected to remain favorable (Alpine Convention, 2013). Pütz *et al.* (2011) conclude that for the Swiss resort of Davos, losses of up to 10 % of the regional income may be prevented by artificial snow-making, and according to Rixen *et al.* (2011), it is probably reasonable to support skiing as a regional strength where it exists. Due to the comparably low mean altitude of the ski areas in Vorarlberg however, prudence needs to be applied in considering where will future climate conditions be more favorable towards snow-making, and especially the implications of the energy and water demand and the specific building of water reservoirs, decreasing the natural attractiveness of the area. To limit the negative economic implications imposed by the climate change, some resorts at lower altitudes could exit the ski market in a planned fashion, by ceasing the ski operation and focusing on re-naturalizing the area and offering summer time activities and snow-shoeing and ski touring in the winter, as less capital-intensive activities (OECD, 2007).

To enhance their operational efficiency, the cableway operators could start looking into increasing the synergy with summer activities in and around the resorts, e.g. mountain-biking, paragliding, summer tobogganing, adventure parks and themed walks. The length of the season could be shortened, e.g. by not opening in the quiet pre-Christmas period, or by closing earlier in the spring to decrease costs (OECD, 2007; Alpine Convention, 2013). The resorts in general could improve their offering of gastronomy, spas, health clubs, music events and festivals, fitness activities, climbing, hiking routes, and mountain farming (Ibid.). The winter tourism offer could also be improved by offering flexible ticket prices depending on the conditions of the slopes, winter hiking and snow-shoeing, freeride skiing and ski touring, tobogganing, and by innovating to reduce the required time to learn to ski. Year-round tourism could be boosted by on-and-off-slope entertainment hubs, like the *Mille8* in Les Arcs, bringing together activities and entertainment for the whole family (OECD, 2007; Alpine Convention, 2013; Vanat, 2016). Public transport to reach the destinations needs to be improved, e.g. by improving connections from long-distance trains and buses, and the transportation within a destination also needs to be improved. The increased mobility should persuade more tourists to opt to spend their holiday in the Alps instead of traveling elsewhere. Furthermore, the existing infrastructure and facilities need to be improved, especially considering summer tourism. Infrastructure developments should be based on old capacities, namely renovating and modifying existing buildings (OECD, 2012).

To respond to the changing demand by the ageing demographic of skiers and in general in Europe, service providers need to implement low-barrier hardware and services to allow for elderly people to go about their travels as they want without being specifically treated old. The ageing skier generation needs to be replaced with younger generations to avoid the number of visitors dropping. The expected increases in the demand of health care and cures, disease prevention, revitalization and wellness services and activities should be catered to (Alpine Convention, 2013; Kovats *et al.*, 2014; Vanat, 2016). The LOHAS target group of middle-aged people looking to increase their personal well-being to remain in active work-life longer is expected to actively demand such services. The increasingly well elderly are estimated to travel more with their entire family with, and the choice of destination will presumably depend on the offer of family and elderly friendly services and activities (Alpine Convention, 2013). The convenience and the quality of service provided in a destination is essential for retaining clients. Customer experiences should be made exceptional to win over market share

from competing international tourism destinations with newer offers of environment and activities (Vanat, 2016).

The adaptation efforts of the enterprises and the public need to be *planned* in the sense that long-term viability needs to act as the principle that dictates whether an adaptation measure should be implemented. Stakeholder groups from the ski industry should be prevented from stopping adaptation strategies besides those that aid ski sports. The image of the Alps as a traditional, rural region, with beautiful meadows and snowy peaks is important for attracting more summer tourists to the region and needs to be protected from soil consumption and urban sprawl (Alpine Convention, 2013). The commissioning of new buildings and water reservoirs reserved for artificial snow-making, and the available share of homes on offer as second homes and retirement homes could be limited to some degree in order to retain the image of an authentic destination and to limit damaging the cultural Alpine landscape (Ibid.). Destinations need to better learn to harness the internet and social media as marketing channels to attract younger audiences to the Alps. A marketing strategy should highlight the unique selling point of a destination and aim to portray the authentic identity and unspoilt mountains of the destination; be flexible to attract different interests, age groups and nationalities; and be innovative, in that it offers the recipient a new experience (Alpine Convention, 2013; Vanat, 2016).

Active planning to offer new activities and services and a higher quality of services needs to be undertaken early on to adapt to the expected changes in climatic conditions and demographics. Winter sports tourism dependent regions would do well to start planning the downscaling of ski areas, depending on the altitude, to avoid financial losses due to continued high investments in the face of decreasing incomes. The strategic planning and marketing of replacement activities, the authenticity of a destination where applicable, and the regional strengths, e.g. lakes, mountaineering possibilities or mountain biking, should be undertaken in the earliest of stages to start creating a brand of sustainability and to allow for tourists to associate a region with a very varied and interesting offer of touristic products, that is sustainable in retaining the environmental and socio-cultural conditions expected by tourists and the local population alike.

7 Conclusions

The topic of this thesis is “*The adaptation of European Alpine tourism to climate change*”, and the thesis has covered projected changes in the climate of the European Alps due to global warming, and the resulting effects on the Alpine regions and especially the tourism industry in the Alps. The existing literature reviewed for this thesis supplies a thorough look at past climatic developments and at expected future conditions. Literature also includes a wide array of adaptation measures, some of which are already being implemented by the industry and some of which are mere suggestions. The adaptation options presented in the literature are rather scattered, with individual authors making different, yet mostly complementary, suggestions for adaptation, and the literature does little to compile a thorough look at the different needs of adaptation measures and to evaluate possible outcomes for the implementation of a selection of measures.

The research question, *what does the climate change mean for tourism in the Alps and how should the region adapt*, meant to address this gap. The chosen method was to first document the base for the need of adaptation measures, namely the climate change and its effects, and to present the varied adaptation strategies suggested by the literature. To answer the research question, two different models of adaptation behavior were sketched and the implications of each were described.

Based on the research, it can be deducted that most tourism regions in the Alps are very dependent on ski tourism and intend to do what it takes to ensure the continuity of the income from ski tourism. The preferred adaptation measures seem to be technological and such that are likely not viable under future climate conditions imposed by global warming. The visitor numbers in the Alps are already stagnating and even decreasing at places, and the majority of the skiers of the world belong to the ageing “baby-boomers” generation. Literature indicates that very little is being done to address the issue of ageing on the side of the tourism industry. The ageing demographic, the decreasing consumer interest towards skiing in the younger generations, and the weakening of the conditions in which the ski industry currently operates calls for profound changes in the operation of the entire tourism industry in the Alps.

Investment and public funding should be cut from technological measures to adapt the ski industry to the changing climate in regions whose temperatures together with their

altitude dictate unfavorable conditions for ski tourism. The regions dependent on tourism need to start strategic planning to alter their offering to A) suit the future climate conditions, B) suit changing demographics, C) suit changing customer interests and consumer patterns, and D) ensure an authentic Alpine experience. The urban sprawl in the Alps needs to cease to ensure the cultural Alpine landscape essential for the development of summer tourism. Adaptation strategies need to be planned on the basis of long-term sustainability and avoiding conflict of interests between tourism and the Alpine population, as well as the populations in the surrounding low-lands who need the water flowing from the Alps for agriculture, drinking and the industry.

This thesis highlights the need of behavioral adaptation strategies in Alpine tourism by presenting the effects of the climate change on the Alps together with the implications of different adaptation strategies. The currently known technological adaptation measures may be considered maladaptation to a large extent. The looming declination of the skier demographic will change the income available to the tourism destinations in the Alps, and behavioral adaptation measures are the only way to attract new clients. The declination of the winter seasons in the sense of providing favorable conditions for skiing, the major source of tourism income for many regions, and the improving summer conditions, together with the somewhat declining conditions for summer tourism at the Mediterranean coast, present a strong case for shifting the operational focus towards summer tourism.

The hypothesis formed in the third chapter on the conceptual model holds true. Adaptive strategies should be evaluated based on the ability of the strategy to consider the future climatic conditions in a region, the location of the region, and the current status of the tourism sector. Linking the adaptation measures suggested by the literature to estimations of consequences in a specific region in the future should work as a warning example of what can happen without appropriate attention early on. The aim is to stimulate a more critical assessment of the direction of tourism in the Alps and to encourage to favor sustainable planning early on to allow for better preparedness in the face of changes.

The thesis does not give a fully dependable view on the outcomes of the explained models of adaptation strategies. The complete and correct prediction of future conditions is of course impossible, and rather the presented models are estimations intended to stimulate critical assessment. The thesis does little to present new adaptation

measures, which remain a field worth further research and more of which are required to be invented to provide a more diversified toolbox for the tourism industry. The regional climate projections and vulnerability assessments suggested in the literature as tools to aid tourism managers in decision-making also remain an issue worth continuous research.

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