WP T3: Smart Altitude Toolkit

Activity A.T3.2 Territorial Implementation plan

Climate Adaptation & Mitigation

Project acronym:	**Smart Altitude**
Project name:	Alpine winter tourism territories demonstrating an integrated framework for a low-carbon, high-impact and resilient future
Programme priority:	Priority 2 - Low Carbon Alpine Space
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1. Climate Change in Alpine Winter Tourism Territories

With its strong reliance on specific climatic and natural conditions, the ski industry is regarded as the tourism market most directly and more rapidly affected by climate change. As the Interreg ClimAlpTour Project highlighted in its last report, since the 1980s, the average winter temperature (December–February) in the Alps has increased by 1 °C and inter-year variability has also become more pronounced, with winters with minimal snow falls, such as in 2006-2007, alternating with winters with high snowfall, such as in 2008-2009. The impacts of climate change on the winter season are far from linear but important changes are already observed in snow cover, with a rise in the rain-snow limit and the rapid melting of the snow cover in anti-cyclonic weather or at the beginning and end of winter (ClimAlpTour, 2011).

In terms of economic and market impacts, a critical review of 119 academic publications carried out in 2019 (Steiger, Scott, Abegg, Pons, & Aall, 2019), that examined the climate change risk on ski tourism in 27 countries, highlighted the following general pattern: decreased reliability of ski slopes on natural snow, increased snowmaking requirements, shortened and more variable ski seasons, a contraction in the number of operating ski areas, altered competitiveness among and within regional ski markets, implications for ski tourism employment, change in real estate values. Extent and timing of these consequences depend on the rate of climate change and the types of adaptive responses by skiers as well as ski tourism destinations and their competitors (Steiger, Scott, Abegg, Pons, & Aall, 2019). The same study reports the demand changes observed during recent warm winters, concluding that the impact of snow-poor winter seasons differs greatly between individual ski areas, with higher elevation ski areas and large ski areas found to be less sensitive. Table 1 shows these data for South Tyrol (Italy) and Tyrol (Austria). The South Tyrol region, in particular, provides evidence for the economic benefit of investment in snowmaking adaptation. In fact, the massive investments in snowmaking facilities put in place in the 1990s and 2000s allowed to reduce significantly the losses in demand (number of skiers), although the temperature anomalies in the 1988–1989 and 2006–2007 seasons were almost identical.

Table 1: Impacts of extraordinary warm winter seasons on supply-side and demand side indicators (Steiger, Scott, Abegg, Pons, & Aall, 2019; Segnaposto1)

Authors	Region	Season	Temperature anomaly (temperature difference from current climate normals 1961-1990 or 1981-2010)	Analogue for future climate change	Demand change (skiers visits)	Supply change (operating days)
Steiger (2011a)	South Tyrol (Italy)	1988-1989	+2.6°C	A1B 2050s, B1 2070s	-33%	
Steiger (2011a)	South Tyrol (Italy)	2006-2007	+2.9°C	A1B 2050s, B1 2070s	-2%	
Steiger (2011b)	Tyrol (Austria)	2006-2007	+3°C	A1B 2060s, B1 2080s	-11%	-10%

Climate change is considered as a source of opportunities and threats. While it could potentially benefit summer mountain tourism, it is providing increasing challenges for winter tourism destinations. According to the ClimAlpTour project, 57 of the 666 main ski resorts of the Alps are already considered not to be snow-reliable, with obvious consequences for the competitiveness. The same project analysed 22 pilot areas with diverse environmental, social and economic conditions in order to provide a global perspective on the Alpine tourism. The results confirm the lack of a single simple strategy to cope with the issue at stake throughout the Alps (ClimAlpTour, 2011). The project concluded that future socioeconomic scenarios are as crucial as climate conditions, such as trends in tourism demand, maturity of many destinations and market saturation, globalization with exponential increase in the number of competitors and changed travellers' behaviour, increasing energy costs, reduced water availability affecting also snow making. For these reasons, the traditional development model of the ski resorts is more and more challenged, with the increasing need for more innovative, flexible and sustainable business models (ClimAlpTour, 2011).

ClimAlpTour drew interesting conclusions on the further steps to be taken, based on lessons learnt from the project. We list them in Figure 1, as they are strictly related to Smart Altitude project and should be taken into consideration as an introductory framework by any ski resort approaching the Smart Altitude Decision-Making Tree.

Interreg Alpine Space Project ClimAlpTour, Final project report (2011)
Conclusions: Further steps to be taken

1) Differentiating development strategies to reduce seasonality: Alpine resorts should move away from traditional winter and summer experiences; that is, based only on skiing and hiking. Instead, they should integrate investments in developing wine and food tourism, marketing local products and tasting tours, wellness activities, and hosting sports and cultural events, to mention just a few. All of these products are greatly appreciated at those Alpine resorts that promote them, which are increasingly becoming more popular than those where only traditional activities are promoted.

2) Coordinating locally tailored development strategies under Alpine Convention objectives, in line with sustainable development principles. Not every destination can offer the entire range of activities outlined above. ClimAlpTour results demonstrate that it is strongly advised to develop specific trademarks that make the destination unique by exploiting its specific potential. In turn, this will limit the risks resulting from fierce global competition in tourism. Cases of best practices should be communicated to promote exchange of experience within the Alpine area.

3) Concerted efforts towards long-term adaptation schemes, at both the regional and local levels, should become a priority and last beyond the term of a single political administration. Public investments should be utilized for long-term planning. These must pay particular attention to environmental protection and climate projections. It is necessary to build on and exploit local stakeholders' interest in climate-change issues to create dynamism for exploring potential development options.

Figure 1: Conclusions from Interreg ClimAlpTour Final Project report (2011)

2. Climate Adaptation

In the climate change literature, adaptation is referred to a change in response to environmental conditions that maintains or enhances the viability of a system (Bicknell & McManus, 2006). The European Commission (EC) refers to adaptation as "anticipating the adverse effects of climate change and taking appropriate action to prevent or minimise the damage they can cause or taking advantage of opportunities that may arise". Moreover, EC points out that adaptation strategies are needed at all levels of administration, from local to the international level; however, "due to the varying severity and nature of climate impacts between regions in Europe, most adaptation initiatives will be taken at the regional or local levels" (EU Commission official Website[1]).

Adaptation is therefore a necessary strategy also for mountain regions and winter tourism areas, even if this entails a number of challenges.

[1] https://ec.europa.eu/clima/policies/adaptation_en

Climate variability across regions means it is difficult to understand the regional climate implications at one specific ski area. The expected scenario foresees a contraction of viable ski resorts that favours climatically advantaged regions. However, although these regions and associated communities are likely to benefit from increased or stable tourism revenue, they will still need to adapt to changing climate conditions and prepare for the possibility of increased development pressures, crowding, and infrastructure deficiencies (Dawson & Scott, 2013). In turn, communities loosing ski tourism operations will need to develop economic diversification strategies, due to lost winter tourism revenues and related jobs, and could also see increased pressure on social services and unemployment as well as a drop in real-estate value (Hamilton, Brown, & Keim, 2007); (Scott & McBoyle, Climate change adaptation in the ski industry, 2007).

The more vulnerable ski areas will, at varying points, need to determine if they should invest heavily in adaptations that will aid in the continuation of a snow-based business at least in the short to medium term (i.e. high efficiency snowmaking), if they should invest in adapting and evolving into a multi-season destination (i.e. four-season resort, spa, conference centre), or if they ultimately need to terminate their business altogether (Dawson & Scott, 2013). In order to take these decisions, it is very important that ski area managers consider both supply-side and demand-side implications of a changing climate.

Figure 2 shows an inventory of climate adaptation practices used by ski industry stakeholders around the world, where adaptation options are organized by type of actor in order to reflect the importance of engaging the different stakeholders who are motivated by different factors (Scott & McBoyle, Climate change adaptation in the ski industry, 2007). If we look at ski area operators, the range of adaptation practices are organized into two main types: technological (snowmaking systems, slope development and operational practices) and business practices (ski conglomerates, revenue diversification, marketing, indoor ski areas). However, the importance of other actors for successful adaptation should not be underestimated, including the government and public administrations, the financial sector and the final users.

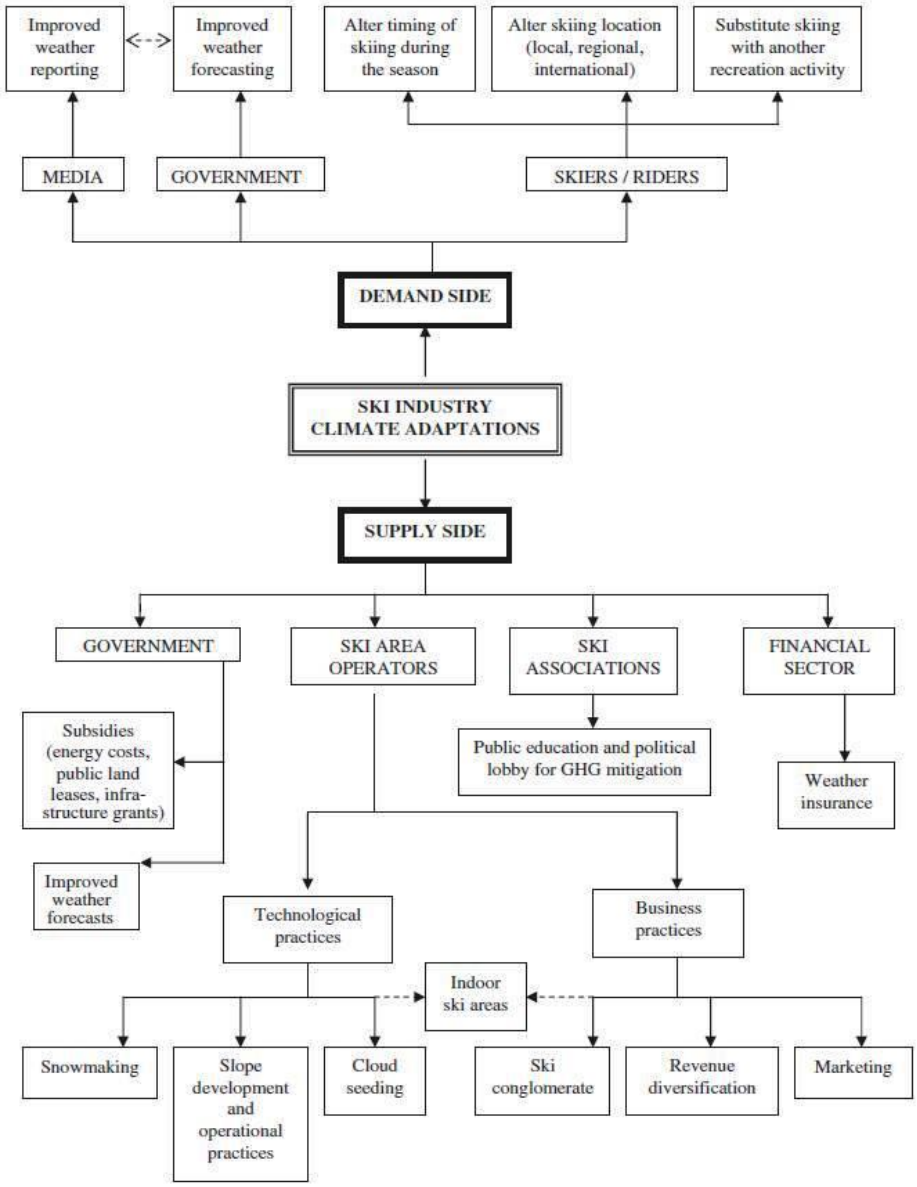

Figure 2: Inventory of Adaptation options in ski resorts around the world (Scott & McBoyle 2007)

Also, the results of the Interreg Alpine Space project ClimChAlp summarise the possible adaptation strategies for ski resorts in accordance with the figure above. Besides snow making, **technological strategies** include shifting slopes to higher altitudes, avoid south facing slopes, increase snow shading (through tree cover along slope margins), build artificial slopes and enhance weather forecasting to support programming of the ski season.

Besides technological practices, also **business practices** should not be overlooked (Figure 2).

The conglomerate business model (joining several ski resorts) may prove to be one of the most effective adaptations to future climate change, as it provides greater access to capital

and marketing resources, thus enhancing adaptive capacity, but also reduces the vulnerability of the conglomerate to the effects of climate variability and future climatic change, through regional diversification in business operations (Scott & McBoyle, Climate change adaptation in the ski industry, 2007).
Cooperation between lower and higher-elevation resorts lead to mutual advantages: the first, acting on wide market segments, could offer activities and services that complement skiing and cheaper accommodation facilities, whereas the second, thanks to cooperation with less well-known resorts (that are, however, often characterized by a richer cultural identity), can expand and differentiate what they offer (ClimAlpTour, 2011).

Revenue diversification is also necessary, especially for most vulnerable ski areas, but not only. Diversify the winter tourist offer and/or the whole year-round offer is now an essential strategy to adapt. It is necessary to identify potential resources for tourism, such as cultural and natural heritage or the wellness segment, and to make them viable. In a number of destinations, there is a demand to focus more on valuable local resources (local products and traditions, natural resources, etc.) for both tourists and local stakeholders (ClimAlpTour, 2011).

Finally, **marketing strategies** should be primarily focused on that particular differentiating element characterizing the resort/conglomerate. Furthermore, ski companies have already begun to experiment with incentives or guarantees to overcome skiers' reluctance to book a ski holiday because of uncertain snow conditions (Scott, McBoyle, & Minogue, 2007), or to reduce the costs of short holidays.

Of course, each strategy has limits and consequences, which should be carefully assessed at the planning stage. Figure 3 summarises the limits for each main adaptation strategy discussed above, based both on a literature review and as a result of interviewing stakeholders in the Australian Alps (Morrison & Pickering, 2013).

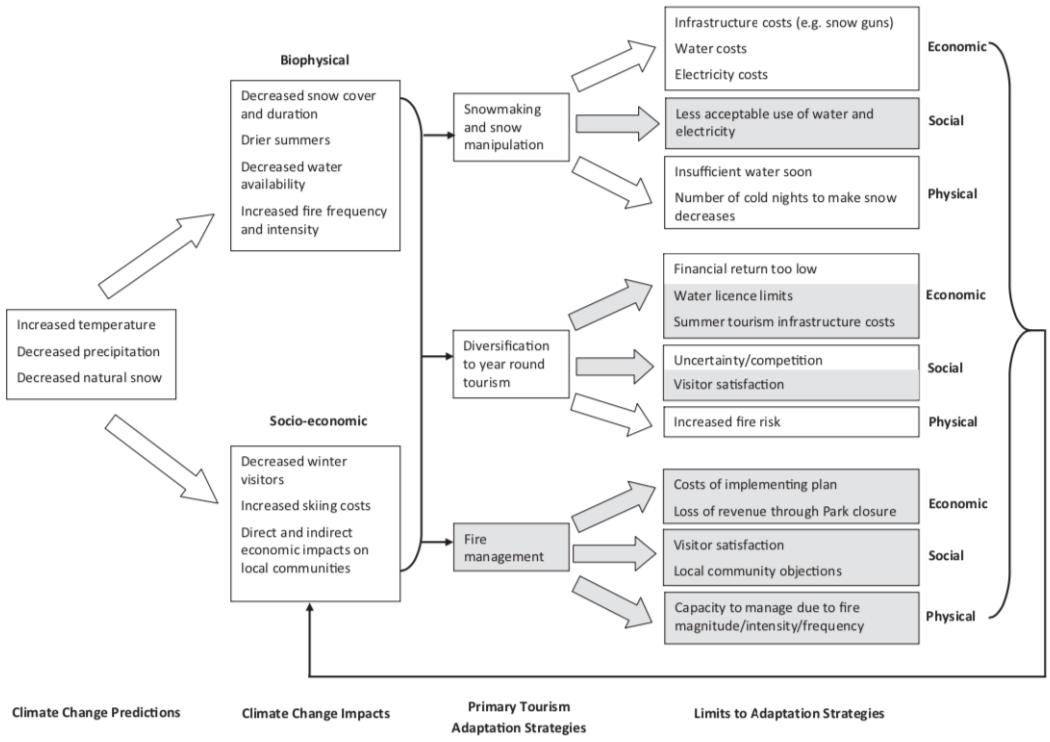

Figure 3: Adaptation strategies and their potential limits (Morrison and Pickering 2013)

Conclusions from the ClimALp project final report are again useful to close this overview of adaptation strategies for ski resorts in the Alps.

The report highlights that **climate change** will not only have negative impacts on winter tourism in the medium to long term but **can also be seen as an opportunity to more rapidly implement the structural change** necessary for dealing with the current crisis that the tourism sector is experiencing. The survival of the ski industry is not in question, but the "one-way exploitation" of mountain areas is.

A second important conclusion is that **adaptation should be mainstreamed into long-term tourism planning** and should not be considered in isolation, as reported below:
"Climate change is just another pressure being placed on already stressed tourism systems, which have specific strengths and weaknesses. Although tourism demand is very adaptive and tourists' behaviour is constantly and rapidly evolving, the tourism supply (referring to Alpine destinations as a whole) needs more time to plan activities in order to respect social, economic and environmental constraints. There certainly are autonomous activities (e.g., artificial snow, ski slope design, etc.) that tourism suppliers can engage in, but the most crucial part of the adaptation effort will be played by "planned adaptation." Climate change is merely an opportunity to involve the most appropriate set of local stakeholders in the process of defining

activities to improve the sustainability of tourism within each Alpine resort" (ClimAlpTour, 2011).

Another important point we wish to report from ClimAlpTour is that in the participatory workshops, that have been taking place over the length of the project, the local stakeholders have proven to be the sentinels of climate changes as they are already deeply interested in this issue and aware of it, expressing the desire for a higher degree of inclusivity and participation. Thus, **engaging local stakeholders** is essential, including the local population and businesses. What is still missing in many areas is the capacity to have the stakeholders sit together and agree on how to proceed to improve the situation, but ClimAlpTour demonstrated that, when consulted in an appropriate way, the local community might indeed have a coherent and "climate change-safe" vision of what the future of Alpine tourism could look like.

A final remark for this chapter is that **policy makers should enable effective and cost-efficient adaptation** as some strategies will require investments, long term planning decisions and amortization times (Hoffmann, Sprengel, Ziegler, Kolb, & Abegg, 2009). Examples on how policy makers could increase the scope of corporate adaptation are: influencing the level of awareness of possible climate change effects, including providing research and information such as improved climate forecasting (Scott & McBoyle, Climate change adaptation in the ski industry, 2007); provide financial support (e.g. tax breaks on adaptation investments, subsidies); provide capacity building (e.g. technical support, skills trainings). Moreover, policy makers should attempt to bring corporate adaptation in line with their desired direction of local or regional adaptation, as defined in regional and local plans (Hoffmann, Sprengel, Ziegler, Kolb, & Abegg, 2009).

3. Climate Mitigation

Due to the impacts that climate change will have on the Alpine Region, climate mitigation strategies are an essential element to be taken into account within the tourism sector. Mitigation measures are defined as those actions, implemented by a business and/or a policymaker, that reduce and curb carbon dioxide emissions in the atmosphere (Lucena, et al., 2018). The Smart Altitude project aims to demonstrate the potential of mitigation strategies such us energy efficiency, renewable energy, sustainable mobility, energy management and smart grid across the Alpine Region. Mitigation strategies set in place by a ski resort, as underline by Lucena, et al. (2018), will have an influence not only on the GHG emissions but also on the resilience of the business model and the energy system, which will be inevitably exposed to future impacts of climate change.

Within this chapter we will assess climate mitigation options for alpine ski resorts.

Climate mitigation in ski resorts

Natural snow reliability has an influence on tourism demand for a specific winter location (Damm, Köberl, & Prettenthaler, 2014). Energy demand in the winter tourism industry is rapidly increasing because, in addition to consumption for ski lifts and snow groomers, the implementation of snow making systems is at present the most widely utilized adaptation strategy (ClimAlpTour, 2011). However, there are some challenges in the snowmaking capacity of a ski resort, namely the increasing temperatures (with a consequent decreased efficiency of artificial snow production) and the potential increase in energy prices if the shift to renewable energy does not accelerate (Damm, Köberl, & Prettenthaler, 2014); (Steiger, 2010).
The costs and benefits of artificial snowmaking are dependent from several factors such as future climate scenario, snow pack scenario and resources availability (Hanzer, Marke, Steiger, & Strasser, 2012) (Damm, Köberl, & Prettenthaler, 2014). In the analysis carried out by Damm et al. (2014), electricity costs were found to be the main variable cost factor of snowmaking.

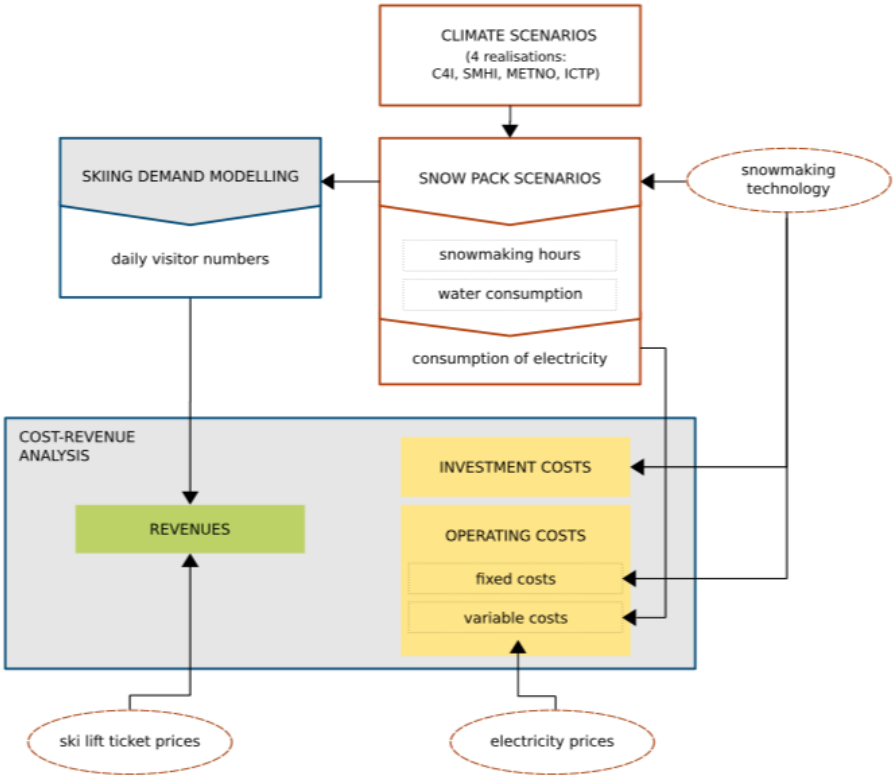

Figure 4: Causalities in determining costs and benefits of artificial snow production (Damm et al., 2014)

Taking this into account, it is of vital importance to assess energy efficiency in artificial snow making: improving energy efficiency will indeed lower the resort's running costs and make the business model more sustainable in the long run.

The strategies that could be set in place to improve the energy usage in a ski resort are: (i) Calculate the specific electricity consumption – Audit Process, (ii) Monitor the consumption data – through the implementation of an Energy Management System (EMS), (iii) Implement energy savings measures, (iv) Implement renewable energy sources (RES) (Motiva, 2008).

The implementation of an EMS, energy saving measures and RES within a ski resort will bring along several benefits, such as (i) Immediate cost savings, (ii) Long-term benefits and an increased resilience capacity towards climate change, (iii) Increased customer appeal (NSAA Association, 2006). These measures could be implemented in the whole ski resort, including ski lifting, snow making and snow grooming, as well as onto building related to the customers frequenting the ski resort.

Specifically, ski resorts operators, in order to curb their emissions, could focus on the implementation of a renewable energy mix in the whole ski area while at the same time implementing measures that will reduce their energy consumption, such as the ones reported in Table 2:

Table 2: Possible climate change mitigation measures for Ski resorts

Mitigation Measures	
Overall ski resort	Monitoring and Integrated Energy Management System (IEMS)
Ski lifting	Monitor and implement an EMS
	Assess ski lifts energy efficiency
	Implement heat recovery
	Implement renewable energy sources (e.g. PV)
	Implement speed control measures (e.g. based on the number of entrances)
Snow making	Optimal water management (flow rates, height differences, main and secondary reservoirs, water concessions)
	Through the analysis of the pumps for the distribution of water and their working points, interesting ideas can be found for the reduction of unnecessary oversize, operation outside the optimum range, replacement of inefficient pumps
	Replace old snow-making systems with modern technology

	Implement an automated snow making system
	Plan which kind of snow making system is the most effective for the ski resort (Fan gun, Hybrid/tower, Hybrid/high-pressure)
	Implement renewable energy sources
Snow grooming	Verification of the systems available for the management of the snow groomers' park and for the management of the snow groomers' routes. The advantages are several: • reduction of maintenance costs; • reduction of fuel consumption through the optimization of routes; • control of the work on the slopes (thickness of the snow); • online monitoring of the machines (e.g. position, speed, with advantages for safety and consumption)
	Replace old grooming machines with newer ones
	Implement hybrid/electric snow groomers
Buildings	Assess the energy consumption of the ski resorts building and improve the heating system and ventilation
	Replace indoor and outdoor lighting with energy-efficient lightbulbs and an automated lighting control
	Improve the energy efficiency of building envelopes
	Implement renewable energy sources for heating and electricity

4. Synergies between Adaptation and Mitigation

The current phenomenon of climate change represents a new challenge for the winter tourism industry in the Alps (Michailidou, Vlachokostas, & Moussiopoulos, 2016). Elsasser and Bürki underlined that it "has to be viewed as a catalyst that will reinforce and accelerate the pace of structural change in the tourist industry and more clearly highlight the risks and opportunities inherent in tourist developments" (Elsasser & Bürki, 2002). This structural change within the tourism sector should be accompanied by the implementation of new policies and strategies, which must consider both climate mitigation and climate adaptation measures.

These synergies between adaptation and mitigation measures are evident, especially when considering a climate-dependent industry such as the winter tourism one (Figure 5). Indeed, the tourism industry is nowadays asked to adapt to new climatic conditions, compiling with environmental constraints, and at the same time have a leadership role in mitigation actions (Scott, D.; Amelung, B.; Becken, S.; Ceron, J. P.; Dubois, G.; Gössling, S.; ...Simpson, M., 2008) (Scott, 2011). When considering ski resorts, future climate conditions will have a direct impact

on their ability to operate and attract tourists. These future conditions "may threaten the implementation of artificial snow, especially in low altitude resorts with physical and economic limitations. Resorts may have to deal with an increase in water and energy consumption, and a reduction in the number of days with low temperatures that are suitable for snow production, threatening their economic viability" (Campos Rodrigues, Freire-González, Gonzalez Puig, & Puig-Ventosa).

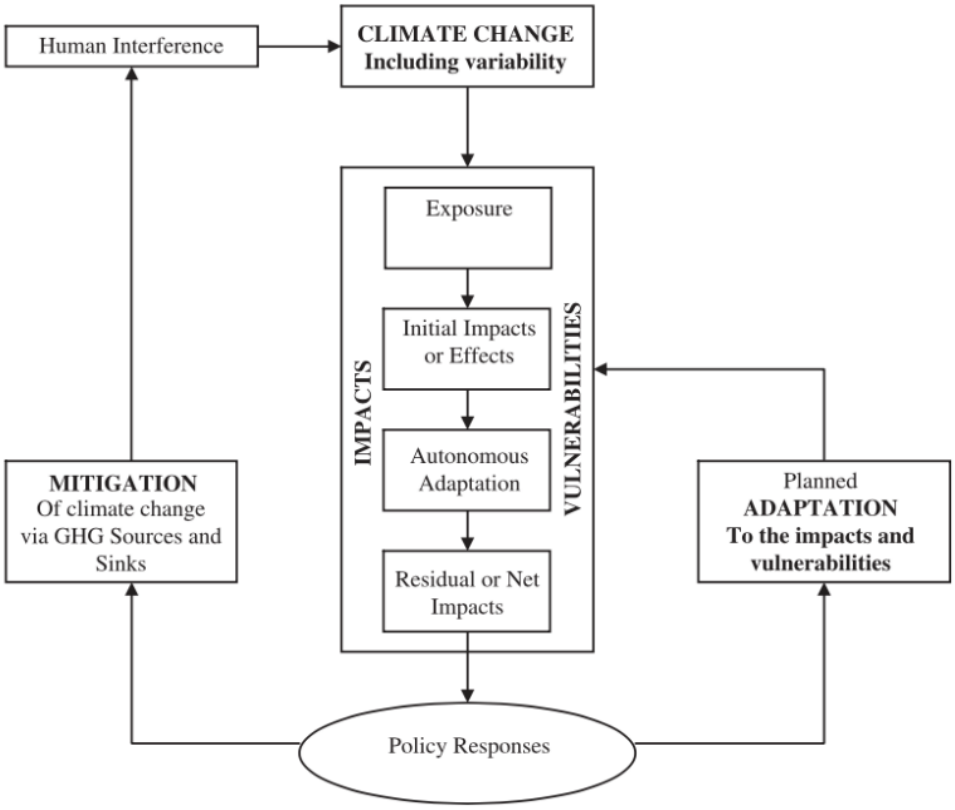

Figure 5 Climate adaptation and mitigation measures (Bicknell & McManus, 2006)

Mitigation and adaptation measures should be both integrated not only within ski resort's business plans but should also be taken into account by local, regional and national policies focusing on winter tourism. This approach could be obtained through the inclusion of different stakeholders in the decision-making process of ski resorts, among which policy makers and tourism associations, as suggested by the Smart Altitude's Decision-Making Tree. Kaján and Saarinen underlined that this process of "indirect policy involvement could assist in forming more sustainable business practices" integrating also land, water and energy consumption regulations (Kaján & Saarinen); (Scott & McBoyle, 2007). These studies underlined the need for new policy frameworks, from the local level up to the European-International one (Kaján & Saarinen); (Scott & McBoyle, 2007); (Mochurova, Kaloyanov, & Mishev, 2010).

On top of constituting an important asset for the future resilience of ski resorts, a mix of adaptation and mitigation measures provides also the opportunity to improve the marketing strategies of an area. Tourists' attitude towards artificial snowmaking as it stands were found to be mixed because of ecological reasons and the increased use of resources that an artificial snow-covered area entail (Pütz, et al., 2011); (Saarinen & Tervo, 2006). Implementing a renewable energy mix, reducing GHG emissions and focusing on the communication of the efforts a ski resort implements could improve the stakeholder perception of the local tourism industry while at the same time reducing the impact of a changing climate (Dinca, Surugiu, Surugiu, & Frent, 2014). For this reason, marketing and communication efforts are underlined as key components within the Smart Altitude's Decision-Making Tree.