WP T3 Smart Altitude Toolkit: planning, optimizing and implementing high impact low-carbon policies

Activity A.T3.1 Decision-Making Criteria: outlining each step and decision-making factor

D.T3.1.1 Smart Altitude Decision-Making Tree

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Table of Contents

Executive Summary

This report describes the Smart Altitude Decision-Making Tree (D.T.3.1.1), designed as a comprehensive approach of parameters envisaged for the implementation of low-carbon interventions in alpine winter tourism areas. It starts with an overview of the impact of climate change in winter tourism territories, providing a literature review of climate adaptation and mitigation in these regions. The importance of achieving synergies between adaptation and mitigation is also highlighted. The Smart Altitude Decision-Making Tree is then reported graphically and described, as a step-by-step process to plan and implement low carbon measures in ski resorts. The tool has been designed for ski resort operators, however engagement of policy makers and relevant stakeholders is essential to support these actions and are here mentioned referring to the links with specific project activities which will tackle these issues (A.T3.2 and A.T3.3).

1. Introduction

This document consists of deliverable D.T3.1.1 Smart Altitude Decision-Making Tree, part of Activity A.T3.1. The Decision-Making Tree aims to support decision makers of Alpine winter tourism regions, specifically ski resort operators, to plan and implement low carbon interventions in relation to energy efficiency, renewable energy, sustainable mobility, energy management, smart grid and climate adaptation. The tree is integrated with the activities and results of Smart Altitude WP T1 (Smart Altitude Dashboard: WebGIS, monitoring systems, KPIs), WP T2 (lessons learnt from the three project's Living Labs), other activities and deliverables of WP T3 (Territorial Implementation Plans, Stakeholder Engagement Plan), WP T4 (involvement of replicators and policy makers), WP TC (promote low carbon interventions). The Decision-Making Tree will be implemented within an online interface (D.T3.1.2), providing an interactive step-by-step online tool, outlining all steps and decisions required for climate adaptation and mitigation in winter tourism resorts.

2. 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)

2.1. 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]).

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

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

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, 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, 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.

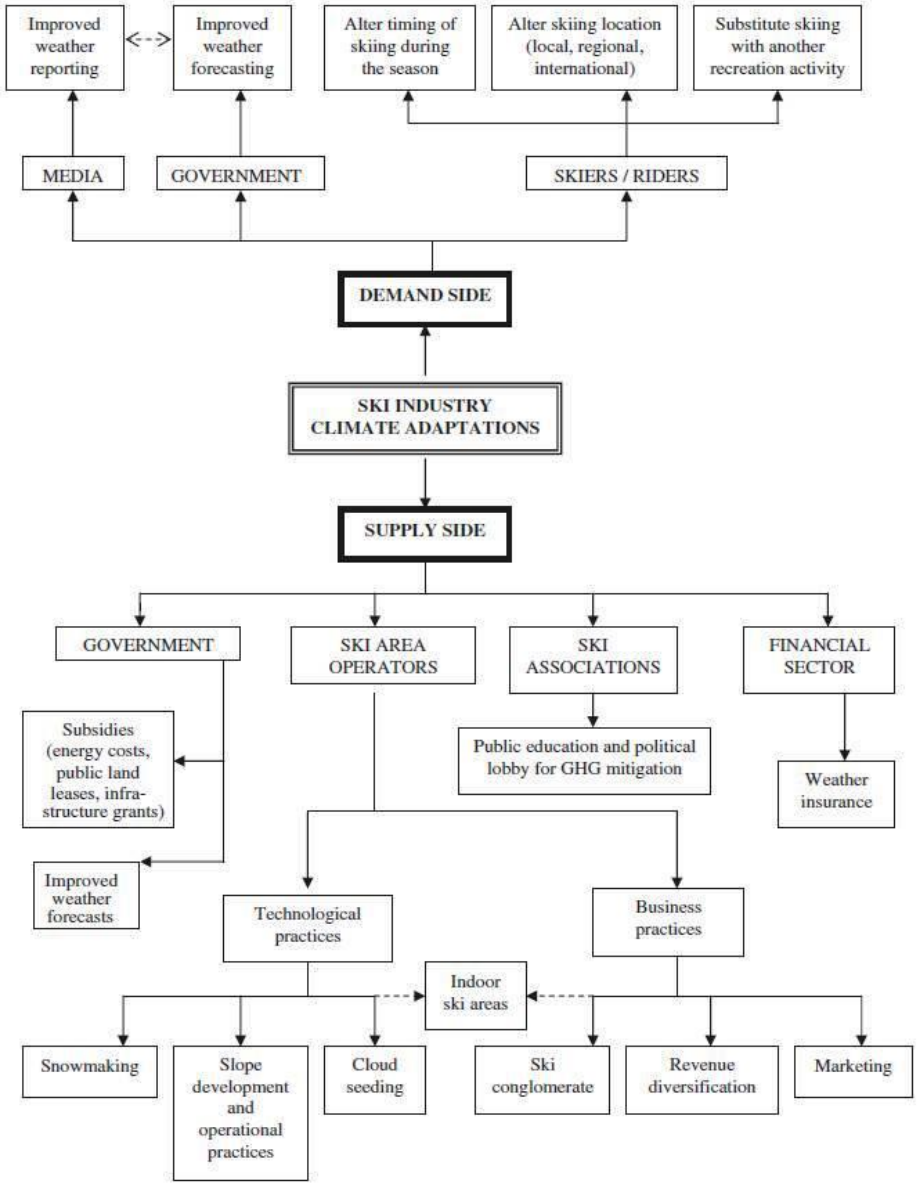

Figure 2: Inventory of Adaptation options in ski resorts around the world (Scott & McBoyle 2007)

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, 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).

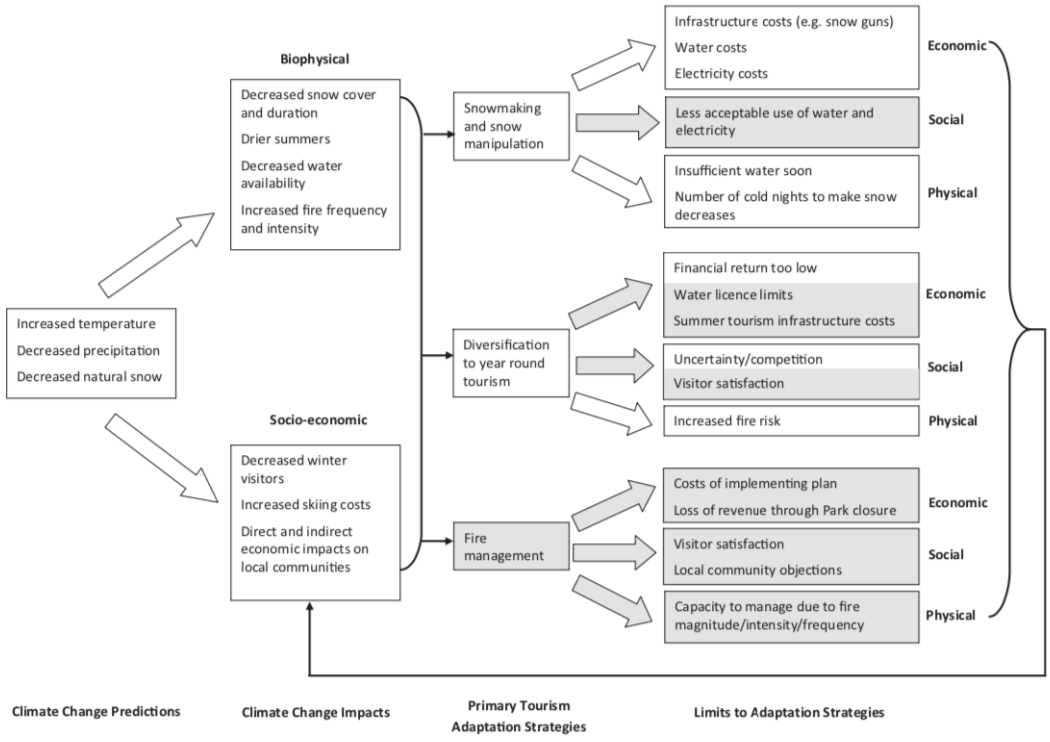

Figure 3: Adaptation strategies and their potential limits (Morrison and Pickering 2013)

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, 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).

2.2. 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.

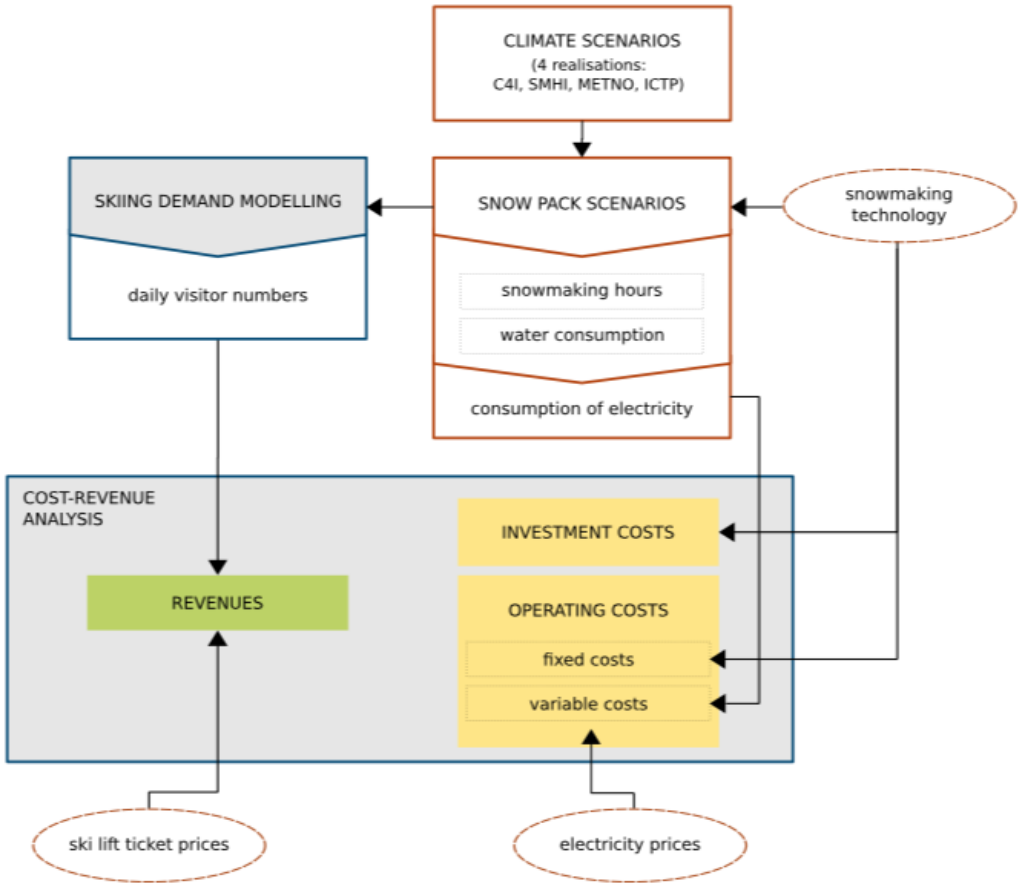

Figure 4: Causalities in determining costs and benefits of artificial snow production (Damm et al., 2014)

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

2.3. 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.

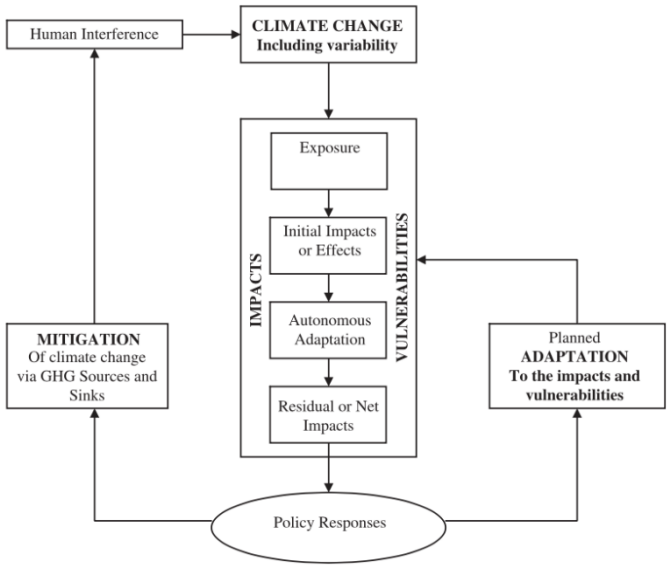

Figure 5 Climate adaptation and mitigation measures (Bicknell & McManus, 2006)

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).

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 (see chapter 3). 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 (see chapter 3).

3. Smart Altitude Decision-Making Tree

3.1. Aim and Objectives

The aim of the Smart Altitude Decision-Making Tree (DMT) is to provide the ski resort operators with a comprehensive approach of interventions useful for the selection and implementation of low-carbon measures, particularly focusing on energy efficiency, renewable energy, sustainable mobility, energy management, smart grid and climate adaptation, which are the key areas on which project's Living Labs focus on.

The DMT is designed as a toolkit outlining steps and decision-making factors, that ski resort operators should go through for successful implementation and refers to elements and tools developed by Smart Altitude and tested by the project's Living Labs and the project's replicators.

Even if the DMT has been designed for ski resort operators, as key decision makers targeted by Smart Altitude, the importance of policy makers and other stakeholders is not underestimated. Indeed, as described in the next chapter, policies of various kind should support the planning and implementation of measures, and relevant stakeholders, including private, public sectors and the final users, should be engaged throughout the whole process.

An online platform (D.T3.1.2) will replicate the DMT in an interactive mode, allowing implementation of mitigation and adaptation strategies, based on territorial characteristics and objectives of the user. Once finalised, the Smart Altitude Toolkit will provide a step-by-step online tool declining key stages and decisions required for a comprehensive mitigation and adaptation strategy of winter tourism destinations.

3.2. Structure and logic

The DMT structure is provided in Figure 6, which summarises the key steps allowing ski resort operators to successfully implement and enhance mitigation and adaptation measures.

Each step refers to a tool developed by the Smart Altitude project, highlighted in the yellow boxes, which enables to perform the step. The tools will be tested by Smart Altitude Living Labs and made available to the replication sites across the Alpine Space.

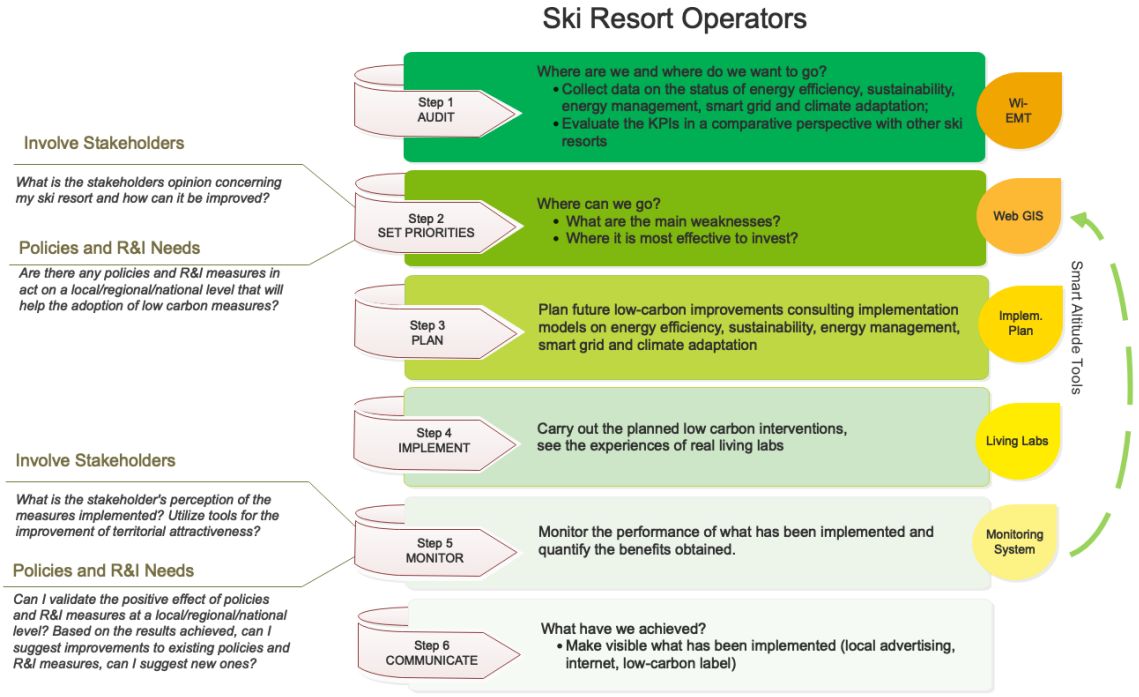

Figure 6: Smart Altitude Decision Making Tree (structure)

The steps, designed within a management cycle perspective for continuous improvement of the strategy set in place, are described below.

Step 1: AUDIT

The first step includes the collection of data regarding the status of the ski area. In order to do this, Smart Altitude partners have developed a tool, called "Wi-EMT" (Winter tourism Eco-energy Management Tool, Figure 7), through which the users can report data describing the current situation of energy efficiency, sustainability, energy management, smart grid and climate adaptation of the ski resort. The tool also allows to evaluate the Key Performance

Indicators (KPIs) of the area in a comparative perspective to other ski resorts that have filled in the same tool during Smart Altitude project.

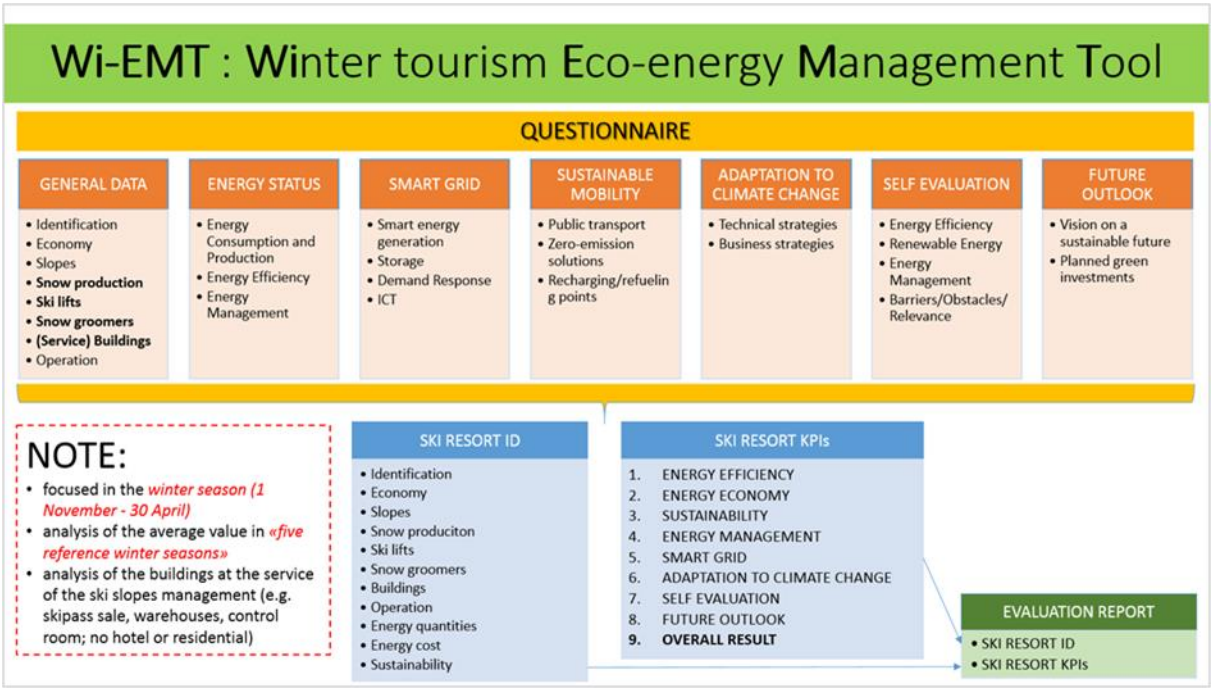

Figure 7: Smart Altitude Wi-EMT

Step 2: SET PRIORITIES

The second step is to set priorities based on results of the Wi-EMT. Moreover, the Smart Altitude WebGIS offers the ability to visualize ski resort performance and potential of renewable sources, through a web visualisation of Alpine Space ski areas with different layers populated through a database. However, it is important to stress that the WebGIS can give an idea about the renewable energy potential in a certain area, but it does not give any indication about how realistic it is for a ski area to tap into this potential. During this phase a participatory method, through the involvement of local,regional and national stakeholders, will allow ski resort operators to receive opinions and identify linkable policies and R&I measures. This should bridge the gap between policymakers and the implementation level, taking into account the territorial assets (Kaján & Saarinen, 2013); (Becken, 2005); (Turton, et al., 2010).

By comparing status quo from Step 1 and potential from Step 2, decision makers can assess the gap and decide where to invest effectively.

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Step 3: PLAN

Following audit and priority setting, decision makers can start with the Implementation Planning of mitigation and adaptation improvements; the Implementation Models on energy efficiency, sustainability (renewable energy and sustainable mobility), energy management, smart grid and climate adaptation, provided by Smart Altitude partners should help in guiding the process (see chapter 3.3).

Step 4: IMPLEMENT

After planning, real implementation of planned measures can start. The implementation of Smart Altitude interventions is conducted by 3 Living Labs (Les Orres, Madonna di Campiglio, Krvavec), based on the engagement of relevant stakeholders. The Smart Altitude Living Labs represent lighthouses of innovative and high impact low carbon interventions in ski resorts, in several topics (advanced energy efficiency, integrated energy management systems, RES integration, smart grid), in different geographic areas.

Step 5: MONITOR

Monitoring the performance of what has been implemented and quantifying the benefits obtained is crucial, as in any management cycle, in order to ensure continuous improvement. The Smart Altitude Monitoring System is the tool that allows to monitor effects and impacts of implemented measures; impact evaluation allows to start the process again by setting new goals and targets and continue with implementation of further mitigation and adaptation options. During this step, the direct involvement of stakeholders identified during step two should be considered. As underlined in previous literature, this could assist operators and policy makers in forming an integrated policy plan, increasing the ability of the ski area to adapt to a changing climate and to attract tourists (Kaján & Saarinen, 2013); (Scott & McBoyle, 2007).

Step 6: COMMUNICATE

A further step that cannot be left behind is marketing and exploitation of results: it is crucial to make what has been implemented visible to stakeholders also in terms of estimated effects and benefits. This will allow to be accountable towards local, regional and national stakeholders and to maximise attractiveness towards the wider public and final users (tourists). Stakeholders can be both targets and promoters of communication activities. This step is linked to activity 3.3 of Smart Altitude (Stakeholder engagement plan for attractive low carbon territories).

The **engagement of policy makers and other stakeholders** is crucial since the beginning of the cycle. This is highlighted on the left hand side of Figure 6, especially in steps 2, 5 and 6. More

insights into this matter will be provided by Smart Altitude "Report on territorial stakeholder engagement" (deliverable 3.3.1), to which we refer for more details.
In general, relevant stakeholders should be engaged already in the data collection process and surely when setting targets and goals, based on a Stakeholder Analysis, which allows to identify and prioritise stakeholders based on their interest and influence on the project to be implemented, and thus to set the strategy for their engagement throughout the process. Their opinions and expectations should be carefully assessed while setting goals (step 2) and finally reviewed at the monitoring stage (step 5). Finally, stakeholders can be both targets and promoters of communication activities (step 6).
Policies and Research & Innovation (R&I) are also important, enabling or hampering the effective implementation of mitigation or adaptation measures. A policy grid review can help in identifying and assessing these at the beginning of the process (step 2) and recommendations for policy improvement and better R&I measures may be formulated at the monitoring stage (step 5). Further details on these tools will be provided in Smart Altitude "Report on territorial stakeholder engagement" (deliverable 3.3.1).

3.3. Integration with Smart Altitude Implementation Plans (AT3.2)

Within Activity 3.2, Smart Altitude will provide a set of implementation models to maximize GHG reduction, adaptation to climate change, economic impact and stakeholder benefits along 6 axes: energy efficiency, sustainability (renewable energy and sustainable mobility), energy management, smart grid, climate adaptation, value creation through low-carbon innovation. The models will evolve from an analysis of the best existing technologies and research prospects, ski resort best practices and the experience of the 3 project Living Labs. Moreover, they should provide insights on risk and revenue sharing, business models, financing, potential investors, infrastructure management and contracting. They will be summarised and compared within a Territorial Maximization report (D.T3.2.1), providing a SWOT analysis, recommendations for replicability and innovation needs identification. Results will be integrated in the Project Toolkit (T3.1). The implementation models should support Smart Altitude replication in other sites, by providing any policy or decision maker the evidence of the economic, social and environmental benefits achieved by the models suggested.

3.4. Integration with coherent and inclusive climate policies and territorial attractiveness (AT3.3)

As explained in chapter 3.2, the action of ski resort operators should be supported and integrated with policies and effective stakeholder engagement.

As findings from ClimAlpTour Project show, the tourist destinations and their actors are the base of the tourism economy and are thus the key actors for implementing measures, however their action must be supported and be coherent with that of governmental actors in order to move towards a long-term adaptation and mitigation strategy of winter tourism regions. Municipalities, cantons and regions, as well as national governments, have great importance, both because of their role in legal execution, but also because of their potential role in raising awareness among actors and creating the framework conditions that promote adaption and mitigation (ClimAlpTour, 2011). Besides policy makers, the following stakeholders are highlighted with different roles:

- supra-regional tourism institutions (e.g., lobbying, information, and awareness-raising);
- actors at supra-national levels (e.g., creation and coordination of legal frameworks for adaption);
- actors from research, NGOs, and other organizations (e.g., professional and critical monitoring, awareness-raising).
- local actors (energy, SME, local economy, environment, tourism sector and local communities).

Each stakeholder group has different degree of importance and specific functions in the adaption and mitigation process and all should be considered and engaged.

Furthermore, climate change adaptation and mitigation strategies should be seen within an overall framework of promoting sustainable business models for winter tourism destinations which should become the most attractive as possible. According to ClimAlpTour results, among the crucial actions to be taken there is the need for Alpine tourism destinations to be identifiable; key ingredients for this are the local culture, handicrafts, gastronomy, agriculture as well as transportation and energy models, which have huge impact on these areas. Thus, sound reflection on how to improve their sustainability would be appropriate for most Alpine resorts (ClimAlpTour, 2011).

Finally, for successful engagement and collaborations across stakeholders, the different perceptions on climate risks and adaptation/mitigation solutions should be considered and adequately addressed.

Results from the literature (Steiger, Scott, Abegg, Pons, & Aall, 2019) show that climate change perspectives in the ski industry differ substantially, both among ski area operators and between ski area operators and other stakeholders (i.e. accommodation sector, the destination management, local and regional government, and NGOs). The latter generally perceive climate change to be more 'real', the potential impacts more 'severe', and the adaptation capacity of the industry more 'restricted', while ski area operators seems to be highly optimistic on the long-term effectiveness and sustainability of snowmaking as main adaptation measure to be implemented. However, snowmaking is often not considered an adaptation to climate change, but rather a strategy to cope with current climate variability and meet customer expectations. A long-term effective adaptation strategy would entail assessing climate change vulnerability and risks at regional level and find medium-long term strategies to cope with it successfully through a mix of adaptation and mitigation measures. This approach requires the collaboration of all stakeholders, including private, public and research, especially because the ski tourism industry is very image-sensitive and cannot afford to lose credit access or attractiveness, thus is usually reluctant to recognise its vulnerability.

4. Conclusion

To conclude, a wide range of ski tourism stakeholders will be impacted by the consequences of climate change and, even if each of them has differential interests and perceptions, they will all benefit from credible and decision-relevant information, therefore efforts should be put into appropriate communication, awareness raising and collaborative approaches.
The Smart Altitude Decision-Making Tree goes in this direction, offering a practical tool for planning and implementing low carbon and adaptation strategies in ski resorts.

Smart Altitude Activities 3.2 and 3.3 will be complementary in providing valuable insights into enabling technological solutions and policies to support adaptation and mitigation in ski resort areas and recommendations for effective stakeholder engagement.

In developing the next activities of the project, the results from other projects and studies, such as recommendations from ClimAlpTour described in this report, will be highly useful and should be capitalized.

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