Centro Euro-Mediterraneo
per i Cambiamenti Climatici

Research Papers
Issue RP0127
February 2012

Division: Climate Impacts and Policies. An Economic Assessment

Climate change and Tourism in the Alps: a position paper in view of the upcoming Alpine Convention Fourth Report on the State of the Alps on Sustainable Tourism

By **Balbi Stefano**
Cà Foscari University of Venice, Department of Economics and Euro-Mediterranean Center for Climate Change
stefano.balbi@unive.it

SUMMARY Whereas the implementation of the Tourism Protocol of the Alpine Convention seems far from its completion, the Alpine Convention fourth report on the state of the Alps entitled \Sustainable Tourism in the Alps" is under preparation and it is expected by the end of 2012. One of the main critical challenges that Alpine tourism needs to face in the quest for sustainability is climate change. In recent years several research and cooperation projects focusing on the Alpine region have been dealing with the issue of climate change. In particular the Alpine Space Programme, starting with ClimChAlp (2006-2008), focused on the issue of adaptation to climate change in the following call (2008-2011) through several projects: CLISP, ClimAlpTour, Manfred, AdaptAlp, AlpWaterScarce, ParaMount, PermaNet, SILMAS, AlpFFIRS. These projects led to a capitalization project named C3Alps that recently started. At the same time, the Alpstar project, which also started recently, will focus on climate change mitigation and on making the Alps a carbon neutral environment. The Euro-Mediterranean Centre for Climate Change (CMCC) contributed to several of these Alpine Space projects (ClimChAlp, AdaptAlp, ClimAlpTour and C3Alps). Other non Alpine Space projects have also contributed to this research and cooperation issue, such as CC.ALPS (by CIPRA), KLIWA (by various German and Bavarian institutions), Histalp (Austrian weather service), etc. However, ClimAlpTour is the only project that explicitly focused on tourism. This paper builds on these projects' findings, especially for what concerns the implications for the tourism sector, and on the existing relevant literature.

1. The past climate in the Alps

After two decades of scientific research, mountains are nowadays recognized as early indicators of global climate change. Indeed, the Alpine region in Europe is amongst those areas that are most rapidly affected by climate change.
The years **1994, 2000, 2002,** and **2003 were the warmest on record in the Alps in the last 500 years** (Beniston 2005 in: Agrawala 2007). With a certain degree of local variability, **glaciers in the Alps have lost 50% of their volume since 1850** and snow cover is decreasing especially at the lowest altitudes and in autumn and spring (Castellari 2008). **The mean temperature of this region has increased up to +2°C for some high altitude sites over the 1900-1990 period** against +0.78°C in the last 100 years at a global level (Solomon et al. 2007; ClimChAlp 2008).
Major predictable consequences in the Alpine region include impacts on hydrological cycles, biodiversity, agricultural productivity, energy management, and tourism sustainability (Balbi et al. 2012). The latter is the focus of this paper.

The environmental, cultural, and economic diversity of the Alps has traditionally brought a large set of tourism activities to the Alpine region. **Tourism is a key pillar of the economy in the Alpine countries**, generating around 50 billion euros per year in the Alpine region and providing 10%-12% of jobs. However, Alpine tourism is mainly natural resources- and climate- dependent (Urbanc and Pipan 2011). Some of the Alpine tourism activities are likely to be affected by temperature increase - mainly negatively with regard to winter sports - but climate change may induce modifications to the entire Alpine tourism sector beyond the increase in average temperature. Hopefully, this will stimulate a reorganization of tourism demand and supply towards a more sustainable paradigm, as advocated by the **Tourism Protocol of the Alpine Convention**. Nevertheless, climate change is likely to have a great impact on the regional economy and sustainable tourism planning need to take this change into account (Agrawala 2007). The climate change dimension thus emerges as new imperative for Alpine communities in planning for sustainability and **only climate-compatible tourism should be regarded as sustainable tourism** (Abegg 2011).

Long-term climate data series (temperature, rainfall, etc.) have been used to establish past changes in the climate. The **Histalp** project on alpine climate data series highlighted four alpine zones - represented in Figure 1 - with similar changes in average temperature for three reference periods (1850-2007, 1850-1975, 1975-2007, see Table 1). The data highlights an accelerating warming process. Although the change in temperature is unequivocal, it remains relatively difficult to identify a significant trend about rainfall. Indeed, the southern and eastern Alps have experienced a decrease in rainfall since the 1960s (Chaix 2010, in: Urbanc and Pipan 2011).

Table 1. Increase in temperatures for three reference periods (linear trend). (Histalp project)

	1850/2007	1850/1975	1975/2007
NW	+1.71 °C	+0.84 °C	+1.63 °C
NE	+1.52 °C	+0.77 °C	+1.5 °C
SW	+1.51 °C	+0.75 °C	+1.53 °C
SE	+1.37 °C	+0.725 °C	+1.62 °C

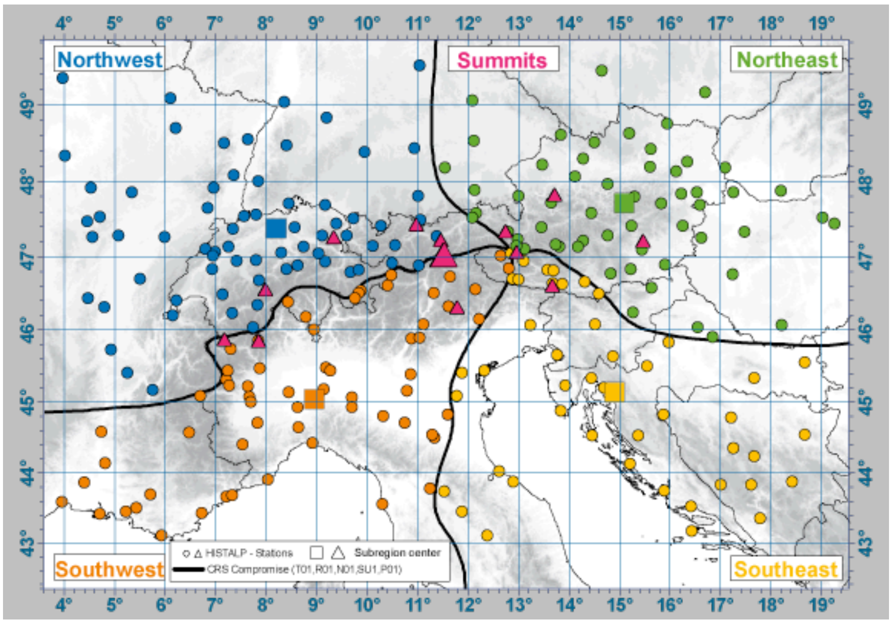


Figure 1. Map of positions of measuring points used in the Histalp project. Division of the Alps into four climatically homogenous sub-regions (NW, SW, NE, SE). (Histalp project)

2. The future climate in the Alps

Data about past average trends is certainly informative but its usefulness can be questioned when it comes to the estimation of future climate dynamics at the local level. This is because (a) the climate system exhibits a **complex and non linear behaviour**, and (b) **different micro-climates** may coexist and be influenced by local topography and land use (Chaix 2010).

Further, it is the exacerbated climate variability, and in particular the extremes, that are responsible for the highest impacts (Gallée 2010). Thus, the scientific community is progressively emphasizing the relevance of focusing not anymore on averages and trends, but on **the variability of the phenomena** and on **extreme events**. Extremes, here in the tourism sector, can be very diverse instances, but typically hydrological and climatic events with given probabilities of occurrence (return period). Indeed, while average precipitation records don't show any dramatic change yet, it is expected that the risk of extreme events like floods, droughts, avalanches, glacial hazards, and large-scale mass movements will increase (Castellari 2008).
Projections about climate change trends and the related impacts are pervaded by uncertainty, in particular those looking at the time frames of interest for planning and management of economic activities including tourism, e.g. one or two decades ahead. While it is evident that there is not enough quantitative science for deterministic simulations of the climate of the years to come, it is also clear that the knowledge developed by climate change science is solid enough to be implemented in current planning activities, providing in particular methods and tools for dealing with uncertainty and multiple scenarios (Giupponi et al. 2012).

Regional climate models (RCMs) (see Jacob et al. 2007; CLISP 2009; Prudence and Ensembles EU projects) may offer credible scenarios for interpreting the future Alpine environment, indicating potential differences between the various regions of the Alps. Further, when combined with local data, these models can be employed to simulate future conditions at the local level in view of testing alternative possible scenarios (see Box 1). However, different climate models produce sometimes highly divergent behaviour, especially in difficult topography such as for the Alps.

Box 1. RCMs for local simulations - The case of Auronzo-Misurina /IT (Balbi et al. 2012)

Scenarios of possible future winter seasons were developed within the **ClimAlpTour** project. Data about projected weather conditions, concerning temperature and snow cover were produced with the SkiSim 2.0 model (Steiger 2010), consisting of two main components: the snow model and the snowmaking module. SkiSim 2.0 required as input data:

1. daily data of Auronzo and Misurina climate stations in form of long time series recording precipitation, temperature (min, max) and snow depth and/or fresh snow;
2. monthly change signals of climate scenarios for temperature and precipitation. This data, downscaled to each climate station, was provided by the **CLISP** project (CLISP 2009).

In the **CLISP** project all the parameters were calculated in terms of an absolute change from the reference period (1961-1990) to the 20 year mean of two future periods (**2011-2030** and **2031-2050**). The climate signals from the regional climate model **REMO UBA M 2006** were considered because of (a) the high geographical resolution (10 km) and (b) both **A1B** and **B1** SRES scenarios of IPCC were available.

2031 - 2050		CURRENT	A1B	B1
Variation of average winter temperature		-	+1.58°C	+1.20°C
Variation of average winter precipitation		-	+7.9%	+8.3%
Snow days per season (max 126)	Auronzo	55	20	32
	Misurina	121	111	113

CLIMATE SCENARIO	DESCRIPTION
CURRENT	There are no changes from the recent past despite CO_2 emissions
A1B	Rapid globalisation and economic growth with total exploitation of all Energy resources available (higher variation of climate than B1)
B1	More efficient technologies and socio-economic development oriented towards services

At the overall level, the possible impacts of climate change in the Alps are:

1. Generalized **increase in average temperatures (1.5°C by 2050 and 3.5°C by 2100)**, decrease in number of ice and frost days with greater warming of winter than summer temperatures;
2. Changes in rainfall patterns (mean precipitation show an increase of **+15% in winter and -15% in summer**, with more probable **heavy precipitations and floods in winter, and droughts in summer**;
3. Increase in evapotranspiration (water lost into the atmosphere from rivers, lakes plants and soil) and generalized **reduction in water resources**;
4. **Glacier retreat** on massive scale;
5. **Earlier onset of snowmelt** with a resultant shift in maximum runoff from spring to winter;
6. **Reduction in snow cover** and snow reliability of many winter sport regions;
7. Changes in the regimes of watercourses, with increasing **dry watercourses in summer**;
8. Changes in agricultural practices, biodiversity, and thus landscapes, with an **upward shift of many biological zones**;
9. **Increase in risk of natural hazards** such as rock falls, landslides, debris flow, ice falls and ice avalanches;
10. Increase in the probability of **heat waves**, as in summer 2003;

(AdaptAlp 2011; Chaix 2010, in: Urbanc and Pipan 2011; BMU 2007; Beniston 2006).

All of these impacts could directly or indirectly affect tourism activities in various ways.

3. Possible impacts on Alpine Tourism

In considering the impacts of climate change on tourism in the Alps it's necessary to distinguish between the winter and the summer seasons, because the final effects might diverge substantially. While the effect of climate change on the winter tourism season will be predominantly negative (except for the snow reliable ski areas), there could be significantly beneficial effects for the summer tourism season. On the one hand the expected decrease in snow and ice cover, may lead to a rethinking of tourism development beyond the traditional vision of winter sports, on the other hand the climatic attractiveness of Alpine summer holydays might increase, also with regards to the global competition (e.g. Mediterranean seaside destinations).

3.1 A snowless winter?

The World Tourism Organization started warning about the possible negative implications of climate change for winter tourism and sports since 2003 (UNWTO 2003). As a result of temperature increases, the snowline will rise by about 150 m for every 1°C of warming (Solomon et al. 2007). Further, the seasonal distribution of snow may change considerably inducing an earlier termination of the season (Beniston et al. 2003). However, it is highly unlikely that the changes will be linear. Thus, the inter-annual and intra-annual variability of snow fall and cover are also destined to increase, leading to higher level of complexity in managing the ski areas, especially with regards to the snow deficient periods.

As a consequence, many ski resorts could be seriously threaten and only high-elevation facilities (above 1,500 meters) could be able to host winter sports. Nowadays already 57 of the main 666 ski resorts of the European Alps are considered not to be snow-reliable[1] (Agrawala 2007). The orientation and the gradient of slopes also have an important impact on the reliability of snow cover.

Indeed, **downhill skiing** is the most vulnerable activity. Also **cross-country skiing** faces the risk of the absence of snow during individual years, which could preclude the activity. Trails are often at relatively low elevations, but snow cover is frequently less exposed to the sun where the trails are located amongst shaded forests or are exposed to the north. Moreover, the techniques for packing the snow and planning the trails are also effective (Chaix 2010, in: Urbanc and Pipan 2011). **Free-ride, back-country skiing, snow-shoeing**, and all those activities which take place into the wildest areas of the Alps, are likely to be affected by an increased risk of natural hazards, and in particular of avalanches, due to the increased instability of the natural snow condition.

However, climate change is also an opportunity for those resorts that are snow-reliable, as they will face less competition in the future (Simpson et al. 2008). Snow reliable ski resorts will probably be the winners of the climate change induced winter tourism competition, at least from an economic point of view. This is why there exists a growing pressure for the construction of cable cars and lifts at higher altitudes and on glaciers. Thus, it is not only the impacts of climate change per se, but also the impacts of adaptation which threaten to have a negative effect on the environment (BMU 2007).

3.2 The endless summer?

The summer season in the Alps might become more appealing due to the expected increase in temperatures and the decrease in precipitation, while the typical length of the season might be extended. At the same time the competing Mediterranean destinations might loose some climatic attractiveness, thus favouring a renaissance of the Alpine summer holydays (Abegg 2011). The increase in temperatures is also likely to bring more tourists to the Alps especially when they attempt to escape the heat waves at lower elevations (e.g. as in summer 2003). However, as the pressure on water resources will increase, especially in summer, there exists the risk for water scarce areas to not be able to fulfil the water demand during the tourism peaks (Hohenwallner et al. 2011).

With the increase in temperatures, it is also expected an increase in the popularity of water based activities, such as **swimming, windsurfing, kite-surfing and sailing**, both in natural and artificial water bodies (e.g. artificial lakes and swimming pools). This could potentially induce negative

[1] In general, a ski resort is considered to be snow-reliable if, in 7 out of 10 winters, a sufficient snow covering of at least 30 to 50 cm is available for ski sport on at least 100 days between December 1 and April 15 (Burki at al. 2007).

environmental consequences if not properly managed (Chaix 2010, in: Urbanc and Pipan 2011). The **SILMAS** ("Sustainable Instruments for Lakes Management in the Alpine Space") did consider climate change and the results are expected by the end of 2012.

White-water activities, such as **rafting, kayaking and canyoning**, depend on the behavior of water courses. Climate change, will increase the stress on water basins, with more severe low water levels in summer. The risk of rivers drying up will probably increase, even if glaciers melt could compensates for the hydrological shortage in the short term. It is thus important for water managers and public authorities to deal with the problem of water management with great care (Chaix 2010, in: Urbanc and Pipan 2011; Hohenwallner et al. 2011).

The principal threat to **hiking, mountaineering, and high-mountain activities**, as for the winter season, is the increase in natural hazards such as avalanches and falling ice blocks caused by melting glaciers, landslides due to increased incidence of extreme rainfall, and mudslides and rock falls resulting from the melting of permafrost. The **PermaNet** project explicitly focused on the impact of climate change on permafrost (see Kellerer-Pirklbauer et al. 2011).

Mountain biking may be also be influenced by the increased risk of natural hazards but otherwise it should not be affected by climate change (Urbanc and Pipan 2011).

Because of climate change, the ecological conditions for forests in the Alpine Space are also fundamentally changing, with unknown effects on the forests' essential protective, ecological, economical and social functions. The **Manfred** project investigated this specific issue. Given that forests are a fundamental asset of Alpine tourism, these changes might have significant implications for the tourism sector. A further risk to summer tourism activities is that of wildfires, which increased in the last decades due to the abandonment of land, but that might be exacerbated by climate change duo to the increase in frequency of extreme summer conditions (droughts and extreme temperatures) (Valese et al. 2010, **AlpFFIRS**).

4. Adaptation

The Alpine region is extremely vulnerable to climate change but the local conditions are very different across the region in terms of expected changes in climate, tourism typology and intensity, and capacity to adapt, making it impossible to envision a single way to tackle the issue (Balbi et al. 2011).

Adaptation can take various forms. One main distinction lies between technological and non-technological adaptation (Abegg 2011). **Technological** adaptation is about cushioning against the expected changes in view of maintaining the existing assets by means of technological solutions (e.g. snowmaking). **Non technological** adaptation is more oriented towards behavioural changes, long-term tourism planning and risk management, also through financial means. Further, adaptation can be **autonomous**, i.e. pertaining to the individual actors of the tourism system, or **planned**, when the tourism system acts collectively for this purpose.

Whereas tourism demand is very adaptive and the tourists' behaviour is constantly and rapidly evolving, the tourism supply, meaning the Alpine destinations as a whole, need more time to plan their actions in order to respect their social, economic and environmental constraints (UNWTO, UNEP and WMO 2008).

There certainly are autonomous actions that can be taken by the tourism suppliers, but the most crucial part of the adaptation effort will be played by the so called "planned adaptation". Therefore, adaptation should be regarded as a thoughtful and concerted process of tourism development planning for the long-term, and definitely beyond the mandate of one political administration (Balbi et al. 2011). Moreover, tourism is a highly subsidised economic sector, so public funding need to take into account a development oriented towards climate resiliency, and ultimately, sustainability (Abegg 2011).

4.1 Pursuing the "white dream"

In the last two decades hundreds of millions of Euros have been invested into **artificial snowmaking**. Nowadays half of the Alpine ski slopes are supported by artificial snow coverage (Abegg 2011). On the one side snowmaking has been and will be an important tool to deal with climate variability, partially compensating the projected decline in natural snow (Scott and McBoyle 2007). On the other hand the cost of snowmaking will increase disproportionally, as not only more snow will be required, but it will also have to be produced under higher ambient temperatures. In addition, there are considerable externalities in terms of water consumption, energy demand, landscape and ecology (Abbeg, in: Weiermair et al. 2011).
According to the CIPRA-International the seasonal production of artificial snow covering one ha of slope requires 4,000 m^3 of water and 25,000 kWh of electricity (Hahn 2004). Water consumption for snowmaking is immense. For example, in Davos/CH it represents 21.5% of total annual water consumption and in Scoul/CH 36.2% (Abegg 2011). The same implications are valid for energy consumption, although there are areas where renewable energy could be utilized for this purpose, as the wind turbine in Sattel-Hochstucki/CH.
Other technological measure to adapt, while maintaining a skiing-oriented strategy include:

1. **slope design** and grooming, in order to better take advantage of the topological characteristics of the ski area;
2. **snow farming**, which implies the creation of snow deposits;
3. concentration of ski areas at **higher altitudes** and glaciers.

The latter is an extremely delicate issue given that: (a) the environment at higher altitudes is more fragile and the risk of natural hazards is greater; (b) the cost of investments and maintenance is more expensive; (c) the impact on the landscape also increases.

However, these technological measure perpetuate a **very resource consuming and scarcely flexible tourism business model**. A skiing-oriented strategy is a capital intensive and highly technological strategy, which tends to create scarcely environmental- and climate- compatible economic monocultures (Abegg 2011). Every investment in artificial snowmaking increases the tourism dependency on skiing related activities, instead of reducing winter tourism dependency on snow.
Indeed, a model of economic development based on snow, no matter if natural or artificial, is still somehow surviving in the Alps, even at low altitudes, notwithstanding the **maturity** of the traditional ski product (Macchiavelli 2009; Bourdeau 2008). Conversely, it has been demonstrated that a higher artificial snow coverage does not necessarily imply better commercial results (Abegg 2011).

A prudent adaptation strategy would maintain the existing skiing and snowmaking infrastructure, where the climatic and environmental conditions are more favourable (approximately above 1,500 m above the sea level), while it should instead be considered with great care any further snow-based development plan (WWF 2007). At the same time the **distortive public subsidies** that are destined to these activities should be suspended, in order to reflect the real economic feasibility of this business model. A more competitive market could also stimulate efficiency in use of the existing infrastructure, for instance by increasing the degree of **synergy with summer tourism** (e.g. downhill mountain biking supported by cable cars, mountain biking in cross-country itineraries, etc.).

The **natural snow-based winter tourism activities** are more flexible, compared to downhill skiing. Free-ride, back-country skiing, and snow-shoeing, when offered under controlled conditions - for instance with the supervision of Alpine guides - can capitalize the periods of snow, while taking into account the increased risk of avalanches. Although fully exposed to the variability of the climatic conditions, these activities are human labour (rather than capital) intensive and there seems to exist a market niche that is not adequately covered throughout the Alpine arc (Daidola, in: WWF 2007). In some destinations, these activities are averted in favour of mass tourism, while they should be supported by adequate legal and security framework. Further, **snow-park facilities** could also represent a "light" snow-oriented option for small and family friendly ski resorts. A well designed facility can run with one supporting lift and may require a small amount of artificial snow. At the same time the market demand is young and growing.

4.2 Pursuing snow-independency

The future socio-economic scenarios are as crucial as the climate conditions. In the last few decades, the positive trend of tourism demand in tourism has decreased in Alpine destinations and the average duration of the journey has diminished substantially. Many destinations have reached their maturity stage and the market seems saturated. Globalization has exponentially increased the number of competitors and changed the behaviour of travellers (Balbi et al. 2011).

Tourists' adaptation is certainly autonomous, but the choice of the destination depends more on the guest's segment than on climate change. Thus, while intensive skiers will probably react by choosing different destinations with snow-reliable ski areas (Ketterer and Siegrist, in Weiermair et al. 2011), others might have very different holyday targets. Tourists are far from being an homogeneous block and various fruition behaviours can be observed. Balbi et al. (2012) modelled eight main segments of winter tourists. For instance, non-skier winter tourists (not downhill nor cross-country) are estimated around 25% in France and 48% in Italy (Agrawala 2007). **Segmentation** of the tourism offerings is fundamental in order to satisfy an **heterogeneous demand**.

Thus, a wider approach to adaptation also means adopting a **marketing strategy** in the face of global competition, for instance by defining and promoting the unique selling point of the destination, in an integrated fashion with the surrounding region. Three are the main objectives that should be pursued: (a) **identity**, (b) **flexibility**, and (c) **innovation.** Identity is fundamental for being recognized as an authentic and distinguished destination. An Alpine tourism destination needs to be identifiable. **Local culture, handicraft, gastronomy, protected areas and agriculture** are elements of strength, among the destination's specificities, and should be incentivised. Flexibility will be required by the increased variability in climate conditions and in the behaviour of tourism demand. Light and human labour intensive investment are required. Innovation, not only concerning the products (e.g. diversification, see Box 2), but also of the processes (e.g. booking, transports, etc.), should be oriented towards long-term sustainability.

Authentic destinations, with more local products, original culture and regional economic cycles might be the real winners of the tourism industry of the future (Ketterer and Siegrist, in Weiermair et al. 2011). This is particularly relevant for low-lying ski areas, which have the option of deciding to reduce winter tourism offerings in ski resorts of low altitude and increasingly **concentrate on summer tourism**.

On the regional scale destinations could **establish partnerships** between operators with the objective of sharing products (e.g. "soft mobility") or system production methods (e.g. systems of water and waste management) (Ketterer and Siegrist, in Weiermair et al. 2011). Partnerships are also crucial with regards to commercialization. Very often in the Alps little destinations (even within the same municipality) tend to prefer individual actions rather than pursuing integration with the neighbouring competitors. This is and extremely weak point in the context of global competition. Finally, partnerships could be established with the insurance sector in other to plan for a more protective **risk allocation**.

Box 2. Examples of strategies of diversification across the Alpine arc (Urbanc and Pipan 2011)

Climate Vulnerability	Summer	All-Season	Winter
Low	folklore festivals; nature trails; interpretative guided tours; activity parks; horse riding; golf	indoor sports (e.g. tennis, rock-climbing, soccer, swimming pools); wellness/spa centres; farmers markets; gastronomy and local products; museums; artisan workshops; agri-farm holidays; architectonic heritage; family activities; health tourism	Christmas markets
Medium	rock climbing; water activities; para-gliding		ice-skating; ice-karts; bob sledding; hiking; sport competitions
High		glacier activities	off-piste; cross-country;

4.3 Adapting to natural hazards

Adapting to the increased risk of natural hazard is an imperative task that already affects the Alpine region beyond the point of view of tourism. However, the tourism sector could significantly contribute to this purpose. The **AdaptAlp** project identified the ten most significant actions required at this time to prepare for the risks caused by global warming in the Alps (AdaptAlp 2011).

1. **Improve public preparedness and personal responsibility by encouraging participation in emergency planning.** Tourists and tourism operators should be aware of the possible risk of natural hazards, especially with regards to the most sensitive activities (e.g. free-ride), hazard related information should be accessible, preparedness enhanced, and the functioning of early warning systems and/or emergency plans, publicly disseminated.
2. **Incorporate climate change adaptation into spatial planning.** The new tourism infrastructure should be carefully assessed in terms of location and construction quality. Stricter standards are necessary for the new winter tourism infrastructure, in particular (CLISP 2011). It's fundamental to keep endangered spaces free of tourism development.
3. **Involve local stakeholders in a risk dialogue.** When dealing with climate change and natural processes and their effect on citizens, tools such as participative planning processes are of high significance for improving the sustainability of tourism within each Alpine resort.
4. **Encourage cross-border networking on integrated risk management.** Nearly every valley in the Alps faces the same kinds of problems when dealing with natural hazards, however the adaptive capacity of different tourism systems might change significantly, on the basis of national policies and economic conditions. Cooperation should be enhanced.
5. **Encourage a "common language" and harmonised procedures when developing and using hazard maps.** Given that Alpine tourists may come from different countries where different "risk languages" are utilized, there exists an issue of potential ambiguity in risk communication. Thus, harmonization could benefit the tourism sector as well.
6. **Increase the size of flood plains, floodwater conduits and basins.** Hydrological risk will probably increase. One main measure to adapt should be the conservation and maintenance of floodplains and natural retention areas. Not only do these plains have a moderating effect in

flood situations, but they can also serve other recreational and conservational purposes that increase the quality of life in the Alps.

7. **Think of flood risk management in terms of an entire river basin to find solutions that are sustainable.** There is the need to recognise the synergies between all the uses of a natural resource. A sustainably managed river basin can be highly resilient. Flood protection activities can improve the local ecology by creating naturalised water retention areas, creating new recreation areas for tourism, stabilising the groundwater level and improving the water supply to a region, with indirect benefits for the tourism system.
8. **When planning for natural hazard risks consider all the environmental risks within a defined area.** A multi-hazard view requires coordinated action among different planning sectors. Synergies must be created between all public sectors involved in risk prevention so that the proposed solutions will serve everyone involved. Tourism is a very faceted economic sector that can contribute a lot in this view.
9. **Use risk-management tools to explore the social and economic consequences of various adaptation measures.** Planning for natural hazard risks calls not only for a careful study of a region's vulnerabilities, but also for a comparison of the costs of prevention measures versus the potential cost of damage after an event. It is therefore important to include the cost and benefits of tourism, especially where this sector significantly contribute to the regional economy. Neglecting the implications for tourism could lead to very flawed results.
10. **Support the collection and interpretation of local climate change data.** To get an accurate picture of the future climate of the Alps, scientists require more data at a local level, and data that is collected in the same way between weather stations and regions. More in general, the issue of data harmonization is endemic for the Alpine tourism. Cross-referencing harmonized climatic and tourism data could significantly enhance the quality future analysis.

5. Mitigation

Tourists cause 4.4% of global CO_2 emissions. These emissions are projected to grow at an average rate of 3.2% per year up to 2035 (Peeters and Debois 2010).
Mitigation and adaptation are strongly interconnected issues, especially for Alpine tourism. Although adaptation will be needed regardless of the emissions containment efforts at the international level, Alpine tourism can play a significant role in terms of mitigation. Indeed, the potential of mitigation for Alpine tourism is beyond the concrete results in emission reduction, because "green and carbon neutral tourism" is a valuable label itself that can be capitalized within the tourism market. Moreover, the key compartments in terms of CO_2 emissions reduction potential are transports and energy (Abegg 2011), which are the two major weak points for many Alpine destinations. Further, the increasing cost of energy is progressively eroding the margins of the accommodations and transport compartments.

Box 3. A general mitigation strategy (Simpson et al. 2008).

In general, a successful mitigation policy could consider four main steps that any tourism-related business or institution can implement as a practical response to climate change.

1. The first step is to eliminate the emission of greenhouse gases by **keeping away from certain activities that can be avoided without a considerable change to the tourism product** or service quality (e.g. heli-ski).
2. The second is to reduce the emission of greenhouse gases by **focusing on energy efficiency** practices in specific activities (e.g. thermal insulation, efficient light bulbs).
3. The third step is to **substitute practices** that are responsible for a large amount of greenhouse gas emissions with practices that have a lower carbon footprint (e.g. private to public transports).
4. Finally the institution or business unit can **offset remaining emissions** to achieve full carbon neutrality (e.g. offsetting for journeys by air, selling Gold Standard Certified Emission Reductions).

CO_2 compensation activities should be part of a comprehensive and integrated strategy. Compensation should come after the other possible mitigation measures, as a second best option (Abegg 2011).

5.1 Transportation

Tourism traffic, meaning the return journey to reach the destination, is responsible for the greatest part (75%) of CO_2 emissions in tourism (Abegg 2011). The 40% of CO_2 emissions is originated by aviation, 32% by road transport, and 3% by other sources (Simpson et al. 2008). However, **84% of the transportation needs for Alpine holydays are satisfied by privately owned cars** (Abegg 2011). This is probably due to the fact that most of the Alpine resorts are not easily accessible with public transports. Mitigation measures include: financial instruments, carbon tax on road transports on the basis of the technical standards, enhancement of alternative transportation systems, and public awareness campaigns. Most of these measures are beyond the scope of this document[2].
A side aspect of transportation is that of mobility within the destination. While mobility can be an attractive factor itself, as in the case of the 20 Alpine Pearls (**Alpine Peals project**), for many Alpine resorts this is still an open issue (Urbanc and Pipan 2011). Many of the case studies of the **ClimAlpTour** project were considering the option of making the village centre a pedestrian area and creating parking lots on the outskirts, with public transport such as electric buses within the central area. However, most of the times it is the expected passenger volume that do not allow for an economically viable public transportation systems, even though the majority of tourists wish to forget about their car for the time of their holyday.
The issue of transportation is also interconnected with that of adaptation for what concerns the risk of natural hazards. This is the focus of the **PARAmount** project ("im**P**roved **A**ccessibility:

[2] For more information please refer to the first report on the state of the Alps of the Alpine Convention ("**Transport and Mobility in the Alps**").

Reliability and security of **A**lpine transport infrastructure related to **mount**ainous hazards in a changing climate").

5.2 Energy

There exist several options to reduce energy consumption and use energy in a more efficient way. The focal areas of intervention are thermal **heating of accommodation and water heating**. Older buildings need to be upgraded, while construction subsidies need to be directed to the highest efficiency standards. The construction of **second homes**, which is detrimental to the regional economy, the landscape and the climate policy in the long-term, need to be limited. Second homes are under utilized by owners while the heating systems are very often operating during the entire season. For instance, the annul thermal energy need for 3,400 second homes of Goms/CH is estimated to be around 30 GWh, and half of this consumption is due to the periods of non-utilization (Abegg 2011).
Tourism dedicated buildings and facilities need to reach a greater level of energy efficiency. Solar energy, which is very efficient at certain elevations and in absence of fog, is still inadequately deployed (Abegg 2011). The use of woodchips for domestic heating has been very positively evaluated by the tourism operators that implemented it (Pechlaner et al., in: Weiermair et al. 2011). In general, the potential of all the renewable energy sources (e.g. solar, hydro, wind, biomass and geothermal) is underutilized (Abegg 2011). According to CIPRA-International the Alps have the potential to become an energy self-sufficient region by 2050 (CIPRA 2010).
The **switch from fossil fuels to renewable energy** sources must be encouraged, but not to the detriment of the natural environment. The production of biomass and the construction of wind power and hydro power plants in the Alps are a potential source of conflict (CIPRA 2010).
One further issue that is part of the Alpine Convention scope is the reduction of the environmental impact of the energy infrastructure.

Box 4. Mitigation guidelines for accommodation (Simpson et al. 2008).

a) **Establish environmental management systems (EMS).** EMS help to understand resource consumption and to identify areas where resources can be saved.
b) **Reduce energy use.** This can be achieved by replacing old machinery, and installing power-saving devices, such as switch-cards in rooms.
c) **Use renewable energy only.** Accommodation establishments can either install renewable energy sources, including photovoltaic or solar heating, or they can buy renewable energy from specialized power providers.
d) **Reduce the use of materials.** There are opportunities to substantially reduce resource use, and in particular packaging. For instance, soap containers can be replaced with dispensers, and one-way packaging for butter or jam can be entirely avoided.
e) **Recycle wastes.** Hotels can substantially reduce overall waste produced, as well as recycle most of the remaining waste.
f) **Rethink food in restaurants.** Restaurants can make a major contribution to reducing greenhouse gas emissions by offering locally produced food with a lower share of meat, and by avoiding environmentally problematic resources.
g) **Constructions.** Whenever new accommodation establishments are built, they should be constructed in a way to make them independent of fossil energy sources – it is now possible to use 100% renewable energy for operations if this is considered prior to the commencement of building.
h) **Communicate green action.** Accommodation establishments are ideal meeting points to provide customers with information about pro-environmental action taken.

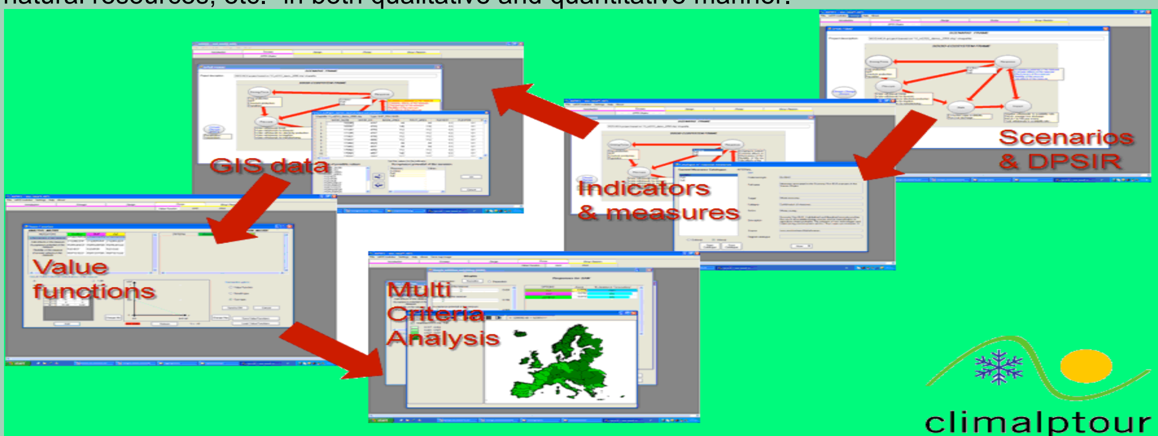
6. Public participation and capacity building

Tourism is a very interconnected economic activity depending on tangible and intangible goods and services of both natural and anthropogenic origin. **The issue of climate change and tourism in the Alps, both in terms of adaptation and mitigation, cannot be isolated from other relevant and**

interrelated issues such as spatial planning, natural hazards, water management, energy, transports, etc. Therefore, it is necessary to integrate a climate change perspective into the discourse about tourism planning and sustainable development both at a local and at a regional level (OECD 2006).
Further, **the people must be involved at different levels** - e.g. public decision makers, Alpine citizens, tourism operators and tourists - because much of the possible future outcomes will depend on their behavior. Thus, this process of integration, is fist of all, a process of collective capacity building. In this view, climate change is but an opportunity to involve the most appropriate set of stakeholders into the process of definition of the actions to be taken for improving the sustainability of tourism in the Alps.
Much can be achieved at the local level, while maintaining a regional perspective. At the destination level it is fundamental to involve the local community in a discussion about the future of their tourism system, and more specifically about the prospects for supporting tourism performances in a sustainable way, and, in doing so, to raise awareness on possible climate change impacts and promote the elaboration of strategies for local and sustainable development.
Participatory methodologies are particularly indicated in this kind of contexts in order to efficiently manage the stakeholders' involvement in decision-making. For instance, the participation of local actors and experts can be managed through the design of a sequence of steps culminating in one or more workshops for the ideation and discussion of the set of alternative strategies and for their assessment. The workshops should ideally include a representative range of stakeholders and decision-makers and should be chaired in such a way as to be impartial to sectoral interests and to ensure that external knowledge input is also regarded as credible and impartial (Simpson et al. 2008).
For instance, a participatory methodological framework and a decision support system (i.e. the e-tool) were designed for the **ClimAlpTour** project, with the aim of facilitating participatory processes in the field of local development and adaptation to climate change, with enhanced capacity of using scenarios in the process of integration among local and scientific knowledge (See Box 5).

Box 5. The ClimAlpTour e-tool (Balbi et al. 2011)

Within a workshop setting, the e-tool allows end-users - **local administrations, NGOs, stakeholders in general** - to explore and assess **alternative adaptation strategies** with reference to future climate change scenarios for each case study area. This is achieved through an iterative process based upon the application of participatory methods and **multi-criteria analysis (MCA)** developed upon the indicators analysed during project activities - e.g. potential effects of the strategies on local employment, on natural resources, etc.- in both qualitative and quantitative manner.



In the e-tool, the **DPSIR scheme (Driving forces, Pressures, State, Impacts, Responses)** is adopted as a generalised conceptual framework and as the initial interface that allows the user to formalize the problems of the destination by means of **indicators**. The most relevant indicators can be selected for the **quantification of the criteria** in the **Analysis Matrix**, upon which the selection of options should be performed. These indicators can then be weighted according to the **preferences** of those involved in the analytical process in order to eventually identify the collectively preferred adaptation strategy.

References

Abegg, B., 2011. Tourism in climate change. CIPRA Compact 1/2011 [online]. Available from: http://www.cipra.org/en/alpmedia/publications/4606 [Accessed 13 February 2012].

AdaptAlp, 2011. Common Strategic Paper [online]. Available from: http://www.adaptalp.org/ [Accessed 13 February 2012].

Agrawala, S. (Ed.), 2007. Climate change in the European Alps: adapting winter tourism and natural hazard management, OECD Publishing, Paris.

Alpine Pearls project's website, http://www.alpine-pearls.com/en/home.html. [Accessed 13 February 2012].

Balbi, S., Giupponi, C., and Bonzanigo, L., 2011. Climate change and its impacts on tourism in the Alps: The pilot area of Auronzo di Cadore (Belluno). Euro-Mediterranean Centre for Climate Change, Lecce. Available from: http://virgo.unive.it/climalptour/publications/regione_en_e book.pdf [Accessed 13 February 2012].

Balbi, S, et al., 2012. An Agent-Based Integrated Assessment of Winter Tourism Development in the European Alpine Region. Submitted to Environmental Modelling & Software.

Beniston, M., 2006. Mountain weather and climate: A general overview and a focus on climatic change in the Alps. Hydrobiologia, 526: 3-16.

Beniston, M., 2005. Mountains climates and climatic change: an overview of process focusing on the European Alps, Pure Applied Geophysics, 162, 1587-1606, Birkäuser Verlag, Basel.

Beniston, M., et al., 2003. Estimates of snow accumulation and volume in the Swiss Alps under changing climatic conditions. Theoretical and applied climatology, 76, 125-140.

BMU, 2007. Climate change in the alps: facts - impacts - adaptation. German Federal Ministry for the Environment, Nature Conservation and Nuclear Safety in cooperation with the Alpine Convention.

Bourdeau, P., 2009. Mountain tourism in a climate of change. Alpine space - man & environment 7, Global Change and Sustainable Development in Mountain Regions. Innsbruck University Press. Innsbruck, Austria.

Burki, R., Abegg, B., and Elsasser, H., 2007. Climate change and tourism in the Alpine Region of Switzerland, in: Amelung, B., Blazejczyk, K., and Matzarakis, A. (Eds.), Climate change and tourism: assessment and coping strategies [online]. Maastricht - Warsaw – Freiburg, pp. 165-172. Available from: http://www.undp.hr/upload/file/207/103939/FILENAME/ Tourism_and_climate_change_Assessment_and_Coping_Strategies.pdf. [Accessed 13 February 2012].

Castellari, S., 2008. Climate change, impacts and adaptation strategies in the Alpine Space: some results from the INTERREG III B project ClimChAlp. Proceedings of the conference on Mountains as Early Indicators of Climate Change. Padova, Italy, 17-18 April.

CIPRA, 2010. Energy self-sufficient regions, Compact 03/2010 [online]. Available from: http://www.cipra.org/en/alpmedia/dossiers/25 [Accessed 13 February 2012].

Chaix, C., 2010: Climate Change and tourism in the Alps: An analysis based on the pilot sites of the Alpine Space project ClimAlpTour [online]. Available from: http://www.institut-montagne.org/ori-oai-search/notice.html?id=institut-montagne-ori-wf-1-77971&format=dc_id&resultBackUrl= [Accessed 13 February 2012].

ClimAlpTour project's website, http://www.climalptour.eu. [Accessed 13 February 2012].

Climate Change Adaptation by Spatial Planning in the Alpine Space (CLISP), 2009. Report of Working Package 4- Vulnerability Assessment. Task 4.3.3.3 Processing of regional climate model data & providing climate projections for MRs (CLM and/or REMO), Climate change exposure indicators, The Alps [online]. Available from: http://www.clisp.eu/content/?q=node/19 [Accessed 13 February 2012].

Climate Change Adaptation by Spatial Planning in the Alpine Space (CLISP), 2011. WP4 Synthesis Final Report [online]. Available from http://www.clisp.eu/content/?q=node/19 [Accessed 13 February 2012].

ClimChAlp, 2008. Extended Scientific Final Report of the ClimChAlp project: The Climate Change Assessment Report [online]. Available from: http://www.climchalp.org/ [Accessed 13 February 2012].

Ensembles project website, http://www.ensembles-eu.org/ [Accessed 13 February 2012].

Gallée, H., 2010: Climate Changes over the Alps [online]. Available from: http://www.institut-montagne.org/ori-oai-search/notice.html?id=institut-montagne-ori-wf-1-77971&format=dc_id&resultBackUrl= [Accessed 13 February 2012].

Giupponi, C., Balbi, S., and Bonzanigo L., 2012. Local development and climate change adaptation in the Alps: a case study on sustainable winter tourism in the Dolomites. Submitted to Ecological Economics. First review stage.

Hahn, F., 2004. Innevamento artificiale nelle Alpi: una relazione specifica. alpMedia approfondimenti / dicembre 2004, CIPRA International [online]. Available from http://www.cipra.org/pdfs [Accessed 13 February 2012].
Histalp project's website - historical instrumental climatological surface time series of the greater alpine region [online]. http://www.zamg.ac.at/histalp/ [Accessed 13 February 2012].
Hohenwallner, D., et al., 2011. Water Management in a Changing Environment: Strategies against Water Scarcity in the Alps Project Outcomes and Recommendations [online]. Available from https://www.sbg.ac.at/zgis/alpwaterscarce/03_Work/WP03_InformationAndPublicity/3.2_AWS_Website_Documents/Recommendations/WaterManagementHandbook.pdf [Accessed 13 February 2012].
Jacob, D., et al., 2007. An inter-comparison of regional climate models for Europe. Prudence Special Issue, Climatic Change, 81, Supplement 1, May 2007.
Kellerer-Pirklbauer, A., et al., 2011, Thermal and geomorphic permafrost response to present and future climate change in the European Alps [online]. Available from: http://www.permanet-alpinespace.eu/products.html [Accessed 13 February 2012].
KLIWA project's website, http://www.kliwa.de. [Accessed 13 February 2012].
Macchiavelli, A., 2009. Alpine tourism: development contradictions and conditions for innovation, Journal of Alpine Research 97, 1 [online]. Available from: http://rga.revues.org/index843.html. [Accessed 13 February 2012].
Manfred project's website, http://www.manfredproject.eu/. [Accessed 13 February 2012].
Organization for Economic Co-operation and Development (OECD), 2006. Putting Climate Change Adaptation in the Development Mainstream [online]. OECD Policy brief. Available from: http://www.oecd.org/dataoecd/57/55/36324726.pdf. [Accessed 13 February 2012].
Paramount project's website, http://www.paramount-project.eu/ [Accessed 13 February 2012].
Peeters, P., and Dubois, G., 2010. Tourism travel under climate change mitigation constraints. Journal of Transport Geography 18, 447-457.
Permanent Secretariat of the Alpine Convention, 2007. Report on the State of the Alps, Alpine Signals – Special edition 1,Transport and Mobility in the Alps [online]. Available from: http://www.alpconv.org/archive/index_en [Accessed 13 February 2012].
Prudence project's website, http://prudence.dmi.dk/. [Accessed 13 February 2012].
SILMAS project's website, http://www.silmas.eu/. [Accessed 13 February 2012].
Simpson, M.C., et al., 2008. Climate change adaptation and mitigation in the tourism sector: frameworks, tools and practices, UNEP - University of Oxford - UNWTO - WMO, Paris.
Scott, D., and McBoyle, G., 2006. Tourism and Climate Change Policies for Mitigation and Adaptation. Mitigation and Adaptation Strategies for Global Change 12, 1411-1431.
Solomon, S., et al. (Eds.), 2007. Contribution of Working Group I to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change. Cambridge University Press, Cambridge.
Steiger, R., 2010. The impact of climate change on ski season length and snowmaking requirements in Tyrol. Clim Res 43, 251-262.
Urbanc, M., and Pipan, P. (Eds.), 2011. ClimAlpTour - Climate Change and its Impact on Tourism in the Alpine Space, Geografski inštitut Antona Melika ZRC SAZU, Ljubljiana.
Valese, E., et al., 2010. The Alpine Forest Fire Warning System (ALP FFIRS) project [online]. Available from: http://www.alpffirs.eu/index.php?option=com_docman&Itemid=21&lang=it [Accessed 13 February 2012].
Weiermair, K., et al. (Eds.), 2011. Coping with Global Climate Change: Strategies, Policies and Measures for the Tourism Industry, Innsbruck University Press, Innsbruck.
United Nations World Tourism Organization (UNWTO), 2003. Climate change and tourism. Proceedings of the 1st International Conference on Climate Change and Tourism. Djerba, 9-11 April.
UNWTO and UNEP and WMO (2008), Climate Change and Tourism: Responding to Global Challenges, (prepared by Scott, D., et al.), UNWTO, Madrid, and UNEP, Paris.
World Wide Found (WWF), 2006. Alpi e turismo: trovare il punto di equilibrio [online]. WWF Italia, Milano. Available from: http://www.wwf.it/UserFiles/File/WWF%20Turismo/Dossier/Alpi_e_turismo.pdf. [Accessed 13 February 2012].

CMCC Research Papers

02

Centro Euro-Mediterraneo per i Cambiamenti Climatici

The Euro-Mediteranean Centre for Climate Change is a Ltd Company with its registered office and administration in Lecce and local units in Bologna, Venice, Capua, Sassari and Milan. The society doesn't pursue profitable ends and aims to realize and manage the Centre, its promotion, and research coordination and different scientific and applied activities in the field of climate change study.