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THE
ALPINE
CONVENTION
IS THE FIRST
INTERNATIONAL
TREATY FOR
THE PROTECTION
AND PROMOTION
OF PEACE AND
SUSTAINABLE
DEVELOPMENT
OF A CROSS-BORDER
MOUNTAINOUS
REGION

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Guidelines for Climate Change Adaptation at the local level in the Alps



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Guidelines for Climate Change Adaptation at the local level in the Alps

*The Summary of the Guidelines presented here is the outcome of the work of the Task Force on Climate Change (CC) of the Italian Presidency of the Alpine Convention. The initiative launched during its mandate (2013-2014) is based on the need to implement the Alpine Convention's Climate Action Plan for the Alps and provide guide-lines based on updated scientific knowledge, to strengthen, harmonize and promote local adaptation policies and measures in the Alps. The aim of this initiative is to create a board to discuss local impacts of climate change, help assessing vulnerability factors & resilience capacity and support local adaptation Strategies and Action Plans providing advice towards mainstreaming adaptation into sectoral policies, in coherence with the recommendations of the EU. The Task Force is composed by experts from the Alpine Convention's countries and open to scientists and key stakeholders involved in the main projects on climate change in the Alps. **A complete version of these Guidelines is also available on the official website of the Alpine Convention (www.alpconv.org).** Please note that in this Summary many sources haven't been reported in detail that can be found in the full version.*

Guidelines for Local Adaptation in the Alps (Paragraphs)

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The Alpine Policy Context

Stage (i)
Assessment of impacts, vulnerability and risks

Stage (ii)
Planning for adaptation

Stage (iii)
Implementation of adaptation measures

Stage (iv)
Monitoring and evaluation of adaptation interventions

Cross-cutting issues

1.1 Why develop guidelines for climate change adaptation at local level in the Alps?

Adapting requires developing good sectorial policies and working to maximize co-benefits for climate and other domains. These Guidelines aim at conveying adequate information on climate impacts and adaptation needs to the different sub-national governance levels. Information is a primary resource being able both to stimulate autonomous adaptation once markets start to respond to it (e.g. predictions on regional rainfalls and storm patterns) and to develop appropriate land-use planning and performance standards that can drive to safer public and private investment. Also public and private financial safety nets can improve preparedness and adaptation capacities throughout a territory.

Table 1: The Alpine framework and the European framework on Climate change adaptation

The Alpine framework on Climate change adaptation	The European framework on Climate change adaptation
<ul style="list-style-type: none"> • Declaration of Alpbach, 2006 • Evian Conference, 2009 • Action Plan on Climate Change in the Alps, 2009 	<ul style="list-style-type: none"> • EC (2009), White Paper. Adapting to climate change: Towards a European framework for action; • EC (2013), An EU Strategy on adaptation to climate change; • EC (2013), An EU Strategy on adaptation to climate change: impact assessment; • EC (2013), Guidelines on developing adaptation strategies; • EU-Committee of the Regions (2013), Climate change adaptation: Empowerment of local and regional authorities, with a focus on their involvement in monitoring and policy design; • Ecologic Institute – Berlin (2009), Design of guidelines for the elaboration of Regional Climate Change Adaptations Strategies (tender of EC DG-ENV); • EC (2013), CC adaptation practice across the EU; • EC (2013), Study of Adaptation Activities at Regional Level in the EU”; • EEA (2012), Climate change, impacts and vulnerability in Europe, 2012; • EEA (2013), Adaptation in Europe; • UN (1992), United Nations Framework Convention on Climate Change.

1.2 Climate change: the interlinked challenges of mitigation and adaptation

A strategy of tackling climate change ought to be developed in two different directions (EC White Paper 2009):

- a reduction of the greenhouse gas emissions with the target of slowing down global warming in the long-run (mitigation actions);
- an increase in the resilience of human activities and ecosystems to prevent or minimize the unavoidable impacts in the short-run (adaptation actions).

As a matter of fact, whatever the warming scenarios and however successful mitigation efforts could be, the impact of climate change will increase in the coming decades because of the delayed impacts of past and current greenhouse gas emissions. Therefore adaptation measures are needed to deal with the unavoidable climate impacts and their economic, environmental and social costs. By following coherent, flexible and participatory approaches, it is much cheaper to take early, planned adaptation actions than to pay the price of not adapting.

Due to the specific and wide-ranging nature of climate change impacts on the Alpine territory, adaptation measures need to be taken at all levels, from local to regional and national. A proper adaptation strategy should aim at minimizing the risks connected to climate change, protecting public health, life quality and properties as well as preserving the nature by improving the adaptation capability of natural ecosystems and the social and economic systems.

In addition, a robust adaptation strategy should be able to exploit advantages and achieve co-benefits of new opportunities. Adaptation action can bring new market opportunities and jobs, in such sectors as agricultural technologies, ecosystem management, construction,

water management and insurance. European companies, including SMEs, can be early first movers in developing climate-resilient products and services and grasp business opportunities worldwide. In line with the Europe 2020 Strategy, adaptation strategies aim at moving towards a low-carbon and climate-resilient economy, promoting sustainable growth, stimulating climate-resilient investment and creating new jobs.

Therefore, adaptation and mitigation should not be considered alternative or conflicting approaches. Rather, they both represent complementary aspects of a comprehensive and more successful policy to tackle all the impacts of climate change. While mitigation operates on a longer time scale (up to 50-70 years) and requires a world-wide coordinated approach to reduce gradually and eventually totally curb greenhouse gases emissions at planetary level, adaptation acts mainly at local level (from national downwards) and can be modulated according the different local situations (i.e. local impacts, vulnerabilities and resilience capacities). As the Stern Report highlights, if adaptation measures are not properly taken, the costs of mitigation will be higher and more serious will be the consequences of the climate change, before it can be stabilized by the long-run effects of mitigation policies.

1.3 Adaptation policies in the EU and in the Alpine countries: the significant role of the regional and local level

Climate change impacts do not respect administrative borders. Impacts are expected to vary across the EU, and within each Member State. To be effective, climate change adaptation requires responses at all levels of governance – the national, regional, local and collectively at the EU level.

The EU Strategy on adaptation to climate change (April 2013) is based on three priorities:

- promoting action by Member States;

- better informed decision-making;
- increasing resilience in key vulnerable sectors.

It supports the exchange of good practices between Member States, regions, cities and other stakeholders and emphasizes action at local level for implementing an integrated adaptation strategy.

There is no single kind of local level. Local urban settings show different features than rural areas resulting in different vulnerability profiles concerning the sensitivity of local systems to climate-induced changes (e.g. local dependency on ecosystem services and products, concentration of property values or economic activities, etc.), in relation to the adaptive capacity (availability of easily accessible infrastructures or public services, of financial resources for protection or recovering, of skilled human resources, etc.) and goals or strategies that may lead to different decisions, according to OECD.

Three main reasons identified by OECD to focus adaptation on the local level are:

- Climate change impacts happen locally and affect local livelihood, economic, health and social aspects by means of localized phenomena in response to local geographical, environmental, economic, social and political factors;
- Vulnerability and adaptive capacity are context-specific, depend on the interaction of many socio-ecological factors and processes. Thus abilities to reduce exposure, recover from negative impacts or take advantage of opportunities of climate change impacts can be developed locally;
- Adaptation is best observed and measured at local level, resulting in individual decisions (e.g. crop selection, equipment purchase, skills training, contingency planning) allowing for monitoring and evaluation of efficiency or effectiveness of adaptation.

Some essential issues can influence on management and governance of adaptation on the local level:

- Adaptation knowledge gaps are a major barrier to establishing an adaptation process;
- Political commitment by local policy-makers is crucial for local entities to advance on adaptation;
- Technical support, guidance and tools are vital in supporting local entities in developing vulnerability assessments, identifying adaptation options, developing a monitoring and evaluation framework for local adaptation. It is therefore crucial that adaptation is pursued in accordance with the regional level to create a clear interface enabling local and regional actors to communicate and cooperate effectively and a better organisation and identification of capacities and responsibilities of regional and local authorities.

2. Policy guidance for the development and implementation of sub-national Adaptation Strategies in the Alps

From a policy perspective, adaptation means taking climate scenarios and their possible socio-economic impacts into account into all types of policy-making and planning. To do so, a forward thinking and more collaborative policy involving all the political, social and economic actors are required. Adapting requires developing good sectorial policies and working to maximize co-benefits for climate and other domains. These Guidelines aim at conveying adequate information on climate impacts and adaptation needs to the different sub-national governance levels. Information is a primary resource being able both to stimulate autonomous adaptation once markets start to respond to it (e.g. predictions on regional rainfalls and storm patterns) and to develop appropriate land-use planning and performance standards that can drive to safer public and private

investment. Also public and private financial safety nets can improve preparedness and adaptation capacities throughout a territory.

Four stages for adaptation process:

- (i) assessment of impacts, vulnerability and risks
 - (ii) planning for adaptation
 - (iii) implementation of adaptation measures
 - (iv) monitoring and evaluation of adaptation interventions
- The findings from stage (iv) feed back into stage (i), ensuring that adaptation action is iterative and dynamic over time.

Stage (i): Issues to be considered during the assessment of impacts, vulnerability and risks:

- Current climate-related hazards and predictions concerning their expected changes
- Current and future impacts of climate-related hazards
- Quantification of the vulnerability of natural/ human systems and their resilience capacity
- Development trends and socio-economic factors that can reduce future impacts and vulnerability.

Stage (ii): Issues to be considered during the planning for adaptation stage

- Current strategies to manage risks arising from climate-related hazards
- Viability and effectiveness of current strategies in the future
- Further adaptation measures to be used for reduce impacts and improve resilience (including e.g. soft, “command and control”, market, financial, educational instruments)
- Costs and benefits of each adaptation measure
- Identification of proper cross-sectoral policies to be suited in a comprehensive adaptation strategy
- Consistency of the adaptation strategy with national, local or sectoral development objectives
- Barriers or present opportunities for integrating climate

change risks and adaptation measures into national, local or sectoral policies and planning.

Stage (iii): General objectives of adaptation strategies

- Avoid or minimize all or only part of the expected or observed impacts
- Restore levels of human well-being to pre-climate change levels
- Maintain current levels of risk or possibly reduce them cost-effectively within agreed budgets or pre-defined acceptable levels.

Stage (iv): Monitoring and assessment steps and methods

- Start from the objectives and preferred tools for implementing the CC Adaptation process
- Use of an indicators-based system addressed to measurable, achievable, realistic and time-framed targets (alternatively: e.g. conducting public surveys, monitoring the number of visits to a climate change community website and monitoring the number of requests for climate change literature)
- Introduce adjustments in the action, targets and methods based on feedback from monitoring actions.



Figure I: Roadmap and the key steps to implement sub-national Adaptation Strategies

2.1 Climate change in the Alps

The Alps have been identified as one of the most vulnerable areas to climate change in Europe. They show a high socio-economic and ecological importance, but also a high vulnerability to a wide range of natural hazards, increasing population and environmental pressures. Studies (e.g. MANFRED Project 2012) outline impacts due to climate changes already reported in the past and the major climate models predict for the coming decades an intensification of the trends (see fig. II).

Main climate change impacts to the Alpine region:

- the temperature increase recorded in the Italian Alps within the last 30 years is threefold the average increase registered in the entire boreal hemisphere. The overall increase in temperature is approximately +1 °C in the annual mean, and more pronounced in summer maximum and winter minimum;
- time series of snow height recorded in 41 meteorological stations in the Alps and spanning over the period 1920-2005 highlight a clear decreasing trend. This trend is even more evident in the last 30 years because of snowfalls have decreased by 18% with respect to the reference period 1959-2002; minimal drops of 40% have been registered at stations at low elevations.

Variations forecasted for future years:

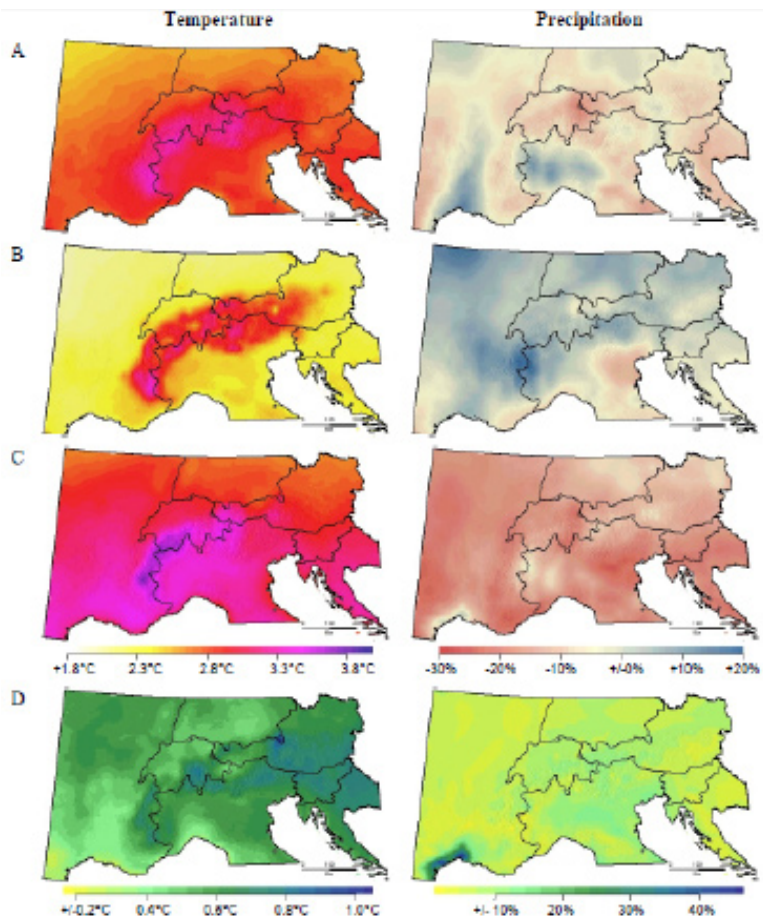
- temperature: a continuous rise in the average temperature is foreseen with an increase ranging from 2 to 6 °C according to the different emission scenarios.
- Rainfall: there is a change in rainfall patterns with very marked seasonal variations. Forecasted changes in long-term rainfall amount vary between different Alpine regions, but due to changes in rainfall intensity and

seasonal shifts, extreme events are likely to become more frequent and intense.

- Snowfall: the minimum snow presence elevation (snow reliability line) will increase. Some authors claim that an increase in air temperature by 1°C will result in a rise by 150 m in the minimum snow presence elevation; this implies a much more pronounced reduction of the snow cover at low altitude and a consequent severe impact on winter tourism.
- Permafrost and glaciers: the limit of the melting for the permanently frozen ground will increase and there will be an acceleration of the ice retreat. Glaciers will continue to decrease in mass, depth and surface extension at a growing rate.

The significant decrease in summer precipitation and the rise in winter precipitation, increasingly in the form of rain instead of snow, together with the acceleration of the cryosphere melting, will result in significant changes in the hydrological mountain regime. A significant reduction of the run-off in summer and especially a considerable increase in the run-off in winter is foreseen with consequences on the level of landslide risk and future availability of water resources. An increase in glacial risk is expected because presently stable areas gradually will become more subject to events such as collapses, rockfalls and landslides.

Figure II: Climate anomalies for the Alps, scenario by 2080



Source: MANFRED project (WSL Institute, Switzerland, 2012)

2.2.1 Mountain forests



Impacts, vulnerabilities and resilience factors

Mountain forest trees have a long life span (often up to 2-3 centuries and more) and their distribution is mainly determined by climate and soil conditions. Climate change can affect their stability through extreme events (wind gusts, dry periods, forest fires, floods, avalanches), expected to become more frequent, and pest diseases attacking weakened trees growing in a changing climate.

There is general consensus within the scientific community that climate changes will impact forest vegetation in three major ways:

- upward altitudinal and latitudinal shift of the forest timberline and a shift in the distribution of species (already observed across Europe);
- increase in forest growth rate (already observed across Europe, with also reduced pressure playing a role);
- further development and impacts of pests and diseases, due to changed climate condition that stress tree health.

Adaptation objectives

Climate adaptation objectives at local level regarding forest management should integrate the following aspects:

- we have to deal with trees living 1-2 centuries and we face more uncertainty in forestry planning; forest management plays accordingly a major role;
- social changes have to be considered in the adaptation strategies: pressure to reduce forest management costs, high and increasing demand for wood (material utilization, energy, bio-based industries), a new balance between protection and wood mobilisation, measure to increase stability and resilience, growing attention to ecosystem services, migration to agglomeration areas, demographic transition;
- forestry has to integrate risk management in its objectives and practice, defining the most exposed areas and being prepared for the occurrence; some help must be granted to forest owners when damages occur;
- forest structures must be developed towards resilience: plants and groups must develop stability, regeneration should be as extended as far as possible in order to allow a quick recover in case of extreme events;
- mixed forests, natural regeneration and uneven-aged, patchy structures should be favored in order to maximize the natural gene pool and the resilience of the forest;
- reliable monitoring of damage occurrence and exchange of data and experience (and cooperation) are important in tackling risks and damages connected to climate change;
- it will also be important to communicate the important role that alpine forests play and the services they provide to the local and regional society, in order to make the beneficiaries aware of the role of forests and open to compensate the services they receive from the forests.

2.2.2 Water resources



Impacts, vulnerabilities and resilience factors

Climate change in the Alps is strictly related to water resources, as a change in temperature and precipitation pattern has strong consequences on the snow line, glacier melting, and evapo-transpiration and consequently on the water discharge in the downstream water courses.

These changes are likely to increase flood hazard and to decrease water availability during summer for agricultural activities and human consumption.

In the last 130 years rainy days have decreased whereas dry days seem to have increased by 2 units per century. Drought events are expected to be twice more frequent than today in 2050 and tree times more frequent in 2070. Climate changes are causing an increase in water temperature; this, in addition to other secondary impacts, can degrade water quality and cause further problems on the ecosystem. The higher intensity in precipitation is likely to induce an increase in erosion processes and, as a consequence, an increase in

the nutrient and sediment transport in streams and rivers. Climate change will also affect the demand of water resources: water availability will be more variable and probably reduced, and water quality will need additional monitoring actions. Furthermore, it is expected that the requests of defence of the environment and of the ecosystem will become more pressing and demanding, in order to guarantee human health, the equilibrium of the ecosystem and the prevention of natural hazards.

Adaptation objectives

The adaptation strategy to climate change in the field of water supply requires:

- a) balance between humid and arid regions;
- b) safeguarding of the resources against depletion, e.g. groundwater protection measures;
- c) improvement of groundwater regeneration, e.g. utilization and management of rain water;
- d) obligation to use retention of water for agricultural uses in dry summer months and prohibition of water drainage directly from rivers.

“Grey” measures

Optimizing use of the available water resources (adjustment of the offer where appropriate, efficient irrigation and distribution system, strengthening of water detention reservoirs devoted to artificial snow production).

Strengthening of the current methods for monitoring the status of surface, ground water and snow water equivalent resources.

Improving the current database and predictions of water consumptions and of run-off volumes and the interregional exchange of data and monitoring systems.

Technological upgrade of the measuring systems (e.g. remote sensing, etc.) where appropriate.

2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors

2.2.3 Energy

“Green” measures

Re-qualification of the rivers keeping into consideration the minimal vital flow (MVF) and of the ecological status.

Creation of buffer zones among rivers and cultivated areas where appropriate.

Restoration of the ecological integrity of the riparian and lateral areal (transition zones) of the rivers where possible, in order to strengthen their role of regulation of bio-geo-chemical processes.

“Soft” measures

Management: ensure the creation of flood and, where appropriate, drought management plans in accordance with the 2007/60 Directive and the compliancy to the water quality standards (2000/60 Directive).

Legislation and planning: recalculate the historical water requirement and water grant where appropriated and ensure the minimum vital flow (MVF).

Communication: promote events for awareness raising in the area affected by the variation of the hydrological cycle (extreme events, drought, high runoff variability, etc.).

Economy: define incentives for the release of products characterized by efficient water usage requirements and/ or high water quality level where appropriate; planning of economical tools for the management of climatic risk (insurance, etc.) where feasible.



Impacts, vulnerabilities and resilience factors

Increase use for renewable sources

The demand of using renewable energy sources (RES), such as sun, wind, geothermal, hydropower, etc. increased after the assessment of climate change causes was clarified. Especially Europe, which strongly depends on foreign fossil fuels, is developing RES-promoting policies.

In the Alps the situation is slightly different compared to the rest of Europe: the presence of manufacture industries is limited, as well as the related energy consumption and CO₂ emissions, but other sources such as road transport and household heating are increasing in the last ten-fifteen years. The use of renewable sources with low carbon emission increased significantly in the Alps, but it is still far from the auto-sustainability.

Increase use of Hydropower

The most relevant renewable energy source in the Alps is the hydropower, which is foreseen to suffer a production loss due

to decreasing river flows. Considering current climate change situation, the energy scenarios should include not only the variation in the energy demand, but also the variability of renewable sources due to climate change. Possible restrictions can be expected for electricity generation in thermal-power plants linked to higher temperatures in both atmosphere and water temperatures and summer run-off. One of the most problematic issues for the renewable energy sources is the landscape impact of the “collectors”: dams, solar panels, windmills, etc.

Adaptation objectives

The direction that Alpine countries should take is from one side towards increasing use of renewable energy, from the other side to drastic savings in energy consumption coupled to a much more efficient energy usage.

Benefits from RES generally include:

- Energy security: reduced dependence on foreign energy imports.
- Environment: mitigating global climate change, regional acid and eutrophic precipitations, local air pollution, and indoor air pollution.
- Employment: technology development, manufacturing, installation and maintenance services.
- Technological development and competitiveness: rise of new and “greener” industrial products and processes.
- Rural development: improved energy services and income-generation opportunities.
- Reliability: greater energy availability and/or reliability in areas where service from electric power grids may be intermittent or unreliable.

The political and social objectives to be achieved regarding the aspects of energy production in the Alps can be summarized as follow:

- Advanced renewable energy technology solutions.
- Expanded use of RES, in combination with increased energy

efficiency as well as rational energy use in all sectors.

- Increasing energy usage efficiency through consumptions reduction, improving energy efficiency of existing buildings and sponsoring information campaigns for citizens.

2.2.4 Air quality and human health



Impacts, vulnerabilities and resilience factors

Climate change and the related meteorological conditions can alter the state and the behaviour of the atmosphere and have an impact on the formation and transport of air pollutants. A warmer and dryer climate can lead to higher levels of several air pollutants, especially those formed in the atmosphere through chemical and photochemical reactions as fine particulate matter (PM10 and PM2.5) and tropospheric ozone (O3).

In addition, the particular meteorological conditions like thermal inversions and local wind systems of the Alpine region hamper the dilution and transport of pollutants, significantly increasing the vulnerability of certain local

2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors

populations to atmospheric pollution due to a highest exposure. There is therefore concern that climate change could increase the burden of illness and mortality associated with air pollution.

Depending on each particular site or locality, impacts of climate change on air pollution can be worsened by several specific topographic, atmospheric and human factors that must be carefully considered to evaluate the magnitude of potential air pollution hazards.

For example, a substantial fraction of the Alpine inhabitants live in close neighbourhood with the cross-Alpine transport corridors and are consequently exposed to the adverse effects of transit traffic on air quality with potential negative consequences on health.

Finally, other factors that may further worsen future air quality in the Alps relate with the expected increase in forest fires risk and the increase in frequency and intensity of heat waves in the next decades. The extent to which human health is affected by climate change implications on air pollution depends on (1) the exposures of populations to its consequences, (2) the sensitivity of the population to the exposure, and (3) the ability of the local socio-economic system and populations to adapt to the new situation.

Adaptation objectives

Setting air quality adaptation objectives at sub-national level requires to carefully consider the information produced by institutional bodies and environmental agencies at the European level, and to work in close coordination with the National and Regional adaptation strategies. In order to avoid maladaptation, it is important to avoid objectives and adaptation options that are likely to increase vulnerability to climate impacts in the future. Instead, it is important to prioritize objectives and adaptation measures that are co-beneficial or have positive synergies with other policies such as the climate change mitigation objectives.

General objectives in air quality management at local level in

the Alps are the following:

- Strengthening current air pollution prevention policies to account for the effects of climate change.
- Combining local air pollution and global climate change mitigation policies.
- Adjust and strengthen current surveillance and monitoring systems to ensure prompt responses to the potential increase of acute atmospheric pollution situations.
- Ensure adequate early warning systems to ensure prompt communities response before intense air pollution episodes to reduce exposition and avoid health risks. To be effective and complete, an early warning system requires: (i) risk knowledge, (ii) monitoring and warning service, (iii) dissemination and communication and (iv) response capability.
- Privilege cost-effective options: prioritise adaptation options that also offer opportunities for decreasing emissions of methane and other ozone precursors in industry, mountain farming, mining and transport activities. Many win-win options are relatively cheap.
- Strengthen technical and managerial measures to decrease emissions of fine particulate from biomass burning, livestock and agriculture activities.
- Promote soil management practices that can enhance both the adsorption of pollutants and carbon sequestration.

2.2.5 Mountain agriculture and livestock farming



Impacts, vulnerabilities and resilience factors

Water resources and irrigation requirements

Changes in precipitation patterns and average air temperatures increase will affect hydrological regimes with an immediate impact on the use and distribution of water within agricultural uses. Seasonality of precipitation and interannual variability may affect crop yields, crop quality and even crop choice. The projected increases in temperature will lead to higher evapotranspiration rates, thereby increasing crop water requirements across the Alps.

Crops growth conditions, productivity and distribution

Increase in temperature coupled to an increase in atmospheric CO₂ levels will have a fertilising effect on crop growth for certain species and on grassland productivity. Higher temperatures at critical times of the growing season may prolong the vegetative period resulting in a short-term increase in agricultural yield and more productivity. Furthermore, the extension of the frost-free period in

elevated areas will further increase the extension of growing season of major Alpine crops. Finally, the rising temperatures will cause changes in current distribution of crops, extending the potential distribution area of some crops and reducing it in others. Climate change is expected to increase the spatial distribution and intensity of existing pests, diseases and weeds due to higher temperatures and humidity.

Soil fertility, erosion and hydro-geological hazards

Future increase in forest fire risk, drought events, and more intense precipitations will probably intensify hydrological erosion in the next decades. Furthermore, Increase in temperatures accelerate the process of mineralization of the soil organic matter decreasing soil organic carbon pools.

Livestock production and reproductive fitness

Climate affects animals both directly and indirectly. Indirect effects include climate influence on grassland and crops, and on water availability. Additionally, climate may also affect survival of pathogens and/or their vectors, which may cause risks for health in animal and human populations.

Adaptive capacity

The main factors that define the resilience of mountain agriculture to climate change are: i) the exposure of farming socioeconomic systems and agro-ecosystems to the impacts of climate change; ii) the sensitivity of such systems to the exposure; iii) the ability of the local farmers and their socioeconomic system to adapt to the new situation. Exposure depends mainly on biophysical factors, such as geographic context and site-specific climatic conditions. Sensitivity is related to the specific characteristics of the social-ecological systems and refers to the degree to which farming systems are able to respond to a change in climate conditions, either positively or negatively.

Ability of farmers to adapt to the new climate conditions may be considered as a function of wealth, technology, education, information, skills, infrastructure, access to resources, and stability and management capabilities.

2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors

Adaptation objectives

Climate adaptation at local level must integrate i) considerations to enhance positive synergies with other crosscutting aspects such as biodiversity, air quality, energy; ii) the principles of international and national/ regional adaptation strategies with special regard to the CAP (Common Agricultural Policy); iii) the long term economic and environmental sustainability of the mountain farming and iv) involvement of local stakeholders in the process of definition and implementation of adaptation initiatives.

Promote sustainable soil and land management

Adaptation requires higher soil resilience against both excess (intense rainfalls) and lack (extended droughts) of water. A key element to respond to both problems is to enhance soil organic matter. In this sense adaptation objectives should be targeted to incentive good soil management practices to maintain its main functions.

Enhance sustainable water management

Selecting more suitable crops to heat stress and droughts may reduce irrigation water demand. Other management low-cost techniques may be promoted to enhance water retention and minimize water evaporation during extreme events such as minimum tillage or mulching.

Define intervention measures to support farmers during the adaptation process

Support interventions range from providing ad hoc insurance mechanisms to cope with extreme events hazard to farm management and technical equipment facilities. Some collective facilities that may be provided by local authorities in order to support farmers are, for example, maintaining local abattoirs, creating meat-cutting rooms and sales outlets to support the development of farm processing activities, promote short distribution channels, or provide equipment on Alpine pastures.

Linking mountain farming with eco-tourism

Mountain farming might be a source of attractiveness for mountain tourism. To cope with lower productivity of organic

farming, particularly during the substitute process from intensive agriculture, local authorities should financially support it (e.g. incentives, collective facilities).

Ensure stakeholders involvement, and disseminate climate change impacts and “know-how” information. These social tools are crucial to ensure an adequate perception of the identified risks and a satisfactory degree of acceptance of the adopted adaptation measures.

2.2.6 Transport



Impacts, vulnerabilities and resilience factors

Projected changes in snow and rainfall patterns, more intense floods, landslide and avalanche events induced by more intense precipitation, increase in wind storms and blizzards will probably increase costs for infrastructures maintenance and will also compromise the security of the daily transportation services. Climate change will also likely impact on the dynamics and

transport modes in the Alps. It is expected that, due to the increase in average temperatures, non-motorized transport modes such as walking and biking will be favoured during the winter season. On the other hand, surface transport modes in alpine cities can be substantially disadvantaged specially during summer season, due to the expected increase in hot days and heat waves or extremely sunny days.

Finally, climate change is also negatively affecting inland water transports in the Alps by modifying hydrological cycle. Lower river discharges especially during summer season negatively impact transportation by reducing navigability of inland rivers and lakes, with a consequent increase in transport prices and negative effect on competitiveness.

Adaptive capacity

The extent to which transports are affected by climate change implications depends on (i) the exposure of transport infrastructures to climate change risk sources (e.g. magnitude, intensity and extension of a climate-induced hazard), (ii) the sensitivity of infrastructures and transport systems to the specific degree of exposure, and (iii) the ability of the local socioeconomic and transport system to adapt the sector to the new situation.

Exposure to climate change induced hazards may differ locally, depending on how many and to what degree transport systems, infrastructures or other related elements are situated in hazard zones or exposed to natural hazards and are hence subjected to potential climate change physical impacts and related socio-economic costs. *Sensitivity* is related on one side to the physical sensitivity of transport infrastructures to extreme events (e.g. resistance of transport infrastructure materials to a certain extreme weather event), and on the other side to the degree of criticality of the exposed transport element, as a measure of its relative importance for the entire network performance.

Ability to adapt is related to the knowledge and capacities developed by local governments, the professional

and recovery organizations, as well as the capacity of communities and individuals to effectively and proactively anticipate the impacts of current and future hazard events induced by climate change.

Adaptation objectives

Adaptation policies and measures should be long-lasting and should not contribute to the increase of greenhouse gases emissions nor of pressure on natural resources. Thus, climate adaptation at local level in mountain transports must integrate i) considerations to enhance positive synergies with other crosscutting aspects such as biodiversity, air quality, energy and carbon neutrality ii) better prevent and control natural hazards and limit their consequences on transport sector and iii) ensure sustainable development in terms of transport infrastructures and policies.

Here below a brief list of possible actions is reported:

- define local transport risk areas following harmonised procedures (e.g. by following integrated risk assessment protocols), taking into account risks resulting from climate change (landslides, rock slides, avalanches, floods, fires, etc.);
- Increase resilience of local transport infrastructures (e.g. adapt building codes and regulations to more climate-proof materials and infrastructures);
- reinforce local prevention and strategic management of natural hazards especially concerning transport infrastructures;
- introduce the concepts of participative planning processes, the involvement of stakeholders, a concept for risk dialogue and for strengthen individual preparedness and precaution;
- keep in contact with higher governmental levels to ensure vertical coordination of local adaptation initiatives with the national and Alpine region adaptation framework;
- anticipate the risks of transport infrastructures deteriorating due to climate change (e.g. develop a map of local itineraries and infrastructures potentially at risk along

2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors

with crisis management plans and a survey on prospects for the following decades);

- reinforce the territories' adaptation capacity to climate change (e.g. adapt existing tools and planning methods for an innovative management looking towards the future);
- foster vertical and horizontal co-operation of local public and private bodies, to enhance crisis management;
- promote the development of reliable detection and warning systems; inform the population and make it aware of its responsibilities.

2.2.7 Extreme events and natural hazards management



Impacts, vulnerabilities and resilience factors

Floods

An increase in winter floods is expected in future, as well as an earlier flood peak due to snow melting.

Debris flows

In recent years, debris flows have tended to originate at higher altitudes in some parts of the Alps and a decrease has

been observed in some medium altitude areas. The increase in the amount of material available close to glaciers and the evolution of heavy precipitation patterns could, in turn, prompt local increases in the evolution of debris flow activity.

Glacial hazards

Loss of stability of the hanging glaciers and the increase in the number and size of glacial lakes, as a consequence of glacier retreat and ice temperature rise, appear to be the two main consequences of climate change in the context of glacial hazards. The risk of outburst floods arises not only from glacial lakes but also from emerging intraglacial cavities filled with water.

Mass movements

An increased number of rockfalls were observed at high altitudes during the 2003 heat wave. The degradation of permafrost in steep slopes is a major factor for the reduced stability of rock walls and the rockfall pattern. Increased precipitation and the rising snow line may lead to more frequent and extended slope instabilities.

Snow avalanches

A change in avalanche hazards in connection with climate change is uncertain, although it is assumed this would follow snow cover evolution. A decrease in avalanche hazards is likely at low and medium altitudes, however heavy precipitation events may counteract this trend.

Adaptive capacity

In many communities, disaster risk preventions occur mostly as a reaction within a relatively short time period after an extreme event rather than in form of proactive prevention. In regions, where the principles of integrated risk management are already considered in practice today, the adaptive capacity is higher. An holistic strategy for disaster risk reduction with consideration of structural, non-structural, organizational measures and their best combination is the most appropriate approach for climate adaptation in this sector.

The implementation of the EU water framework and flood directives shows that the following factors improve remarkably the adaptive capacity at the local level:

- a detailed analysis of natural risks with consideration of multi-risk approaches;
- the involvement of the local stakeholders, actors and the public in the planning of disaster risk reduction measures;
- the review of the functionality of the existing protection measures under increased loads (process intensities);
- the implementation of local early warning systems, and the coordination between all relevant actors and government levels.

Adaptation objectives

Climate adaptation at the local level in natural hazards and risk management practice must follow a) the principles of international and national/regional adaptation strategies, b) the principles of integrated risk management, c) the current knowledge in the field of expertise that is evolving continuously, and d) must involve the local stakeholders. The overall goal of adaptation to climate change in the field of natural hazards is to limit existing risks to human health, material assets, economic activity and the environment to acceptable levels, and prevent the emergence of new unacceptable risks. In other words, the main target is to achieve and preserve adequate levels of safety in relation to natural hazards and to respect sustainability.

An adaptation plan in natural hazard management at the local level must consider:

- the targeted safety level in respect to sustainability;
- the local risk culture e.g. the level of individual awareness, preparedness and precaution;
- a concept for monitoring and analysing the continuous changes in the environment;
- the actual risks due to natural hazards and the possible future risks; the knowledge about the climate change fitness of existing protection measures;

- the need for risk reduction measures under current and future climate conditions;
- the different options for risk reduction (in terms of “grey”, “green” and “soft” measures), and the effectiveness/efficiency of their combinations; the long-term development of the community in terms of risk-appropriate land use and adaptive capacity;
- the residual risks after the implementation of risk reduction measures, and a plan for coping with residual risks and unexpected natural hazards;
- the link to the local emergency plan and to existing early warning systems;
- the way how cross-sectoral coordination between all relevant stakeholder at local level and the collaboration between local and regional level administrations work in the long run;
- the concepts of participative planning processes, the involvement of stakeholders, a concept for risk dialogue and for strengthen individual preparedness and precaution.

2.2.8 Tourism



2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors

A warmer climate and more frequent extreme weather events in the Alps will have important consequences for Alpine tourism in terms of changes in tourism offer and demand patterns, especially for winter tourism. Several studies conducted in different Alpine countries point out that in the coming decades there will be a decrease in snowfall, along with a widespread reduction of the snowpack and the reduction of the snow reliability, and consequently the length of the ski season.

Furthermore, climate change is projected to have substantial impacts on sensitive mountain environments (glaciers, glacial lakes, aquatic ecosystems, landscape), with implications on the attractiveness of mountain environments for tourism and the occurrence of natural hazards for tourist areas and infrastructures.

With respect to summer Alpine tourism, changes in climate may have both negative and positive implications. Negative impacts relate with the worsening of Alpine tourist resources quality due to climate change, like a reduction in water quality and quantity or glacial landscapes beauty reduction.. The expected decrease in summer runoff in Alpine rivers in conjunction with an increase in water demand could substantially reduce water levels in the main pre-alpine lakes compromising their navigability, with negative consequences on tourism.

On the other hand, positive impacts relate with an increase of climatic suitability for general tourism activities in Alpine regions as a result of climate change. The extension of the summer season and the occurrence of milder temperatures in the spring season could increase Alpine tourist destinations.

Adaptive capacity

The extent to which the tourism sector may be affected The extent to which the tourism sector may be affected locally by climate change implications (or vulnerability) depends on: *the exposure of tourist infrastructures and services to climate*

change hazards (e.g. degree to which a local tourist system is exposed to significant climatic-related variations such as snowpack reduction depending on local slope and aspect, climate suitability or changes in scenic beauty reduction); *the sensitivity of local tourist systems to the specific degree of exposure* (e.g. the degree to which a system is affected, either adversely or beneficially, by climate-related stimuli such as changes in snow cover day); *the ability of the local socioeconomic and technological system to adapt the tourist sector to climate change*, including climate variability and extremes.

Adaptation objectives

Climate adaptation at local level in Alpine tourism industry should integrate: i) considerations to enhance positive synergies with other cross-cutting aspects such as biodiversity conservation, water management, transport facilities, energy supply and carbon neutrality; ii) considerations to mitigate natural hazards regarding control and prevention initiatives in more exposed mountain touristic areas; iii) actions to ensure sustainable development of tourism sector in terms of nature and landscape protection and the planning of more long-term climate-proof tourism infrastructures.

General adaptation objectives are the following:

- Reduce economic dependency on skiing, diversifying tourism products towards activities that are less dependent on snowpack variability
- Make Alpine localities interesting tourist destination in all seasons of the year, boosting its tourism potential also in the absence of snow and taking advantage of climate change opportunities
- Reduce exposure of winter sports to climate change constrains, using managerial and technological adaptation

- options where environmentally and economically feasible. In each local case the potential adaptation options must be evaluated considering potential financial constraints and environmental implications to avoid maladaptation.
- Enhance disaster risk reduction, related to climate change in mountain tourism sector through the adoption of technical measures for the protection of people and properties.
- Strengthen cross-sectoral collaboration in tourism adaptation policies, in particular by establishing horizontal coordination to enhance coherence and positive synergies between tourism, energy, transport and climate policies.
- Ensure meaningful involvement of local tourism stakeholders in the definition and implementation of adaptation strategies to ensure successful adaptation.
- Provide appropriate information on climate change impacts, vulnerabilities and opportunities of the tourism sector in the Alps.

2.2.9 Biodiversity and Ecosystems



Impacts, vulnerabilities and resilience factors

The transformations induced by climate change on the structure of ecosystems and consequently habitats, will lead to a progressive, often fast, new climate regime that will change the ecological functions and thus ecosystem services. The species will be subject to changes in local conditions and their ability to survive in a changing ecosystem could be compromised. Some species can disperse quickly in an alternative habitat available and appropriate, others will undergo a gradual relocation and eventual extinction. Consequently, the climate change will be acting on ecosystems, directly or indirectly, able to produce a variety of effects on populations:

- distribution of the population due to changes in habitat;
- modifications of their ability to scatter;
- phenological changes: changes in the lifetimes of the various stages of development;
- ecological changes: lack of synchrony between food availability and stages of development;
- diffusion of alien species, with related changes in species composition, habitat structure and function of ecosystems by affecting their resilience with effects on the services they deliver to human communities.

Adaptation objectives

- Political awareness of the mutual dependence between climate change and protection of ecosystems and biodiversity must be translated into concrete actions at all levels (national, regional and local). This awareness should consider systemic adaptation actions, according to an ecosystem logic, to maximize the synergies between control of climate change and conservation of the multifunctionality of the ecological systems.
- Maintain and restore biodiversity and ecosystems that sustain our resilience and capacity to mitigate and adapt to climate change. The planning of Green Infrastructures

2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors

as an evolution of ecological networks constitutes a promising approach to be implemented in specific measures.

- Enhance the ability to act according to a cross-sectoral framework that integrates agriculture, environment and economic policies towards the recognition of natural capital and its functions.
- Maintain the functionality of ecosystems that provide ecosystem services through this cross-sectoral framework through concrete actions of the system of ecological matrix. Up to now, our patterns of consumption and production have deprived the ecosystems of their ability to withstand climate change and deliver the services we need. The consequent impact on the functionality of ecosystems and biodiversity cannot be dealt with separately due to their interdependence.

2.2.10 Spatial Planning



Impacts, vulnerabilities and resilience factors

Although in the Alps there are differences within the spatial planning systems depending on the size, the administrative structure and traditions of the country, it is possible to assess their adaptation capacity and vulnerabilities and resilience factors.

The CLISP project identified a large number of instruments with potential relevance to climate adaptation; nevertheless, up to now only very few regulations and instruments have focused directly on climate adaptation, or include adaptation as a planning objective. National legislation and other instruments (including adaptation strategies or plans) often does not compel lower administrative levels to include adaptation in spatial planning instruments.

The fact that many legal regulations and instruments are not fully binding tends to reduce the actual implementation of adaptation activities, thus lowering the theoretically high potential of spatial planning systems and existing instruments and procedures in the Alpine countries for implementing adaptation actions. As a result, the broad range of informal planning practices is not yet fully utilized, as widely recognized by experts and practitioners in the field.

The explicit inclusion of climate adaptation in the objectives and principles of spatial planning instruments would give adaptation activities a higher policy priority and create additional justification for implementation at regional and local level. Moreover, although there is some awareness of adaptation needs, local planners and politicians still hesitate to implement adaptation activities, which would lead to self-imposed restrictions on urban development, or conflicts with other local interests.

Concerning the flexibility of the spatial planning instruments, the main weaknesses lay in their rather static character, which cannot be easily adjusted to the adaptation requirements of a region. Another deficit is identified in the binding nature of planning policies or programs, when implemented at the local level.

Adaptation objectives

In order to address adaptation issues, spatial planning instrument should firstly consider climate change scenarios in their projections of protection objectives, then some expected climate change effects should be integrated into spatial planning instruments. It is then useful to create synergies between spatial planning and sectoral planning, including promoting those individual activities which contribute to ensure the climate change fitness of spatial planning and its instruments, that are not embedded in a coherent multi-level spatial strategy on climate adaptation but may deserve significant attention.

In order to strengthen the adaptive capacities and improve the climate change fitness of spatial planning in the Alps some enhancement options have been suggested:

- Rethinking the political and legal framework
- Focusing spatial planning policies and instruments
- Improving the knowledge base
- Cooperation, participation and engagement
- Providing financial and human resources
- Raising awareness and sensitizing stakeholders.

Spatial planning should rethink its mandate and key objectives. Spatial planning makes considerable indirect contributions to climate adaptation and offers much potential in this area. The adaptive capacity of spatial planning could be enhanced if climate adaptation were to be addressed more directly, and defined as a spatial planning objective in planning legislation and other frameworks.

Future spatial planning is concerned not only with growth and new developments. Coordinating shrinkage, relocating settlements and building or deconstructing infrastructures are becoming more and more important planning options. Increasing the adaptive capacity of spatial planning also means planning for uncertainties, and developing scenarios for possible future developments.

Sources related to this section can be found in the complete Guidelines available online (www.alpconv.org)



28 2.3 Identification and selection of local adaptation options

Local authorities basically address vulnerability and ordinary risk management without using climate projections, but relying on environmental agencies as advisers and retaining the will and power to make actual decisions on the matter. However, in order to develop coherent and effective adaptation plans local administrations need not only expert knowledge but also consistency with national adaptation strategies. Furthermore national authorities should translate global indicators in locally applicable ones and develop specific projections of climate change and its impact to be applied on-site.

2.3.1 Cost benefit and multi-criteria analyses: feasibility assessment

The assessment of the economic, environmental and social costs and benefits of adaptation plays a critical role in informing the planning stage of the adaptation process. Assessment of costs and benefits provides planners with essential information about when and where to act and how to prioritize and allocate scarce financial and technological resources.

Economically speaking, the main targets of an adaptation strategy are:

- Minimize or avoid all or at least some of the expected or observed impacts;

Table II: Criteria set to assess costs and benefits of adaptation measures

Criterion	Question to be answered by the Policy Maker	In short
Efficiency	Are the outputs achieved optimal relative to the resources allocated?	Outputs / Resources
Effectiveness	Will the option meet the objectives?	Measure / Target
Equity	Will the option benefit vulnerable groups and communities?	Balance on vulnerable groups
Urgency	How soon does the option need to be implemented?	Time required
Flexibility	Is the option flexible, and will it allow for adjustments and incremental implementation and reiteration depending on the level and degree of climate change?	Incrementality
Robustness	Is the option robust under a range of future climate projections?	Measure / Projections
Practicality	Can the option be implemented on relevant timescales?	Implementation / Time
Legitimacy	Is the option politically, culturally and socially acceptable?	Measure coherence with different systems of rules
Synergy/ Coherence with other strategic objectives)	Does the option offer co-benefits (for example, improving agricultural land management practices could lead to reduced erosion/siltation and carbon sequestration)?	Benefits

- Maintain current levels of risk or reduce them cost-effectively within agreed budgets or pre-defined acceptable levels;
- Return levels of human well-being to pre-climate change levels.

Each target has costs and resources may be limited. Trade-offs are to be made between adopting all possible measures and accepting to live with the risks. Planners need to agree on a set of criteria that will be used to assess costs and benefits of a given adaptation measure (see Table II).

According to UNFCCC, three main approaches have proven to be effective in assessing costs and benefits of adaptation options:

1. Cost-Benefit Analysis (CBA)

Cost-benefit analysis (CBA) is often used to assess adaptation options when efficiency is the only decision-making criterion. A CBA involves calculating and comparing all of the costs and benefits, which are expressed in monetary terms. The comparison of expected costs and benefits can help to inform decision-makers about the likely efficiency of an adaptation investment.

2. Cost-Effectiveness Analysis (CEA)

Cost-effectiveness analysis (CEA) aims to find the least costly adaptation option (or options) for meeting selected physical targets. CEA is performed when the objectives of the adaptation measures have been identified and the remaining task is to find the lowest-cost option for meeting these objectives. CEA is applied in assessing adaptation options in areas where adaptation benefits are difficult to express in monetary terms (e.g. human health, freshwater systems, extreme weather events, biodiversity and ecosystem services); but where costs can be quantified.

3. Multi-criteria analysis (MCA)

Multi-criteria analysis (MCA) allows assessment of different

adaptation options against a number of criteria. Each criterion is given a weight. Using this weighing, an overall score for each adaptation option is obtained. The adaptation option with the highest score is selected. MCA offers an alternative for the assessment of adaptation options when only partial data is available, when cultural and ecological considerations are difficult to quantify and when the monetary benefit or effectiveness are only two of many criteria.

2.3.2 Prioritization

Within the climate change adaptation process, the prioritization step assesses the main challenges and helps to identify the best options. The adaptation options enter an agenda of priority actions based on local information about vulnerability and expected impacts, taking into account the outcomes of the approach used for the assessment and rank the options.

The identification of priority options should be considered, evaluated and discussed with all stakeholders and implemented in a coordinated way. Some decision support tools can be used, including multi-criteria analysis, multi-objective analysis and consultation of expert panels.

The essential criteria that can be applied to select the priority adaptation options are:

- Evaluation of the impact of the options based on the following dimensions: i) social (e.g. consequences on levels of cohesion and social equity); ii) economic (a full cost-benefit analysis of the options in economic terms); iii) environmental (e.g. through the environmental impact assessment, in terms of impact on the improvement / deterioration in the quality of water, soil and biodiversity as well as the positive or negative contributions to GHG emissions). Priority will be given

to those options that are most effective in terms of the highest number of adaptation goals achieved and in terms of costs.

- Assessment of the urgency of the risk or the potential risk that the options intend to mitigate. The adaptation options addressed to imminent risks are a priority and need to be taken in the short run.
- Feasibility of the options submitted to evaluation, in terms of ease and speed of implementation.
- Potential interaction of adaptation options with other initiatives already undertaken at regional level that can help to reduce vulnerability. Priority should be given to options showing a positive synergy with them.
- Cross-border implications. Some options may have negative consequences beyond regional borders. These options should be avoided.
- Funding possibilities. Availability of funds to cover implementation costs: existing funding streams in the region, co-financing by the central government or EU funding as well as the possibility of steering private investment.

2.4 Implementation of measures at the local level

For a successful implementation of a sub-national adaptation strategy, the selected measures have to be concrete, feasible, inserted into the adaptation framework and coherent with the sectoral strategies at higher levels.

In order to enable local institutions to act toward an adaptation strategy the following factors have to be considered:

- provision of incentives, funding and authorisation to enable local action;
- strategic direction through regional level strategies or action plans;
- regional coherence of local/municipal plans and measures through coordinating activities.

2.5 Multi-level governance

Any adaptation process is inherently complex, since climate change impacts all regions, most economic and social sectors, different levels of decision-making, and many stakeholders. Different levels of policy-making need to be coordinated and integrated in order to make adaptation work at local level.

Coordination becomes a need at least on three levels: cross-sectoral, inter-regional, and vertical integration of decisions in order to convey a mutual understanding of different approaches on the adaptation problem.

Climate-resilience can be built by means of cost-effective adaptation measures (e.g. assessed using CEA, for instance). This may require enhancing the preparedness and capacity to respond to the impacts of climate change at various levels including the local and regional ones, developing a coherent approach and improving coordination (art.4 UNFCCC).

Adaptation to climate change is a multi-sectoral issue since it affects most economic sectors, but it is also cross-sectoral, due to the interconnectedness of the affected sectors. For example, a shift from ski tourism (including artificial snow-making) to all-year tourism may impact not only the regional tourism economy, but may show an effect also on other sectors (e.g. energy, water, biodiversity conservation).

Due to their intrinsic diversity, the sectors involved might have different objectives: negative effects in some sectors can derive from an adaptation measure undertaken in one sector's interest. Moreover, the stakeholders involved often bring different interests and values that can generate conflicts and resistance to adaptation. Most effective adaptation strategies embrace a "horizontal" integration of adaptation policies across sectors within and beyond the environmental domain, as well as mechanisms easing the dialogue between state, business and civil society in the affected sectors.

Table III: Actions at different governmental levels towards adaptation in Europe

Local action	Regional action	National action	European action
Implementing action			
<ul style="list-style-type: none"> • Planning and implementation of local adaptation strategies • Mainstreaming of adaptation concerns into other policy areas • Spatial integration of adaptation needs through urban planning • Local emergency plans • Allocation of municipal resources and raising of other funds • Upgrading local infrastructure to make it resilient to climate change • Engaging civil society and private actors 	<ul style="list-style-type: none"> • Providing incentives, funding and authorisation to enable local action • Addressing inter-municipal and urban-rural relations of climate change impacts and vulnerabilities • Developing and implementing with cities regional approaches, e.g. in river basins • Ensuring regional coherence of local /municipal plans and measures 	<ul style="list-style-type: none"> • Providing a supportive national legal framework, e.g. appropriate building standards • Mainstreaming of urban adaptation into the different national policy areas and the national adaptation strategy • Funding of local adaptation measures • Providing national information related to climate change and regionally downscaled information • Funding of research and knowledge development for urban adaptation • Supporting boundary organisations that link science and policy to local adaptation needs • Adjusting the degree of decentralisation of competences and authorities 	<ul style="list-style-type: none"> • Providing a supportive European legal framework • Mainstreaming of urban adaptation needs into the different European policy areas, e.g. cohesion policy • Funding of local adaptation measures as well as knowledge development for urban adaptation; • Providing European and global information related to climate change • Enabling and coordinating exchange of knowledge and experience across national borders • Addressing and coordinating cross-border adaptation issues

Adaptation requires a critical mass of individuals from the relevant governmental and administrative bodies motivated to engage in climate change adaptation. It seems essential to create a clear political willingness to take action that only can support the development and implementation of adaptation strategies and measures.

Local and regional levels play a critical role in adaptation that is often a national policy managed under the responsibility of centralised authorities. Nevertheless, different governance systems may command the “in-between” level of regions to play a specific role in order to achieve effective adaptation measures within a specific country.

2.6 Monitoring and evaluation: the follow up of the adaptation policy

2.6.1 The need of indicators- based assessment systems

The indicators employed in the adaption strategies may have different purposes and are used at different stages of the adaptation process. According to the EC White Paper on adaptation (2009), indicators should be used to build a structured information dataset to better understand the territorial and sectoral distribution of vulnerability to climate change impacts.

An indicator provides evidence that a certain condition exists or certain results have or have not been achieved. It can be either quantitative or qualitative. The indicators are often based on a given metrics that requires proper units of measurement allowing for comparisons across spatial and temporal scales.

The selection of indicators for adaptation is generally guided by a number of criteria such as:

- Policy relevance
- Causal links to climate change
- Data quality and accessibility

- Robustness and known uncertainty
- Acceptance and intelligibility

Two groups of indicators are considered to exist, depending on the step of the adaptation process that they address:

- 1) Process-based indicators seek to define the key stages in a process that would lead to the best choice of end point, without specifying that point at the outset;
- 2) Outcome-based indicators seek to define an explicit outcome, or end point, of the adaptation action.

Some criteria can be applied to choose the indicators addressing either “observed change” or “future projections”. The final selection of indicators often is a result of the consideration of both a set of criteria like the ones mentioned above and of the opinions of experts or stakeholders.

Climate change impact and vulnerability indicators are needed both at national and sub-national levels. To allow sharing of good practices and comparative analysis that can inform policymaking at the European level, it is desirable to achieve consistency in methodologies and data collection across countries.

At local scales, available data are of more complex and less standardized type. Assessments at a fine scale allow collecting more accurate information and identifying vulnerable areas or sectors. They can show the root causes of vulnerability and can be used for land use management and adaptation planning purposes. Nevertheless, local datasets can be complex and unique: comparisons may be difficult and update of indicator values costly.

Table IV: Indicators on climate change impacts, vulnerability and risks relevant for Europe

Type of indicator	Main purpose
Climate change (e.g. temperature, precipitation)	Understanding the causes of impacts of climate change
Climate change impacts (e.g. floods, droughts)	Understanding consequences of climate change and determining vulnerability to climate change
Social, economic, health, and ecological vulnerability (determined by biophysical impacts, their relevance for a sector or region, and the available coping and adaptive capacity)	Monitoring and understanding vulnerability, identifying adaptation needs, evaluating adaptation strategies and action (including resource allocation)

(Source: EEA, 2012)

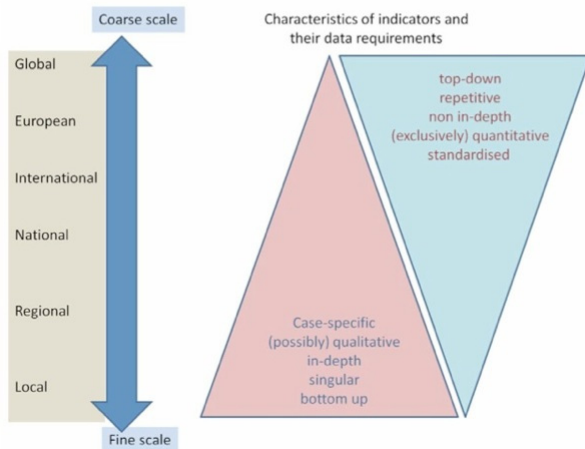


Figure III: The relation of vulnerability indicators and related data to spatial scales

Source: ETC/ACC Technical Paper 2010/12

Table V: Regional/local process-based indicators and regional/local outcome-based indicators

Regional/local process-based indicators	
Sector	Indicator
General	<ul style="list-style-type: none"> - Use of scenarios to inform adaptation options. - Identification of cross-sectoral issues/concerns. - Production of local adaptation guidance. - Production of disaster management plans.
Agriculture	<ul style="list-style-type: none"> - Implementation of measures to reduce soil erosion and desertification. - Introduction of drought and heat resistant crops. - Uptake of insurance to cover weather extremes.
Biodiversity	<ul style="list-style-type: none"> - Monitoring of climate change indicator species. - Removal of spatial barriers to increase natural adaptive capacity. - Extension, connections and establishment of buffer zones around protected areas.
Health	<ul style="list-style-type: none"> - Mapping and control of disease vector species (e.g. mosquitoes). - Provision of climate control equipment for vulnerable people.
Tourism	<ul style="list-style-type: none"> - Modification of recreational facilities to accommodate higher ambient temperatures.
Water	<ul style="list-style-type: none"> - Construction of flood protection schemes.
Economy	<ul style="list-style-type: none"> - Upgrade of transport infrastructure.

Regional/local outcome-based indicators	
Sector	Indicator
Biodiversity	<ul style="list-style-type: none"> - Reduction in degraded ecosystems.
Health	<ul style="list-style-type: none"> - Reduction in deaths during heat waves.
Water	<ul style="list-style-type: none"> - Reduction in water consumption.

2.6.2 Adjustments of and reporting on the adaptation strategy

Monitoring and evaluation of an adaptation strategy, plan or single action consists of the assessment of its progress against set targets and objectives. Examining the effectiveness of adaptation support mechanisms can help to evaluate adaptation funding, identify future priorities, ensure the effective allocation of scarce resources, allow a wiser allocation of public funding for accountability purposes.

The evaluation process is iterative: it starts from the objectives and preferred tools for implementing the strategy and can bring to adjustments in the strategy, its targets and methods. Thus responsible authorities must commit to monitoring the success of the strategy during the implementation phase, preferably regularly (e.g. on an annual basis or more frequently).

Monitoring and evaluation are most likely to be successful where designed to coincide with other *routine policy monitoring and evaluation* exercises, often under the responsibility of the leading regional authority.

Even though a few approaches to monitor progress in adaptation have been proposed, operationalization at the adequate level and for purposes of adaptation tracking are constrained by limited attention to developing tools by which adaptation can be systematically tracked over time and across regions, an absence of debate on metrics, and limited standardization in approaches. However, it is essential to assume a practice-oriented approach as well as a sense of purpose in making any evaluation exercise.

3. Key factors to ensure success of sub-national adaptation strategies at local level in the Alps

A recent survey conducted on national adaptation strategies developed in the Alpine countries¹ has identified three main challenges to be addressed in order to deliver well-framed and effective adaptation planning at sub-national level:

1. *Perception and awareness.* Climate change is still perceived as something distant, as an environmental topic, and climate adaptation is sometimes still confused with climate mitigation.
2. *Knowledge gaps and uncertainties.* Climate change adaptation has to live with uncertainties and knowledge gaps. Different vulnerabilities and varying levels of concern exist between sectors and regions. Different sectors and regions may have different, even contradictory visions for adaptation to climate change.
3. *Policy integration.* Sub-national adaptation policy requires to identify and coordinate different interests and potential conflicts. Competencies in policy and administration are strongly fragmented and assigned to different sectors and territorial levels.

3.1 Dealing with cross-cutting issues: integration and mainstreaming

Adaptation shows a number of possible synergies and integration among focal areas, that if properly managed can support other policies where money and engagement have been spent. For example, actions aimed at promoting conservation and sustainable use of biodiversity can be better supported if the risks of climate change are integrated within sustainable ecosystem management practices (e.g. measures aimed at reducing vulnerability to climate change

can be integrated in sustainable land management projects).

Effective adaptation requires to focus efforts, and often operate at the intersection of policy areas. Success and cost-effectiveness of adaptation call for an integration of concerns and priorities across the full breadth of economic and development decision-making. Coordination becomes possible only in the presence of the necessary policy will.

In our framework, adaptive actions designed for one sector could potentially create negative side effects for other policy sectors, if not coordinated. Likewise, adaptation responses in distinct policy areas can deliver synergies when mutually designed. There is, therefore, a clear need for coordination across a wide range of political, legal and institutional settings, as well as different information management approaches and financial arrangements.

A cross-cutting, complex theme such as adaptation to climate change needs to be addressed with inter-, trans-disciplinary, cross-sectoral, multi-level and inter-regional approaches that allow involve all affected actors with different knowledge, interests and values: all levels of decision-making, all regions, most economic sectors. Finally, using a diverse set of financial instruments can then help implement specific adaptation measures addressing, for instance, the affected stakeholders or sectors, the performed economic, social or environmental functions or a well-defined geographical scope.

3.2 Participation

Adaptation strategies at subnational level have to be developed with a participative approach at all stages, from the drafting to the implementation process. An effective participation brings about several benefits: it allows to better spread out scientific information about climate change; better identify the most significant impacts and vulnerabilities and consequences at the local level; facilitate

the integration of adaptation issues in sectoral policies and governance actions; and it usually leads to a greater understanding and acceptance of the overall adaptation strategy.

Since the first stages, it is fundamental to identify the stakeholders to be involved in the participation process and define the potential instruments to use.

A well-framed participatory process has to be carefully planned and the most appropriate forms of participation assessed (e.g. work tables, seminars, workshops or presentations). Workshops are a particular fruitful way of holding consultations and including the opinions and suggestions of groups and individuals that are not part of the core-group drafting the policy document. Joint events attended by government staff and researchers should be organised to create a space in which communication between these parties can be encouraged and improved.

3.3 Communication and awareness raising

“Effective” climate change communication is a form of public engagement that facilitates an intended behavioural, organizational, political and social change consistent with identified mitigation or adaptation goals.

Effective communication on climate change for local adaptation strategies should consider the following issues:

- The message has to be internally consistent in all aspects.
- Effective messages have to create or make use of existing mental models: a problem initially perceived as distant must be brought home; the invisible causes and impacts must be made visible; the inconceivable solutions must be illustrated; perceived and real barriers to action must be shown as something normal people have overcome.
- Messages are wider than the words or the information they convey: they are accompanied by, and inseparable from elements like imagery, tone of voice, the emotions evoked by pictures, symbols, colors, and music.

- Messages must keep the audience’s attention: suspense should be kept up throughout the delivery.
- At different stages in the behavior change process, people require different types of motivations and practical information.
- Communication should be sustained over time: the same message should not be conveyed overtime, regardless of how the audience evolves in its understanding of climate change.

Communication has to focus on positive sustainability and adaptation issues (e.g. saving money). Provoking fear might generate behavioral change in some cases, however, only if people feel personally vulnerable. Actually this awareness is not sufficiently spread yet.

3.4 Financing

3.4.1 Internal (public) funding

At the regional level, implementation of adaptation strategies should take place within the framework of existing sectoral policies.

In order to minimize the costs of adaptation, it is useful drawing up, at sub-national or local level, a list of priorities affordable within the budget available for individual tasks. In the event that the identified adaptation measures demand a greater commitment by the various sectors or Directrates, additional needs for financial resources and staff should drive to an actual search for additional funding.

At all levels, it is advisable to further examine the potential of innovative funding measures for adaptation.

Many adaptation actions to reduce the vulnerability of a given territory require cross-border cooperation, since they affect areas beyond the administrative borders of a single region, making the adaptation a shared international responsibility.

3.4.2 The role of the private sector

A considerable amount of adaptation costs is likely to be covered with public funding, due to the sizeable social benefits of investment in adaptation. Nevertheless public expenditure decisions have to be taken carefully in order to ensure that public funding and state aid do not foster mal-adaptation.

A growing attention should be paid also to funding sources from the private sector. A changing climate represents both a threat to economic activity and physical assets and an opportunity for new businesses and investment.

The private sector responds in two ways:

- Optimising the use of insurance and other financial services and products to complement adaptation measures and act as “risk sharing” instruments. (e.g. compulsory covering of certain private actors/sectors -e.g. public services, critical infrastructure- by standard weather-related insurance contracts).
- Using revenue from auctioning allowances under the EU Greenhouse Gases emission allowance trading system (the EU ETS) for adaptation purposes especially at the local level, in line with the revised Directive governing the scheme providing that at least 50% of the revenue from auctioning allowances, should be used, inter alia, for adaptation in Member States and developing countries.

3.4.3 External funding (EU and national sources)

Advice and support can be found beyond national borders by joining adaptation projects among countries or cities aimed at fostering connections and exchanges of good practice between authorities, often in the frame of the EU Cohesion Policy (many spending programs target regions directly and are frequently prepared by regional authorities).

38 3.5 Enhancement of trans-boundary cooperation

Most direct and indirect impacts of climate change are of cross-border nature. Trans-boundary issues create interdependencies across national and regional boundaries (e.g. hydrological, social and economic ones in the case of water). International cooperation can ease the identification of approaches for coordination over different political, legal and institutional settings.

Cross-border cooperation, especially when based on large-scale activities and involving several actors, can help to minimize the costs of adaptation and maximize its benefits by developing synergies in adaptation measures and integrating consequences for neighborhood jurisdictions. Many Alpine institutions already have experience of cross-border activities addressing climate change jointly developing adaptation responses (e.g. Alpine Space Programme).

Possible stakeholder engagement approaches vary from quite passive interactions (where the stakeholders provide information), to “self-mobilisation” (where the stakeholders initiate and design the process).

3.6 Ensuring stakeholder engagement

Adaptation occurs through: i) public policy-making and ii) decisions made by stakeholders, i.e., individuals, groups, organizations (governmental agencies or non-governmental organizations) and their networks.

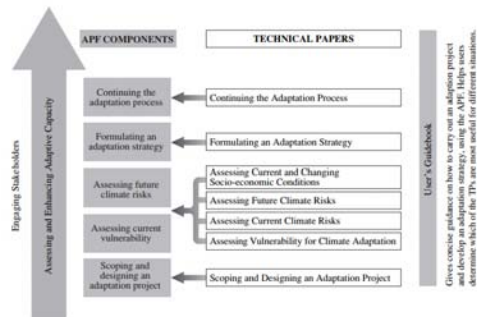
Stakeholders have the current and past experience of coping with, and adapting to, climate variability and extremes. Their principal resources for responding to climate change impacts are their knowledge and expertise. Through an ongoing process of negotiation, they can assess the viability

of adaptive measures. Together, the research community and stakeholders can develop adaptive strategies by combining scientific or factual information with local knowledge, but also experience of change and responses over time.

When designing the engagement approach to be used, it is important to consider:

- The scope of the issues that stakeholders will participate in defining and solving
- The stage at which the engagement is occurring in terms of the policy-making process
- What decisions have already been taken and what positions are already fixed

Figure IV: Ladder of Participation (adapted from Pretty (1994) Typology of Community Participation).



Source: Conde and Lonsdale, 2005

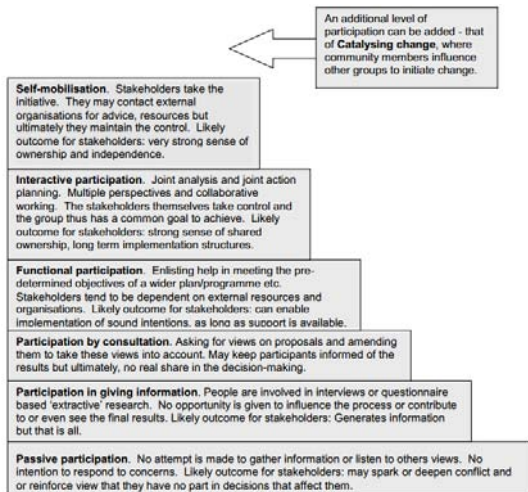


Figure V: The Adaptation Policy Framework Process

Source: UNDP 2004

3.7 Avoiding maladaptation

Maladaptation can be defined as an adaptation process resulting in increased vulnerability to climate change and/or undermining capacity for future adaptation. According to IPCC, maladaptation is “any changes in natural or human systems that inadvertently increase vulnerability to climatic stimuli; an adaptation that does not succeed in reducing vulnerability but increases it instead”.

Maladaptation can result from a mistake to design or implement suitable adaptation policies and measures and a failure in meeting the adaptation action objectives, that may even increase the overall vulnerability and consequent risks of a given region – either directly or indirectly.

Actions can be classified as maladaptation when, relative to more suitable alternatives, they:

- Increase emissions of greenhouse gases
- Disproportionately burden the most vulnerable people

- Have higher opportunity costs
- Reduce incentives to adapt
- Set paths that limit the choices available to future generations
- Transfer vulnerability to a neighboring area or country

Maladaptation shall not be underrated when comprehensive adaptation policies are set up. It became a cause of increasing concern to adaptation planners, especially when intervention in one sector could increase vulnerability of another sector, or increase the vulnerability of a group to future climate change. According to IPCC, conflicts and tensions between different policy areas can be a major cause of maladaptation.

Ideally multi-level governance and cross-sectorial policies should aim at avoiding major costs and support co-beneficial solutions – an issue that is felt as a primary challenge in climate adaptation.

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A complete version of the Guidelines is also available on the official website of the Alpine Convention (www.alpconv.org)

