GUIDELINES FOR CLIMATE CHANGE ADAPTATION AT THE LOCAL LEVEL IN THE ALPS

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The Guidelines presented in the following pages are the outcome of the work of the Task Force on Climate Change (CC) of the Italian Presidency of Alpine Convention. This initiative was launched during its mandate (2013-2014) and it is based on the need to implement the AC's Climate Action Plan for the Alps and contribute, with appropriate guide-lines based on updated scientific knowledge, to strengthen, harmonize and promote local adaptation policies and measures.
The aim of this initiative is therefore to create a table to discuss local impacts of climate change, to help assessing vulnerability factors & resilience capacity and to support local adaptation Strategies and Action Plans providing also advice in mainstreaming adaptation into the sectoral policies in coherence with the recommendations of the European Union.
The Task Force is composed by experts from the Alpine Convention's countries and it is open to scientists and key stakeholders involved in the main projects related to CC issues for the Alps.

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Introduction

Even though much attention has been devoted to mitigation policies in the fight against climate change over the last decades, adaptation is the only response available for the impacts that will occur before even extremely well-designed mitigation measures can have any effect. Nevertheless, the adaptation "mindset" has been often undervalued for long time in many regions.

It is generally believed that early adaptation means lower costs to society and less residual damage. Economic assessments of the monetary benefits of adaptation vary across sectors and require a case by case approach.

One of the main advantages of adaptation is that it provides immediate benefits where it is applied (which is not the case of mitigation) and that is also the reason why much adaptation is delivered autonomously in response to market or environmental changes. Adapting thus often requires developing good sectorial policies and working to maximize co-benefits for climate and other domains.

Adaptation often derives from sustainable development policies enhancing diversification, flexibility, skilled human capital, emergency responses. Certainly, there is a large share of adaptation that requires sound planning and provision of public goods like infrastructure, information and innovation (typically undersupplied with no public intervention).

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.

The Guidelines have been divided in three chapters. In the first chapter assumptions and reasons that urge the development of guidelines on local adaptation are explained in relation to the main Alpine Convention documents and decisions on the matter. The need of a coordinated and integrated pursuit of both mitigation and adaptation is explained and EU relevant adaptation policies are thoroughly examined. In this line, the significant role of sub-national government level in developing effective local strategies has also been highlighted.

The second chapter provides a detailed policy guidance for developing and implementing sub-national Adaptation Strategies in the Alps. The main features of present and future climate change (as predicted by the scaled-down climatic models) are presented for a better understanding of the reasons why climate change is and will be exerting a higher pressure on the Alps than detected or predicted on average in Europe. Accordingly, the Guidelines deal with the impacts, vulnerabilities and resilience capacity across the policy sectors more relevant for the Alps: mountain forests; water resources; energy; air quality and human health; mountain agriculture and livestock farming; transport; extreme events and natural hazards management; tourism; biodiversity and ecosystems; spatial planning. For each of them one or more experts have been reviewing data and results produced not only by the scientific literature but also by the regional or local adaptation strategies/plans in the Alpine countries.

Criteria for identifying and selecting the best adaptation options are examined on the basis of cost-benefit, cost-effectiveness, multi-criteria analyses and prioritization procedures. The implementation of measures is then analyzed considering a multi-level governance approach based on the harmonization of planning measures at different governance levels, with special emphasis on the local level. Once appropriate measures have been implemented, they have to be monitored and their effectiveness regularly assessed. To this purpose, a few suitable indicators as well as methods for the policy assessment and reporting are recalled.

The third chapter presents the key factors ensuring success of sub-national adaptation strategies at local level in the Alps. Cross-cutting issues are examined as participation processes, techniques of communication and awareness raising and financial opportunities (particularly European cooperation and research funds). To this end, the role played by the trans-boundary cooperation as well as the engagement of a variety of economic, technical and social stakeholders are vital. Insights provide help to strengthen sharing of good practices, data and information; increase the social acceptance of adaptation measures; and favour the involvement of the private sector into public policy delivery.

The conceptual and institutional l framework

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

On the basis of the available data on trends and impacts of climate change in the Alps, the X Alpine Conference in Evian (2009) adopted the "Action Plan on climate change in the Alps"[1] following the Ministers' Declaration of Alpbach (2006). The Action Plan sets the general objectives of increasing adaptation capacity and risk reduction, as well as the commitment to proper mitigation policies through the reduction of greenhouse gases (GHG) emissions. The mitigation and adaptation strategies defined in the Action Plan refer, in particular, to the sectors of spatial and land planning, energy, transport, tourism, mountain forests, biodiversity, water management, mountain farming.

The Working Groups and the Platforms, which are established by the Permanent Committee, are actively involved in the implementation and monitoring of the Action Plan and, through actions and projects, they aim at proposing concrete and specific measures for the Alps. As stated in the Alpbach Ministerial Declaration, the Working Groups and Platforms have the task of promoting international research initiatives capable to enhance the knowledge of the effects of climate change in the Alps, thereby providing a sound basis for defining and implementing adaptation strategies which could be applied also to other mountain regions of the world facing similar challenges.

As apparent from the follow-up of the Action Plan presented in the XI Alpine Conference in Brdo (2011)[2], the Working Groups and Platforms of the Alpine Convention have focused on the consequences of the climate change: for each sector involved, they identified measures and good practices as a common basis for a further development of better aimed actions and a new approach to climate change in the Alps.

The above-mentioned approach has been developed in accordance with the contents of the Multiannual Programme (MAP 2011-2016), which was adopted in the Brdo Conference and is presently in force. The MAP mentions the climate change within the five areas of inter-sector activities to which the specific actions of the Alpine Convention have to be addressed.

In order to strengthen the commitment towards effective adaptation and spatial planning strategies in the framework of a changing climate, the Programme of the Italian Presidency of the Alpine Convention,

1Action Plan on climate change in the Alps. «Making the Alps an exemplary territory for prevention and adaptation to climate change», ACX_B6.

2 Action Plan on climate change in the Alps – follow up and implementation, ACXI_B5.

as presented in the XII Alpine Conference in Poschiavo in 2012, mentions (under the section "Priority and main goals") the Adaptation to the climate change as a primary objective.

To this purpose, the Programme points out that comprehensive regional adaptation plans in the Alps are in most cases still missing, where "comprehensive" are meant those plans that collect and systematize the available knowledge providing suggestions to policy-makers for the governance of critical issues such as sustainable land use and risk management[3].

In this framework, it is advisable to recover some goals[4] of the Action Plan, not yet fully achieved, and related to the development of applied research and to the revival of public awareness on the topic.
In particular, the Action Plan mentions the following objectives:

- improve knowledge to better understand the impact of climate change on a local level, particularly as far as water, natural hazards and socio-economic balance are concerned;
- reinforce cooperation in order to gain common knowledge of the existing risks;
- reinforce public awareness, especially among the youth.

In the meantime the European Union, the Alpine countries and regions have been developing the process for a EU Macroregional Strategy for the Alpine region (EUSALP) on the basis of existing programs and instruments capable of fostering the cross-border and transnational cooperation of Alpine States and Regions ensuring a multi-level-governance approach and a proper application of the principle of subsidiarity which are both particularly suitable for harmonizing local adaptation strategies.

Within a climate change adaptation policy (CCAP)[5], the development of guidelines refers to the implementation process when sectors and levels take actions in a coordinated, effective and coherent way. The implementation stage is characterised by a coordinated action on climate change on the ground and involves sectors, regions and plan actions on the ground (Action Plan)[6].

The initiative to set guidelines on climate change adaptation at the local level aims at fostering the implementation stage in order to address the priority defined in the Action Plan on climate change in the Alps as «Making the Alps an exemplary territory for prevention and adaptation to climate change».

3 Italian Presidency of the Alpine Convention 2013-2014. Presentation of the main objectives and priorities, ACXII_B7, p.

4 See Action Plan on climate change in the Alps, ACX_B6, pp.22-23.

5 A Climate Change Adaptation Policy (CCAP) can be defined as the sum of processes at different phases, including the resulting documents applied by governments or administrations with the explicit aim of influencing adaptation to climate change. […] The stages of the climate change adaptation policy process are the following: initial stage (at this stage there is no formal mandate to develop a strategy document; this phase is similar to the problem framing stage); strategy development stage; action plan development stage; implementation stage, which is characterised by coordinated action on climate change on the ground (s. C3Alps WP4 Synth Report).

6 Action Plan on climate change in the Alps. «Making the Alps an exemplary territory for prevention and adaptation to climate change», ACX_B6.

Table I: 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
- Declaration of Alpbach, 2006 - Evian Conference, 2009 - Action Plan on Climate Change in the Alps, 2009	- 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

As reported in the White Paper of the European Commission (2009), the strategy of tackling climate change ought to be developed in two different directions:

- a reduction of the greenhouse gas emissions with the objective 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. We therefore have no choice but to take adaptation measures 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.

In view of 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 levels. The main goal of an adaptation strategy is minimizing the risks connected to climate changes, 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 take several 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, the different adaptation strategies will help move towards a low-carbon and climate-resilient economy, and will promote sustainable growth, stimulate climate-resilient investment and create 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 GHG emissions at planetary level, adaption 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). 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 (Stern, 2007)

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.

Recognizing this, the European Commission adopted an EU Strategy on adaptation to climate change in April 2013, based on three priorities :

- promoting action by Member States;
- better informed decision-making;
- increasing resilience in key vulnerable sectors.

Seeking EU-wide cooperation and coherence, the Commission also supports the exchange of good practices between Member States, regions, cities and other stakeholders. The EU Adaptation Strategy also places emphasis on action at local level as a need towards implementing a fully integrated adaptation strategy.

Three main reasons to focus adaptation on the local level have been identified by several political, economic and scientific organizations (e.g. OECD, 2009):

- 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 they can be developed locally as abilities to reduce exposure, recover from negative impacts or take advantage of opportunities of climate change impacts;
- 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 policies, programmes or actions.

Moreover, there is no single kind of local level. Local urban settings typically show partially 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.) and 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 the development goals or strategies that may lead to different decisions concerning adaptation policies and measures (OECD, 2009).

There are some obstacles concerning both management and governance of the implementation of the adaptation strategy on the local level:
• *Adaptation knowledge gaps*, that constitute a major barrier to establishing an adaptation process including the development of an adaptation strategy;
• *Political commitment by local policy-makers*, that is crucial for local entities to advance on adaptation;
• *Technical support, guidance and tools*, which are vital in supporting local entities in developing vulnerability assessments, identifying adaptation options, and in 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. To further address existing barriers to local and urban adaptation such as lack of awareness, lack of local data and knowledge, and limited funding for adaption measures, a proper support is also to be provided at the European level.

The impacts, risks and vulnerabilities change over space from region to region. Moreover, local scenarios involve interconnected areas localized beyond the boundaries of the territorial unit under inquiry. Local-regional collaboration may enable better organisation and identification of capacities and responsibilities. It has been recognized that regional and local authorities have a significant role to play for adaptation to climate change.

In particular, there are many areas where local (urban) governments can act for adaptation – as shown in the table below.

Table II: The role of local governments in the different aspects of adaptation

Role of city/municipal government	Long-term protection	Pre-disaster damage limitation	Immediate post-disaster response	Rebuilding
Built environment				
Building codec	High		High	High
I and use regulations and property registration	High	Some some		High
Public building construction and maintenance	High		High	High
Urban planning (including zoning and development controls)	High			High
Infrastructure				
Piped water including treatment	High	Some	High	High
Sanitation	High	some	High	High
Drainage	High	High	High	High
Roads, bridges, pavements	High		High	High
Electricity	High	Some	High	High
Solid waste disposal facilities	High	some		High
Waste water treatments	High			High
Services				
Fire protection	High	Some	High	Some
Public order/police/early warning	Medium	High	High	Some
Solid waste collection	High	High	High	High
Schools	Medium	Medium		
Heath care/public health/environmental Heath/ambulances	Medium	Medium	High	High
Public transport	Medium	High	High	High
Social welfare (includes provision for child care and old-age care)	medium	High	High	High
Disaster response (over and above those listed above)			High	High

Source: ECO-LOGIC, Design of guidelines for the elaboration of Regional Climate Change Adaptations Strategies, 2009

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

The term *"climate change"* refers to any change in climate over time, whether due to natural variability or as a result of human activity, while *"climate change impacts"* refer to the observed or projected effects of climate change on natural and human systems. In the case of projected effects, these projections often refer to 'potential impacts', which are those impacts that may occur given a projected change in climate, without considering adaptation.

"Vulnerability" is defined as a function of: i) the exposure to climate change impacts, ii) the sensitivity and iii) the adaptive capacity of a system or territory. "Adaptation" can be defined as being made up of "adjustments in natural or human systems in response to actual or expected stimuli or their effects, which moderates harm or exploits beneficial opportunities" (IPCC).

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, it is required a forward thinking and more collaborative policy involving all the political, social and economic actors.

According to a well rooted interpretation, any adaptation process can be divided into four stages:

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.	

At the outset of any adaptation option it is important for adaptation planners to assess the implications of climate change for natural systems (e.g. agricultural productivity, water supply) and human society (e.g. *human health, economic activity*) to determine whether, and the extent to which, climate change will have an impact, pose a risk or even offer beneficial opportunities.

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.

Building upon the above mentioned assessment (stage i), adaptation options have to be selected for areas and sectors that are the most socio-economically important and/or most vulnerable to climate change (stage ii), on the basis of a set of possible issues.

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.

In a world dominated by scarcity in resource availability, a suitable adaptation strategy also has to provide a rationale, on the basis of common criteria, for deciding when and where to act and how to prioritize and allocate limited financial and technological resources. The choice should be consistent with the overall goal of the adaptation policy that can vary between regions, countries and communities.

Stage (iii): General objectives of adaptation strategies

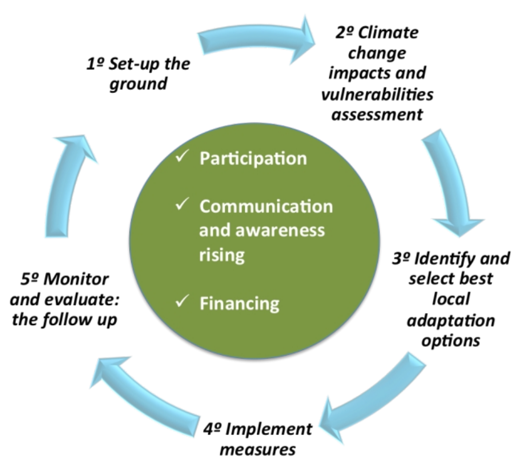
- Avoid or minimize all or only part of the expected or observed impacts
- Restore levels of human well-being to pre-climate change levels
- Maintain current levels of risk or possibly reduce them cost-effectively within agreed budgets or pre-defined acceptable levels.

Finally, once implemented, any adaptation option can be assessed against the agreed objectives. Specific approaches exist to carry out this measurement that will be discussed later on.

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, its targets and methods based on feedback from monitoring actions.

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



The Guidelines for local adaptation to climate change in the Alps have been organized according to the approach presented above. In particular, the sections of the Guidelines can be distributed across the four-steps process describe above, integrated with a section on the Alpine policy context (providing some background and regional information) and a few cross-cutting issues (including participation, communication and awareness raising, finance, and trans-boundary cooperation), as shown in the table below.

Steps of Local Adaptation Strategy in the Alps	**Guidelines for Local Adaptation in the Alps (Paragraphs)**
The Alpine Policy Context	1.1 Why develop guidelines for climate change adaptation at local level in the Alps? 1.2 Climate change: the interlinked challenges of mitigation and adaptation 1.3 Adaptation policies in the EU and in the Alpine countries: the significant role of the regional and local level
Stage (i) Assessment of impacts, vulnerability and risks	2. Policy guidance for the development and implementation of sub-national Adaptation Strategies in the Alps 2.1 The climate change in the Alps 2.2 Impacts, vulnerabilities and resilience capacity in the policy sectors 2.2.1 Mountain forests 2.2.2 Water resources 2.2.3 Energy 2.2.4 Air quality and human health 2.2.5 Mountain agriculture and livestock farming 2.2.6 Transport 2.2.7 Extreme events and natural hazards management 2.2.8 Tourism 2.2.9 Biodiversity and ecosystems 2.2.10 Spatial planning
Stage (ii) Planning for adaptation	2.3 Identification and selection of local adaptation options 2.3.1 Cost benefit and multi-criteria analyses: feasibility assessment 2.3.2 Prioritization
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Stage (i) Assessment of impacts, vulnerability and risks

2.1 Climate change in the Alps

The Alps have been identified as one of the most vulnerable areas to climate change in Europe. The Alps are characterized by a high socio-economic and ecological importance, but also by a high vulnerability to a wide range of natural hazards and to increasing population and environmental pressures. As outlined in the following studies (MANFRED Project 2012), impacts due to climate changes had already been reported in the past and the major climate models predict for the coming decades an intensification of the trends highlighted so far (fig. below).

The main climate change impacts to the Alpine region may be summarized as follow:

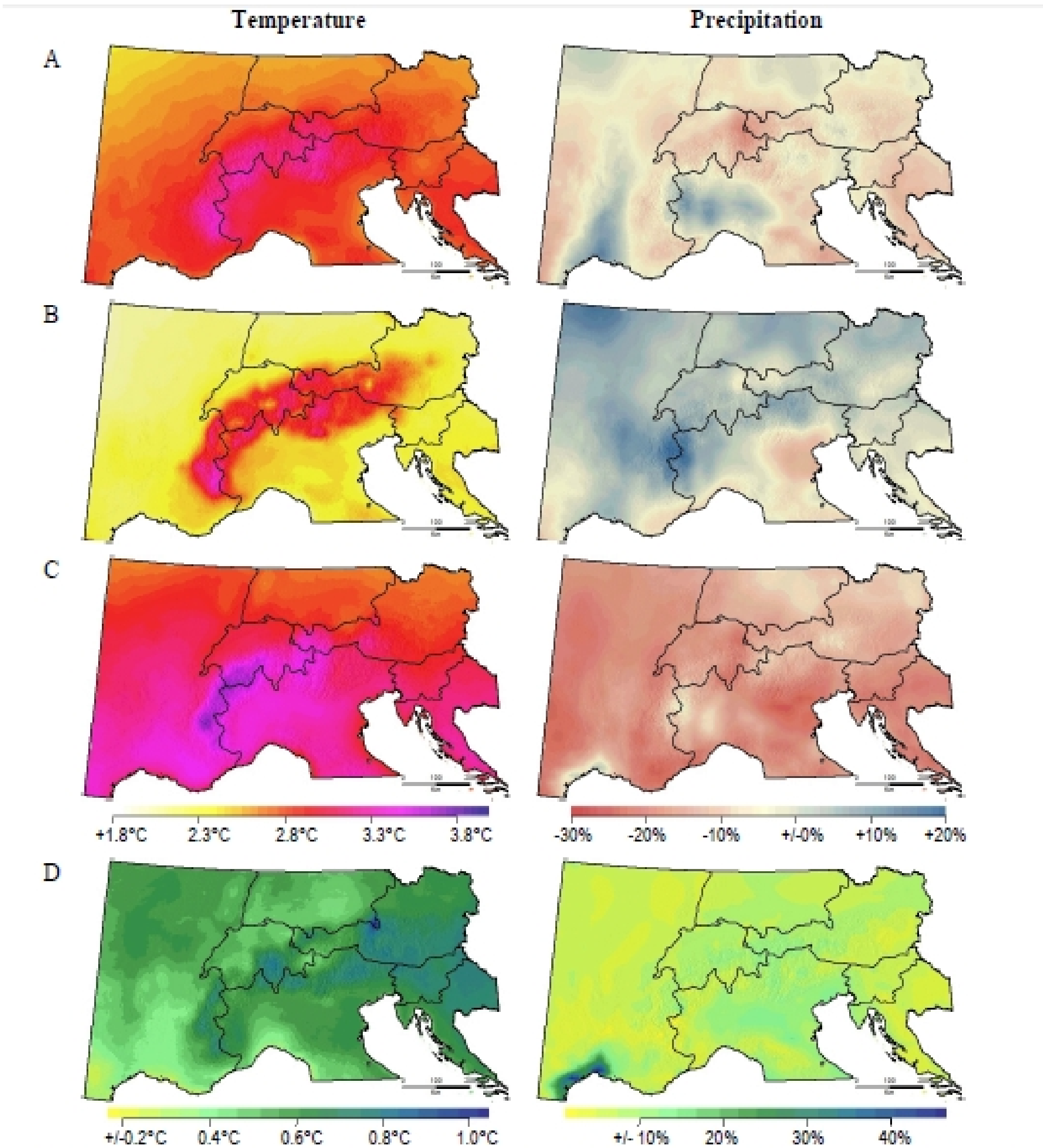
- the temperature increase recorded in the Italian Alps within the last 30 years is threefold the average increase registered in the entire boreal hemisphere. The overall increase in temperature is approximately +1 °C in the annual mean, and more pronounced in summer maximum and winter minimum;
- time 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 can be summarized as follows:

- 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 the different Alpine regions, but due to changes in rainfall intensity and seasonal shifts, extreme events are likely to become more frequent and intense. For example, a decrease in the rainfall amount and an increase in rainfall intensity is foreseen in the Italian side of the Alps, while in the Austrian regions long-term average rainfall amount will remain more or less constant, but with seasonal shifts from summer to winter.
- 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 (Lautenschalger et al., 2009). There will be a significant reduction of the run-off in summer and especially a considerable increase in the run-off in winter with consequences on the level of landslide risk and future availability of water resources (Weingartner et al., 2007). Finally, we also expect an increase in glacial risk 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 Impacts, vulnerabilities and resilience capacity in the policy sectors[7]

2.2.1 Mountain forests

Mountain forests
Alpine forests are subjected to many damages and threats, that are made more relevant by the ongoing climate change: a sustainable management must deal with all threats, trying primarily to assure stability and resilience of forest ecosystems to cope with existing pressures and threats. National inventories provide some information on damages to forests, but the data processing and comparison are difficult, due to different levels of detail and methods of survey (typically, trees broken by extreme events -or dead after a pathogen attack - are quickly removed, mostly to prevent further pest damages, and cannot be surveyed).
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 determined basically by climate and soil conditions: so they are potentially very sensitive to climate change, that 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. **Extreme climatic events** Comparable and reliable data on damages in Alpine forests caused by extreme climatic events such as storm and heavy snow are not fully available. Changes in the last decades have brought to higher and denser forest cover, which increased the risk of storm damages. At the same time the evolution towards mixed forests and irregular structures contributes to reduce the risk, at least to make the restoration of the forest after the event easier. The EFI-ATLANTIC[8] (http://www.efiatlantic.efi.int/portal/) states that storms are responsible for

7 Experts involved for the thematic sectors: *Francesco Dellagiacoma (Mountain forest); Matteo Dall'Amico (Water resources); Marcello Petitta (Energy); Juan Terradez (Air quality and human health, Mountain agriculture and livestock farming, Transport, Tourism; Andreas Zischg (Extreme events and natural hazards management); Riccardo Santolini (Biodiversity and ecosystems).*

8 The Atlantic European Regional Office of the European Forest Institute focuses on the promotion of the sustainable management and competitive utilisation of planted forests along Europe's Atlantic rim region.

more than 50% of the primary abiotic and biotic damages to European forests and has identified 130 wind storms in the last 60 years, described in the database of the regional office. Of the Alpine states (data on national territory) Switzerland had 27 storms, France and Germany 25, Austria 8, Italy 4 and Slovenia 2. Even considering that the database is neither complete nor homogeneous, there is clearly a north/south (and a minor west/east) divide with damages predominantly in the north and western part. The Alps represent a barrier against the most extreme storms.

To the damage caused directly by the storm, secondary damages usually follow, due to biotic agents (most important bark beetles), fire, sun, wind on the weakened stands. Also the impact on the wood market is important and a cause of additional damages. Best current estimates suggest that storm damage to European forests results in an annual reduction of 2% in the carbon sequestration by forests (MANFRED Project, 2012). The amount of damage is a complex interaction between meteorological conditions (especially peak speed of wind gusts) and stand characteristics. Statistics suggests that spruce and poplar are most vulnerable, silver fir, larch and oak least and in general coniferous species being more sensitive than deciduous. Soil conditions, water logging and freezing are important factors influencing root anchorage. Recent thinning, particularly in older stands, increases vulnerability while regular/irregular structure has little influence.

The increase of growing stock and age of the European forests in the last 60 years has contributed to the observed increase of damages. Although there is no consistent recording and reporting system for wind damage across Europe , there is some evidence that storm intensity is increasing and that storm tracks are penetrating further into mainland Europe (i.e. towards the Alps).

An active integrated management of all risks to forests (abiotic and biotic) has become part of standard forest practice. The information on how to deal with them in the aftermath (subsidies for collecting wood, special risks in logging, dealing with the unplanned large amount of work and wood, forest regeneration) is significant but dispersed. An EFI research suggests an European response to large-scale storms. Alpine logging companies, having machineries, training and experience to work in difficult conditions, can play an important role in reaction to the storm.

Forest fires

The MANFRED project shows that forest fires still represent one of the main threats impacting Alpine forests of the southern slope of the Alps. However data 2000-2009 (26.017 forest fires) show a general decrease both in the overall frequency of forest fires and in the mean extension of burnt area per single fire occurrence. Forest fires (as well as big events) can occur all over the year. It is relevant that 75% of the fires started in the 3-4 categories of most thermophilous kinds: those which are likely to expand as a consequence of climate change. During the observation time span there were no significant changes in fire ignition patterns. At Alpine level, in fact, the same four vegetation units are associated with a number of fires higher than average.

In the next future, ongoing climate changes could play a relevant role in influencing both the frequency, the geographical patterns and the regimes of fires in the Alpine region, because they could induce the occurrence of big or extreme fires (the threshold was set at 105 ha with 255 events, 1%, in the category). The relative frequency of fires with ignition points at lower altitudes (0 – 500 m and 500 – 1.000 m) is significantly increasing. The number of natural fires (lighting) is increasing and the frequency of extreme fires is decreasing. Fires will represent a threat to Alpine forests, particularly - but not only - in the southern range. Cooperation, experience and data exchange will be important in fighting forest fires effectively.

Pests

Insects and pathogens usually become aggressive when plants are suffering as a consequence of stress due to climatic conditions or following population explosions after extreme events caused large amounts of dead trees in the area. Most important are bark beetles. It is feared that most pest animals will extend their range due to more favourable climatic condition; some scientist predict a movement northward: simulations show an enlargement of the area affected with a high probability of occurrence at the western border of the Alps to 2080. In the Alps the suitable range of occurrence shifted from the southwest to the northeast.

In addition to the well-known problem of pests, invasive species are a global problem that does not stop at the border of the Alps and could be very relevant, threatening the alpine biodiversity and impacting the important conservation function of the alpine forests.

Adaptation objectives

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

- climate change is under way and in the Alpine region it is more intense than the European average;
- 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;
- it is necessary to focus on adaptation measures: climate change mitigation does not work on regional scale because the problem is global; moreover, the mitigation efforts to avoid climate change have already failed : measures are still necessary to reduce climate change, but adaptations measures must be even more introduced;
- 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;
- highly productive spruce mountain forests will be more affected than high elevation (and less productive) forests.
- 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. A correct information on the multifunctional management of the alpine forests and on the compatibility of the sustainable use with other functions will also bring to a better appreciation of alpine wood and therefore to a better marketing.

2.2.2 Water resources

Water resources

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

Impacts, vulnerabilities and resilience factors

Changes in precipitation regimes, a progressive loss of ice mass and an increase in the snow elevation line bring about a variation of the flow regime in alpine torrents, consisting in a reduction in the summer discharge and an increase in the winter discharge. These changes are likely to increase flood hazard (Lautenschalger et al., 2008) and to decrease water availability during summer for agricultural activities and human consumption (Weingartner et al., 2007).

In the last 130 years rainy days have decreased whereas dry days seem to have increased by 2 units per century (Lionello et al, 2009). Lehner et al, (2006) and Giannakopoulos et al, (2009) estimate that drought events will be twice more frequent than today in 2050 and tree times more frequent in 2070. Van Vliet et al. (2012) claim that both in mountain torrent environment (streams and rivers) and in lakes and humid areas 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 (Garnier M., 2007).

Given the above-described impacts, it is foreseeable that climate change will affect the demand of water resources, which will increase and become less flexible and more vulnerable across the different countries, the water availability, which will be more variable and probably reduced , and the water quality, which 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.

In particular, 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.

Adaptation objectives

In order reduce the expected impacts and to increase the resilience of human activities, some adaptation actions must be put in place. The adaptation actions may be divided In: a) infrastructural and technological measures ("grey" measures), like mitigation structures; b) ecosystem oriented measures ("green" measures) like fluvial re-qualifications; c) non-structural interventions ("soft" measures) like legislative and planning processes and measures oriented at improving the efficiency of irrigation, drinking and industrial usage for optimizing the consumptions.

"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...) where appropriate.

"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) taking into consideration climate change predictions.

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 (grey water) where appropriate; planning of economical tools for the management of climatic risk (insurance, etc.) where feasible.

2.2.3 Energy

Energy

In the last decades the terms of the binomial ClimateChange/Energy have been considered strongly interconnected. Decreasing river flow, change in the diurnal temperature cycle and modification of atmospheric hydrological cycle can, in the next decades, dramatically affect the renewable energy sources.

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 from external fossil fuel sources, concentrated his strength in developing RES-promoting policies for most of the countries.

In the Alps the situation is slightly different compared to the rest of the other European areas: the presence of manufacture industries is not so strong and the associated energy consumption and CO_2 production dropped off, but other sources such as road transport and household heating are increasing (almost doubled) 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

Moreover in the Alps the most relevant renewable energy source is the hydropower, which is foreseen to a future production loss due to decreasing river flows. Considering current climate change situation, the energy scenarios should include and consider not only the variation in the energy demand, but also the variability of renewable sources due to climate change in order to obtain confident projections. 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. Moreover, to have an appropriate production, it became necessary to occupy a significant fraction of the territory with dramatic impacts on the landscape. 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.

Summarizing, benefits from RES generally include some combination of the following:

- 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.

Adaptation objectives

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

- Renewable energy technology solutions have a crucial role to play in addressing today’s energy challenges. Ensuring dependable supplies of affordable RES technologies is essential.
- Expanded use of RES, in combination with increased energy efficiency as well as rational energy use in all sectors, also in order to reduce dependence on imported fossil fuels, thus enhancing energy security.
- Increasing energy usage efficiency through consumptions reduction, improving energy efficiency of existing buildings and sponsoring information campaigns for citizens.
- Commitment on the part of policy and industry is necessary to stimulate demand and significantly increase use of emerging RES technologies.

These objectives can be achieved through combining the rational exploitation of RES and a strong investment in energy consumption reduction and energy efficiency in private and public buildings.

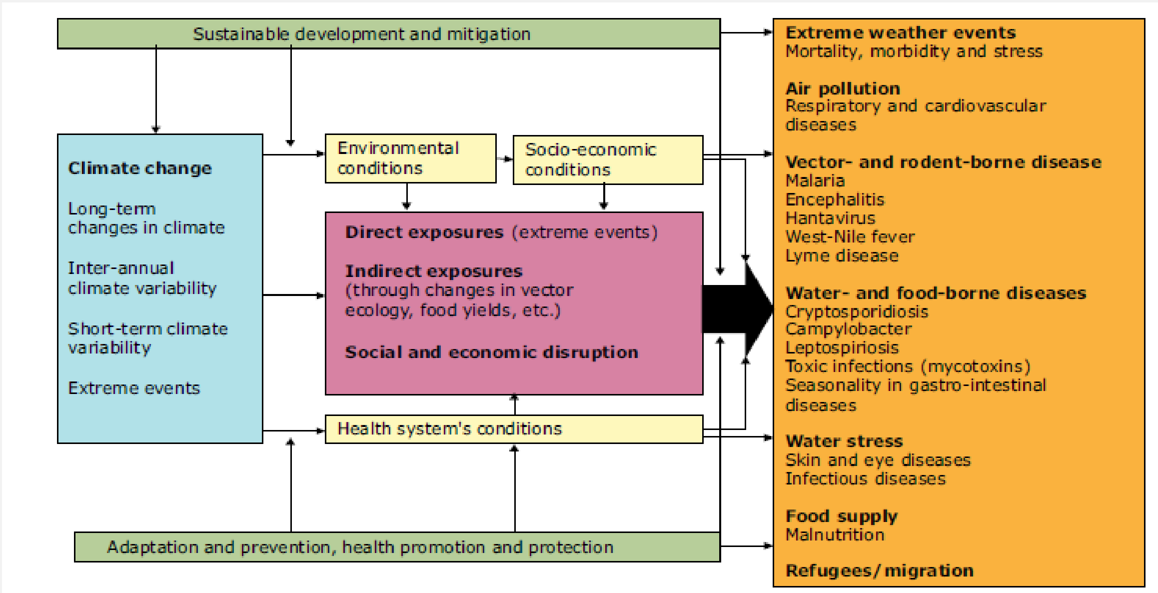
2.2.4 Air quality and human health

Air quality and human health

The main climate-related health risks can be summarised by the following indicators (EEA, 2012):

- floods and health (addressing both coastal and river floods);
- extreme temperatures and health;
- vector-borne diseases;
- air pollution by ozone and other climate-sensitive pollutants.

Figure III: Health risks related to climate change and effects of climate policies



Source: Wolf, 2011, adapted from Confalonieri et. Al., 2007

Floods affect human health through drowning, heart attacks, injuries, infections, psychosocial consequences, and health effects of chemical hazards as well as disruption of services.
The extreme temperatures cause an increase of the mortality and morbidity especially in vulnerable population groups, and a decrease of the general population well-being.
Climate change can lead to significant shifts in the geographic and seasonal distribution ranges of vector-borne diseases in Europe (Semenza and Menne, 2009). Climate can affect vector-borne diseases by shortening the life-cycles of vectors and the incubation periods of vector-borne pathogens, thereby potentially leading to larger vector populations and higher transmission risks. The transmission cycle of vector-borne diseases are sensitive to climate factors but also to land use, vector control, human behaviour and public health capacity.
In addition to climate, the spread of communicable diseases depends on a range of interconnected ecological, economic and social factors, such as land-use patterns and fragmentation; biological diversity; the capacity of public health systems; travel, trade and migration; and human behaviours affecting individual risk factors (Suk and Semenza, 2011).

Climatic variables influence air pollution at local and regional level through their effects on the rate of chemical reactions in the atmosphere (transformation and formation of air pollutants), the height of the atmospheric mixing layers for the pollutants and the characteristics of the wind flows that regulate the transport, removal and deposition of pollutants.
Climate change variability generates changes in the meteorological conditions that can alter the state and the behaviour of the atmosphere and, in turn, have an impact on the development and flow of air pollutants. On the one hand, it can change the height of different atmospheric layers and the rate of chemical reactions in the air. On the other hand a warmer and more variable climate can lead to higher levels of several air pollutants, especially secondary air pollutants (those formed in the atmosphere through chemical and photochemical reactions from primary pollutants) such as fine particulate matter (PM10 and PM2.5) and tropospheric ozone (O_3)

(Winner, 2009) besides some primary pollutants such as biogenic volatile organic compounds (VOCs) like isoprene.

Concerning O_3, which is of major concern in Europe and especially in the Alpine region, temperatures plays a role in various processes which directly affect the formation of this pollutant, by incrementing biogenic VOCs emissions (increased isoprene from vegetation under higher temperatures) and the photo-dissociation of O_3 precursors like nitrogen dioxide (NO_2).

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 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. However, it is difficult to predict the exact extent to which air quality will be influenced by future climate change and subsequently influence human health. In addition to the effects of climate change future air pollution in the Alps will depend also on the success of emission reduction measures at local and global scale (due to the hemispheric transport of air pollutants).

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. Concerning topographical aspects, valleys in mountain areas are often deep and narrow, reducing the volume of air into which the mass of air pollutants can disperse. This gives rise to an increased concentration of air pollutants in comparison to flat areas. Concerning atmospheric factors, atmosphere is the vehicle through which air pollutants moves, and the complex underlying topography of the Alpine region considerably influences its dynamics. This leads to specific meteorological phenomena as frequent air stagnation episodes by thermal inversion and specific wind circulations that often hinder the quick dilution of pollutions causing high concentrations over longer periods, and hence increasing exposures to air pollutants (Jacob et sl. 2009).
Human factors linked with socioeconomic activities such as transportation, farming or industries are important local emission factors that may worsen vulnerabilities to air pollution. During the last decades, a slight increase in annual mean concentrations of ozone has been detected close to traffic (EEA, 2011). Most villages and towns in the Alps have grown along the valleys, especially those with major motorways and railway lines. Therefore 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 (See also MANFRED project. 2012) and the increase in frequency and intensity of heat waves in the next decades .

The adaptive capacity in the context of air pollution is a measure of the ability of a system to adjust to climate change challenges to mitigate potential damages, to take advantage of opportunities, or to cope with consequences (IPCC, 2013). 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

Adaptation to climate change is complex as the severity of the impacts is expected to vary from region to region, depending on physical conditions, and between people, depending on socio-economic aspects, natural and human adaptive capacity, health services characteristics, and response mechanisms. Even if adaptive capacity concerning human systems must be consider generally high in the Alps, different population groups or systems are more vulnerable than others also in relation to air pollution. For example, higher ozone levels may cause asthma in children. People with respiratory and cardiovascular diseases and the elderly are particularly susceptible to increases in particulate matter and ozone pollution (WHO, 2008).

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.

Because impacts of climate change on air quality may have different extent regionally and locally, local impacts and vulnerabilities assessment should be carried out in detail in order to realize the real potential magnitude of the problem, and hence to not overestimate or underestimate objectives and adaptation measures.

A set of very general objectives for climate change adaptation in air quality management at local level in the Alps is listed below:

- Strengthening current air pollution prevention policies to account for the effects of climate change.
- Combining local air pollution and global climate change mitigation policies; air pollution and climate change policies must be integrated now to achieve sustainable development and a low-carbon Alpine space tomorrow.
- 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 needs to comprise four interacting elements namely: (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. There are win-win options that are also 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 the adsorption of pollutants and concomitantly ensure carbon sequestration.

2.2.5 Mountain agriculture and livestock farming

Mountain agriculture and livestock farming

One quarter of the Alpine region –around 4.5 million ha – is potential agricultural land, composed by 83.3% of grassland, 12.6% of arable land, 3.2% of permanent crops and 0.8% of other cultivated land (CIPRA, 2001). Due to the general structural change of agriculture and the related increasing exodus from the mountain lands, farming activities have been steadily decreasing in the entire Alpine region during the last decades.

As a consequence, marginal lands have been abandoned, while farming land has been concentrating in more favourable areas. Although the significance of farming has decreased in favour of other activities such as tourism, it is still important for spatial and regional development and the maintenance of the cultural heritage and landscape (CIPRA, 2011). Productivity of agricultural and livestock systems is critically dependent on many factors, including climatic conditions such as temperatures, temporal and spatial distribution of precipitation and evaporation, and the availability of freshwater resources for irrigation (IPCC, 2008).

It is indisputable that climate change may have serious physical as well as socio-economic impacts in mountain farming, despite there are a wide range of uncertainties with respect to the magnitude of change and even the sign of such impacts. Thus, changes in the physical constraints by climate change may have important implications for farming, and adaptations may be necessary.

Impacts, vulnerabilities and resilience factors

In the coming decades, global warming is expected to affect mountain farming very differently depending on the specific geographical region (Olesen et al. 2011). The observed (Gualdi et al. 2013) and projected climate change in the Alps (Gobiet et al.2013), points to a further increase of temperature in the entire region, changes in precipitation patterns (different among specific Alpine regions) and increase in extreme climate events such as prolonged droughts and heat waves.

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 (Iglesias et al. 2009; Ferrise et al. 2013). The projected increases in temperature will lead to higher evapotranspiration rates, thereby increasing crop water requirements across the

Alps. Even if it is expected that, in the short term, low water availability will be less acute in alpine agriculture, in the long term further alterations of the hydrological cycle together with increases in demand by water-intensive sectors will heighten water stress causing yields declining across the Alpine region (OcCC/ ProClim. 2007).

Crops growth conditions, productivity and distribution

In the Alps with less water scarcity problems, increase in temperature in synergy with an increase in atmospheric CO_2 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 (Fuhrer, et al. 2006; Anderson, 2008).

The increase in productivity is likely to be larger at sites with favourable edaphic conditions, such as the bottom of the mountain valleys, whereas changes in marginal areas may be much smaller. Furthermore, the extension of the frost-free period in elevated areas will further increase the extension of growing season of major Alpine crops (Olesen and Bindi, 2002). However, it must be also considered the greater risk of extreme weather events, such as prolonged drought, storms and floods that will also influence crop productivity. 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 (Ferrise et al. 2013).

Climate change is expected to increase the spatial distribution and intensity of existing pests, diseases and weeds due to higher temperatures and humidity (FAO, 2007).

Soil fertility, erosion and hydro-geological hazards

Soil erosion and the consequent risk of soil fertility loss are important problems in the Alps . 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, affecting edaphic structure and exacerbating topsoil erosion processes. The above mentioned impacts are linked to site factors and changing land management practices that are very different among alpine localities, but they will be exacerbated by climate change and the increasing incidence of extreme weather events.

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. Furthermore, higher temperatures result in greater water consumption by livestock and more frequent heat stress for the animals (Olesen et al. 2005; Lacetera et al. 2013). This in turn causes declines in their physical activity, including feed uptake, and may decrease in quality and in organoleptic characteristic the final product and even cause premature death of livestock (Segnalini et al. 2012).

Adaptive capacity

In the Alps several ecological, demographical, socio economical and political conditions may strongly influence the adaptive capacity of the farming sector. Adaptive capacity at sub-national level may depend on the regional or local systems' potential to adjust farming activities to climate variability, including the ability to learn from experience or to capitalise valuable information received from other similar cases of study. The main factors that define the resilience of mountain agriculture to climate change can be grouped into three categories: 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. Different exposures degree will relates to the degree of climate stress upon localities or sites, and it may be represented as either long-term changes in climate conditions, or by changes in climate variability, including the magnitude and frequency of extreme events. Site-specific topographic characteristics such as altitude, sun exposure, temperatures and precipitation regimes, and edaphic or pedoclimatic conditions may determine to a great extent the exposure of climate change impacts of each Alpine area.

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. Such characteristics may determine the ability of each particular farming system to absorb disturbance from a changing climate, what is known as resilience capacity. In certain regions agriculture remains the base of economic and social life, while in other regions it has become a sector of small importance. Factors such as the existence of developed distribution channels and networks, specific socio-economic features of each farm, the different processing activities or farming business models (e.g. agro-tourism or subscription to agro-environmental contracts) may shape sensitivity within different Alpine localities.

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. The adaptability of mountain farming has been historically high due to the autonomous adaptive capacity of the sector. Farmers have always adapted their farming practices in the short term to changing environmental conditions, for example by altering cropping patterns (Iglesias et al. 2007).

The degree of flexibility of forage and agricultural systems and agronomic techniques in mountain farming are crucial in determining adaptive aptitudes. In this sense, the size of the farm may determine a resilience advantage since smaller farms have a higher agility to re adapt managerial aspects to climate challenges than larger farms located in lowland areas. Other aspects that may determine farmer's capacity to adapt to climate change may be the willingness and ability to diversify their activities and products to be more resilient to climate change constraints.

Adaptation objectives

The mountain-farming sector is directly affected by climate change impacts but it also contributes to the release of greenhouse gases (GHG). In the complex framework of global changes in social, economic, and political Alpine conditions, impacts of climate changes are only one among other driving forces interacting with the farming sector. A sustainable adaptation strategy in the field of mountain farming in the Alps at sub-national level involves anticipating, planning and long-term thinking from farm level to transnational level, and requires integrating adaptation measures from the alpine local authorities to rural development programmes at European level (COM, 2013).

Thus, climate adaptation at local level must integrate i) considerations to enhance positive synergies with other crosscutting aspects such as biodiversity, air quality, energy and mitigation objectives, 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) must involve local stakeholders early in the process of definition and subsequent implementation of adaptation initiatives.

Promote sustainable soil and land management
Adaptation requires higher soil resilience against both excess of water (due to high intensity rainfall) and lack of water (due to extended drought periods). 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: natural fertility, carbon-sink capacity, water retention and soil and biodiversity protection. An interesting approach is proposed by the Conservation Agriculture concept[9] (FAO,2007).

Enhance sustainable water management
Selecting more suitable crops to heat stress and droughts may reduce irrigation water demand. Other managerial and low cost techniques may be promoted to enhance water retention and minimize water evaporation during extreme events such as minimum tillage or mulching. Adaptation strategies to climate change and water scarcity must take into account socio-economic constraints that vary widely depending on production systems, types of cultivation and the competitive situation with other sectors regarding water consumption.

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 to facilitate and secure pastoral management.

Linking mountain farming with eco-tourism
Mountain farming, if derived by conservation agriculture principles, is a source of attractiveness

9 Conservation agriculture (CA) aims to achieve sustainable and profitable agriculture and subsequently aims at improved livelihoods of farmers through the application of the three CA principles: minimal soil disturbance, permanent soil cover and crop rotations.

for mountain tourism. Organic foodstuff offers a promising approach strategy for the Alpine agricultural sector to hedge against climate change impacts and economic losses. 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). Even so, professional marketing will be required to ensure a more suitable strategy to harness a growing consumer demand for high-quality organic products within the Alps. 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. Agricultural consulting services, good practices manuals and support instrument are needed to ensure efficient adaptation at farm and regional scale.

2.2.6. Transport

Transport
Historically, the Alps have played a challenging role in the network of transport infrastructure, allowing the transport of passengers and goods between northern and southern Europe. The current wide network of roads, railways and other transportation infrastructures are crucial to ensure trans-alpine and intra-alpine transports and mobility, and hence, to enhance socio-economic development. Transport infrastructures and operation are sensitive to changes in climate, especially in the Alps. More frequent and intense extreme weather events, acting alone or in synergy with other typical mountain hazards, may negatively impact transport infrastructures locally and on the entire Alpine transport network as a whole.
Impacts, vulnerabilities and resilience factors
The transport sector is one of the economic sectors considered to be more susceptible to the potential adverse consequences of climate change in mountain regions (EEA, 2008). Even if data on past climate-related impacts on transport in Europe are restricted to individual extreme events, and attribution to climate change is generally uncertain, it is very likely that in the coming decades changes in climate variability will cause significant impacts on Alpine transport infrastructure. In particular, projected changes in snow and rainfall patterns (Gobiet et al., 2013), more intense floods, flash floods, landslide and avalanche events induced by more intense precipitation (Beniston et al., 2006), increase in wind storms and blizzards (EEA, 2012) and more intense and frequent heat waves (Fischer et al., 2010) will probably increase costs for infrastructures maintenance and will also compromise the security of the daily transportation services in some alpine localities. The cutting off of traffic routes and eventual traffic disruptions will pose problems to emergency and supply services, to human well-being, to production and distribution services and thus to the Alpine space economy. In addition to the climate change impacts on transport infrastructure, 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, which will lead to a reduction in days with very low temperatures, non-motorized transport modes such as walking and biking will be favoured during the winter season (Caserini and Pignatelli, 2008). 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 (Sabir et al., 2008).

Despite this, it is foreseeable that modal choices in transports at local level in the Alps will be more determined by socio-economic factors, environmental awareness levels or local policy choices than by climate change implications. 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 repercussions on competitiveness. A more variable hydrological cycle as projected for the coming decades will very likely lead to more unstable conditions for transport navigation especially in Germany and Austria (Danube River), Switzerland (Rhine River) and France (Rhone River) were river transport modes are extended (EEA, 2009).

Adaptive capacity

The adaptive capacity of Alpine transport system is a measure of its ability to adjust to climate change challenges, in order to mitigate potential climate change impacts, to take advantage of opportunities, or to cope with its consequences (IPCC, 2013). 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. Overall exposure should consider at least two dimension: on the one hand, geographical exposure, that will be higher in those localities with a vast transport network extending on long distances;, on the other hand, population density, that implies more transit movements per day and hence more people exposed.

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. In this sense, an element of the local transport that is critical for the regular performance of the entire network will be more sensitive than a non-strategic transport element, even if both have the same degree of physical sensitivity. Similarly, the existence of replacement routes may reduce the sensitivity of a local transport network.

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. The ability of the transport sector to adapt to climate change impacts varies from region to region, and is generally higher in those regions and localities where natural hazards are managed by integrated risk approaches in an holistic way.

Adaptation objectives

As stated on the "Action plan on climate change in the Alps " of the Alpine Convention, adaptations goals at national, regional and local level for the transport sector must be an integrated part of the spatial planning adaptation process. The adoption of transport adaptation measures will be also incorporated into existing reduction, prevention and risk management strategies, as well as on the transport planning services. Is important that targeted adaptation objectives enhance a sustainable transport adaptation policy, which considers the different synergies between the transport sector and the other relevant interacting sectors in the Alpine region, in order to "reduce the negative effects of and risks posed by intra-Alpine and transalpine transport to a level which is not harmful to people, flora and fauna and their environments and habitats" (Transport Protocol of the Alpine Convention).

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, being consistent with the others adaptation objectives concerning water and air quality, soil conservation and climate change mitigation. 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 (local risk assessment plans) following harmonised procedures (e.g. by following regional, national and Alpine region 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 (e.g. use participative method of risk governance in the planning process by using decision making tools and organizing workshops with local stakeholders and local technical bodies)(for more information see PLANALP Platform, in section 2.2.7 Extreme events, and natural hazards management and soil conservation);
- 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 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 (e.g. elucidate the links between local emergency plan and to existing early warning systems, concerning transport considerations);
- inform the population and make it aware of its responsibilities.

2.2.7. Extreme events and natural hazards management

Extreme events and natural hazards management

Climate change influences the intensity and frequency of natural hazards in the Alps directly and indirectly. Here are considered only alpine natural hazards particularly influenced by meteorology, i.e. floods, debris flows, landslides, rockfalls and avalanches. Direct effects to these processes are related to the expected increase in the intensity of precipitation events. The increase in precipitation intensity leads to an increase in flood discharge and to a higher activity of mountain torrents with disposition for triggering debris flows.

The increase in temperature leads to an altitudinal shift in the rainfall/snowfall limit, in snowmelt, in the soil water balance, in weathering processes and in glaciers and permafrost. The latter factors influence natural hazards indirectly. The following overview of the climate change impacts on natural hazards has been drawn with the contribution of PLANALP[10] (Platform of Natural Hazards of the Alpine Convention).

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

10 See. PLANALP publication "Alpine strategy for adaptation to climate change in the field of natural hazards" (http://www.planat.ch/fileadmin/PLANALP/planalp_pdf/2012_PLANALP_Alpine_Strategy.pdf)

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
The adaptive capacity at the local level in natural hazards and risk management practice varies from region to region. 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. The solutions implemented after a disaster were in many cases the fundaments for the problems of nowadays. In regions, where the principles of integrated risk management and of holistic problem solution approaches are already considered in practice today, the adaptive capacity is high. In other words, a holistic strategy for disaster risk reduction with consideration of structural, non-structural, organizational measures and their best combination (or the so-called integrated risk management approach) 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.

The Platform on Natural Hazards of the Alpine Convention PLANALP presents an overview of examples for adaptation to climate change in the field of natural hazards , e.g. Alpine strategy for adaptation to climate change in the field of natural hazards.

Adaptation objectives

Making the step from national adaptation strategies to their implementation on community level requires different efforts. Generally speaking, adaptation at the local/community level is made where the governments are directly responsible for the security of their citizens in regard of natural hazards. At this level, the prevention measures are initiated, planned, (partially) financed and also implemented. Therefore, the participation of all the stakeholders is playing an important role. But, at community level, there is on many cases a lack of data regarding the impacts of climate change, a scarcity of adaptive capacity in terms of possibilities for financing prevention measures and an insufficient expert knowledge.

The topographic, geomorphologic and climatic diversity of the Alps requires, however, a regionally and locally differentiated view. Sensitive areas are likely to be affected by natural hazards related to climate change, while others will not experience any change compared to the current situation. Due to this complex heterogeneity, the generalization and simplification of the effects of climate change on natural hazards over large areas or even the entire alpine area is not appropriate and must be avoided in order to prevent the drawing of unsuitable conclusions for risk management. Instead, the impacts of climate change have to be assessed in detail at the local level before initiating any adaptation measure.

Thus, 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 priority objective of a strategy to adapt to climate change must be to at least preserve the current level of residual risk and to take new and additional action on safety in terms of organisation, planning and construction, as necessary. As in the past, particular attention must be paid to implement solutions that achieve sustained success.

Therefore, 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 so as to preserve the basis for sustainable, hazard- and climate-proof development in the long term. 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, including direct and indirect effects of climatic changes to natural hazard processes;
- 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 (e.g. coordination between the effects of structural measures, early warning systems and emergency intervention);
- 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 (continuation of the risk dialogue);
- 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

Tourism

Tourism in the Alps is a high-revenue industry that is highly dependent on climate resources. According to the OECD, the tourism sector provides 10–12 % of the jobs in the Alps (OECD, 2007). Climate change may provoke shifts in tourist flows, with large economic implications. Mountain regions are important destinations for global tourism and snow cover and pristine mountain landscapes, which are the principal attractions for tourism in the Alpine region, are most vulnerable features to climate change impacts.

With an annual turnover of 50 billion EUR, the winter tourism industry contributes significantly on the Alp's economy (OECD, 2007). Within the Alpine countries there are more than 600 ski resorts and 10000 ski installations, 85 % of which are in France, Switzerland, Austria and Italy. Hence, winter sports represent an important and dynamic element in the economies of alpine local communities. It is very likely that the consequences of global warming on Alpine winter sports will be evident and more intense in the next decades than for other tourist activities.

Impacts, vulnerabilities and resilience factors

According to the main climate models and projections, further climate warming is expected in the coming decades (IPCC, 2013). 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 (OECD, 2007). Sufficient snow cover at the right time is an indispensable prerequisite for the economic survival and offer of alpine winter sport industry. Several studies conducted in different Alpine countries agreed 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 (Bosello et al., 2007).

Artificial snow-making is by far the main adaptation option adopted nowadays, covering 38 % of the total skiing area in the European Alps and showing an increase by 48 % since 2004 (Rixen et al., 2011). However, there are both environmental and economic constraints to an expansion of artificial snowmaking (e.g. high water and electricity consumption respectively). Even with an intensification of artificial snowmaking, there is a risk that low-lying ski areas will have not enough snow to meet the minimum requirements for the operability of ski lifts. 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 (e.g. rock falls, landslides, flash floods and GLOF's[11]; Gobeit et al. 2013).

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. Alpine and sub-alpine lakes are a major tourist attraction for swimming, water sports and sailing. An increase in water temperature can create favourable conditions for algal bloom episodes, which negatively affects water quality with negative implications on tourist flows (Ambrosetti et al., 2006; Bosello et al., 2010). 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.

Finally, positive impacts relate with an increase of climatic suitability for general tourism activities in Alpine regions (Ciscar, 2009) 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, in detriment of other destinations less comfortable for summer tourism due to higher temperatures (Isoard et al., 2008).

Adaptive capacity

The adaptive capacity of the Alpine tourism sector is a measure of the ability of the tourism industry to adjust to climate change challenges, in order to mitigate potential climate change impacts or to cope with its consequences, and to take advantage of emerging opportunities (IPCC, 2013).
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). Sensitivity could be environmental -linked to water availability or landscape quality- as well as human -related with local social structure, institutions or population characteristics-, depending on economic structure of the region, local tourism demand and supply system, etc.;

the ability of the local socioeconomic and technological system to adapt the tourist sector to climate change, including climate variability and extremes.

The first two components, exposure and sensitivity, provide an indication of the potential susceptibility of a local tourist system to adverse current and potential impacts. On the other hand,

11 A glacial lake outburst flood (GLOF) is a type of outburst flood occurring when water dammed by a glacier or a moraine is released. A water body that is dammed by the front of a glacier is called a marginal lake, and a water body that is capped by the glacier is called a sub-glacial lake.

adaptive capacity reflects the ability of the system to manage those adverse impacts, and thereby reduce gross vulnerability. Even though the choice of local indicators for measuring this three components is generally subjective and may vary depending on each particular local situation, recent studies on the topic has proposed examples of possible indicators for the tourism sector that could be useful for local assessments.
Adaptation objectives
Climate change represents a serious challenge for Alpine tourism in both the induced risks and the emerging opportunities. However differences across local conditions in the Alps in terms of expected changes in climate, tourism typology and intensity and capacity to adapt, make impossible to visualize and define a single way to tackle tourism adaptation issues. Adaptation efforts should help Alpine localities to remain an attractive and successful tourist destination and to exploit its exceptional potential as a travel destination in the long term. On this way, defining a range of adaptation practices tailored specifically to local conditions is essential. In general, Alpine tourism has large potential for adapting to the changing in climatic situation. Such potential may vary locally, in relation with the local capacity to diversify tourism offers, or the ability to involve other economic sectors (such as agriculture and transports) to create win-win synergies through joint adaptation pathways. In this sense, an integrated planning approach involving other interested sectors and considering future climate challenges may enhance carrying capacity of tourism industry while promoting the principle of sustainable tourism[12] development and hence reducing conflicts between different users, promoting climate-proof and environmental-friendly tourism development in the Alps. Thus, climate adaptation at local level in Alpine tourism industry must 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. A very general list of adaptation objectives in Alpine tourism sector at local level is listed below: • *Reduce economic dependency on skiing, diversifying tourism products towards activities that are less dependent on sno*wpack variability (e.g. diversify the winter tourism offer by increasing forms of winter sports with a lower environmental impact, and less snowpack demanding such as cross-country skiing, ski touring, snowshoeing excursions, hiking etc.) and seeking new economic opportunities which are more environmentally sustainable, climate change resilient and “climate neutral”; • *Make Alpine localities interesting tourist destination in all seasons of the year,* boosting its tourism potential also in the absence of snow and taking advance of climate change opportunities (e.g. encourage initiatives to promote "all-seasons" mountain tourism offers, taking advantage of the expected increase in climate suitability during summer season in the

12 Sustainable tourism is attempting to make as low an impact on the environment and local culture as possible, while helping to generate future employment for local people

Alps, even by reorienting the EU funding support programs;

- *Reduce exposure of winter sports to climate change constrains*, using managerial, operational and technological adaptation options where environmentally and economically feasible (e.g. landscaping to reduce the depth of snow that is needed for skiing, moving to higher elevations and facing north where snow pack is likely to last longer, glacier skiing to bring forward the ski season and provide more certainty for snow availability, and artificial snowmaking). 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 (e.g. tourism infrastructure, hiking pathways and other mountain tourist hot spot) through the adoption of technical measures for the protection of people and properties, favouring the adjustment of existing infrastructure and the use of protective measures through ecosystem approach (e.g. forest management, green infrastructures), on the framework of the integrated natural hazard management plans;
- *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 (e.g. promotion of sustainable and low emissions (soft) mobility linked with tourism industry development, and enhance energy efficiency in tourism buildings);
- *Ensure meaningful involvement of local tourism stakeholders* in the definition and implementation of adaptation strategies to ensure successful adaptation (e.g. promoting wider participation to private development plans by local authorities, environmental associations, market actors and citizens);
- *Provide appropriate information on climate change impacts, vulnerabilities and opportunities* of the tourism sector in the Alps (e.g. adapt the resorts' communicating and marketing strategies to reflect the new adaptation measures and tourist offers).

2.2.9 Biodiversity and Ecosystems

Biodiversity and Ecosystems

In recent years, several initiatives have been undertaken for the assessment of biodiversity and ecological functions at the centre of conservation and management strategies for future planning options (TEEB, The Economics of *Ecosystems* and Biodiversity; COPI, Cost of Policy Inaction; IPBES, Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services).

The diversity of functional characteristics of species that constitute a community is one of the key control factors of the properties of an ecosystem and the functional changes in an ecosystem can be explained – at least partly - by the difference in species or functional composition of the community (Hooper et al., 2005).

Accordingly, the species richness and functional role of species is important for maintaining the functionality of ecosystems and is even more important when there are complementary relationships among species and among particular guilds.. Since the species participating in different ecosystem functions affect their quality, more species are necessary to maintain an ecosystem fully active and multifunctional.

Therefore, if we consider only a single process, it is possible to underestimate the levels of biodiversity required to maintain the ecosystem multi-functionality and to undervalue the vulnerability of ecosystems to climate change (Santolini, 2012). If the species of a functional group operate at different scales, they help to strengthen the resilience of parallel function and reduce competition within the same function (Peterson et al., 1998).

Relation species-functionality: De Bello et al. (2008) define a functional trait as "*a feature of an organism which has demonstrable links to the organism's function",* and its role in the ecosystem or its performance. Although the idea of a particular function is more easy to understand for a species, the concept can be extended to groups of organisms with similar characteristics, which have, sometimes in a different way, similar effects and / or characteristic responses.

Whether at the level of single species or of a larger group of species, functional diversity is considered as a set of characteristics (type, range, relative abundance of species) of a functional community with important consequences for ecosystem processes (De Bello, 2008).

This leads to consider the opportunity to use focal species (Lambek, 1997) or guilds l evaluated through an expert-based approach (Amici and Battisti, 2009), . These guilds characterized by known ecosystem spatial and functional requirements, are capable of effectively describe an ecosystem that assumes a certain level of quality, in relation to the features of the community characterized by the roles expressed by these species (Gregoryand van Strien, 2010; Santolini, 2012).

There is clear evidence that biodiversity has positive effects on the effectiveness of ecological functions and it can be expected that a further loss of biodiversity could compromise the provision of such services (Balvanera et al., 2006). For example in wetlands, not only the increase of floristic diversity improve the productivity, but also favors the retention of phosphorus in the system, thus facilitating the service water purification.

Ecological functionality and Ecosystem services. Consequently, to determine certain functional units of the system by groups of species that identify specific ecological functions (Gregory and van Strien, 2010; Pereria and Daily 2006), means also to define ecosystems that are highly resilient and then dynamically stable and ecologically important. This is all the more important as climate change acts at different levels and in particular on the characteristics of ecosystems that generate ecosystem service, because there are services that can be classified according to their spatial characteristics (Costanza, 2008), connected to a patch of ecomosaic (eg wood raw material) or a geographical area of reference (catchment area).

Therefore, the characteristics of each type of land mosaic has its own potential ability to provide a range of ecosystem services; therefore, changes in land use induced by climate change, may result in decreased performance in the provision of ecosystem services (Burkhard et al., 2012; Scolozzi et al., 2012).. It is well-known, beyond the evolving discussion (Costanza et al., 1998; 2008), that at bigger spatial and time scales, it is necessary a higher biodiversity to supply a regular flow of goods and ecosystem services. For this reason biodiversity becomes a key element to reach objectives of economic, ecological and social management and adaptation to climate change (Hooper et al., 2005; EEA, 2009).

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 (MEA, 2005). 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 (EEA, 2009):

- 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 c
- 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 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

Spatial Planning
Climate change and its impacts are strongly affecting land use and land use development. Both the White Paper on Adaptation to Climate Change of the European Commission and the Territorial Agenda of the EU 2020 emphasize the key role of spatial planning in delivering and supporting adaptation to climate change. Moreover the EU Commission Green Paper “Adaptation to Climate Change in Europe - Options for EU Action” points out the potential of spatial planning to define cost-effective adaptation measures to adapt to the impacts of climate change and emphasizes its “key role for awareness-raising among the public, decision makers and professionals as well as for triggering a more proactive approach at all levels”. Spatial planning could contribute actively to deal with climate change impacts also due to its crucial role in the cross-sectoral coordination and the multilevel governance. In the Alps, CLISP project (2008-2011) represents the main reference to contribute to sustainable, climate-proof spatial planning and territorial development at the local level in particular evaluating the 'climate change fitness' of spatial planning systems (legal and institutional framework, instruments, procedures) and identifying strengths, weaknesses and enhancement options to improve adaptation capacities of 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.

For example, in the field of natural hazard protection and flood management there are some relevant initiatives with an interdisciplinary approach. In this context, more important are also sectoral instruments, mainly at local level, such as – despite differences among countries - the municipal Building Plans, the municipal Urban Land Use Plans the Regional Water Protection Plan. For instance, in the domain of water management, Water Protection Plans usually include hazard zone maps and information of the impacts on water use and public awareness, linking climate change issues to water resource development.

The Hydrogeological System Plan is also an instrument directly related to climate change since it assesses the hazards and risks linked to gravity-induced slope instability and to river flooding. It covers the transitional plan for hydro-geological structures and the transitional plan for fluvial areas. At provincial and municipal level there are also other instruments dealing with climate change adaptation, such those which refer to civil protection activities (e.g. in Italy the Provincial Civil Defence Plans and Municipal Civil Defence Plans).

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

Owing to the cross-sectoral nature of spatial planning, its coordination role is becoming more and more important – especially where the development of integrative, cross-sectoral concepts is needed.

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.

2.2.11 Projects and good practices by sectors

Forest

The MANFRED Project: Management strategies to adapt Alpine Space forest to climate change risks: The Manfred Project facing pest diseases

The MANFRED project (http://www.manfredproject.eu/) aimed to create an Alpine monitoring network for pests, diseases and their management providing for an information platform for institutions, experts and forest owners. It hosts information on all relevant pests, diseases and quarantine pathogens. For 11 relevant pathogens the platform contains extensive data for the years 2007-2011. Austria, Slovenia, Switzerland and the German states of Baden-Württemberg and Bavaria, use the same types of traps and pheromones to monitor the flight patterns of *Ips typographus* and *Pityogenes chalcographus* and exchange information system.

The MOTIVE Project: Models for Adaptive forest Management.

The MOTIVE **(**http://motive-project.net**)** is a large-scale integrated project in the 7th Framework Programme of the EU developed for the years 2009-2013 that evaluates the consequences of the intensified competition for forest resources given climate and land use change. The project focuses on a wide range of European forest types under different intensities of forest management. In particular, MOTIVE examines impacts with respect to the disturbance regimes determining forest dynamics. MOTIVE seeks to develop and evaluate strategies that can adapt forest management practices to balance multiple objectives under changing environmental conditions. The project encompasses the alpine case study Montafon Valley (Austria).

The ALP FFIRS Project: Alpine Forest Fire Warning System .

The ALP FFIRS (www.alpffirs.eu) is a project developed under the Alpine Space Programme 2010-2013 and co-founded by the European Regional Development Fund (ERDF). It aimed to improve forest fire prevention under a changing climate in the Alpine Space, by creating a shared warning system based on weather conditions. The fire regime at any given location is the result of complex interactions between fuels, social issues, topography, ignitions and weather conditions. The analysis of fires frequency and distribution will allow to model forest fire danger in the alpine region. The definition of a univocal Alpine Forest Fire Danger Scale will support the interpretation of danger thresholds as enhancement of emergency plans and operational procedures. Due to the climate change, forest fires as potential disturbance have become an issue in the Alpine region over the last decade. An Alpine network on forest fire impact mitigation will be assembled reflecting common policies in risk prevention management, by fostering mutual aid in prevention, preparedness and suppression procedures.

Water

The Alps facing the challenge of changing water resources: the EEA Report on Regional climate change and adaptation from the water resources viewpoint

Drawing on the most recent knowledge of climate change impacts in the Alps and experiences across the region, this report (http://www.eea.europa.eu/publications/alps-climate-change-and-adaptation-2009) analyses the risks that climate change presents to the region's water supply and quality, identifying needs, constraints, opportunities, policy levers and options for adaptation. It extracts policy guidance on adaptation practice and aims to assist regional and local stakeholders in developing robust adaptation strategies. The focus of the report is on water resources and related adaptation, rather than water-related extreme events like floods, avalanches, landslides or mudflows, which are already well covered by existing studies of climate change impacts in the Alps.

The DynAlp project: Dynamic Adaptation of Urban Water Infrastructure for a Sustainable City Development in an Alpine Environment.

The DynAlp project (http://www.dynalp.com/project/) focuses on city development and the potential impact of climate change on the adaptation and development of urban water infrastructure and addresses the aspect of pluvial flooding risk in detail.

The aim of this project (duration: 07/2012 – 06/2015) is to develop and apply a strategic planning tool for integrated consideration of climate change and city development in view of planning urban water infrastructure. The outcomes are the development and application of a software framework that integrates urban development, climate change projections and drainage infrastructure adaptation. The novelty of this approach lies in an integrated consideration of climate change and urban development in a dynamic temporal scale. This means that not only future target grids of drainage networks are evaluated but also the pathway (in yearly timesteps) to reach that target grid. This enables us to test different adaptation strategies and to identify potential failure points in that pathway. All investigations will apply to Austrian (Alpine) conditions, characterised by cold winters and summers with intense rainfall. The impact of urban drainage systems on both society (e.g. impact of increased rainfall intensities on pluvial flooding) and environment (e.g. pollutant discharges to receiving waters) will be addressed.

The URBAN_WFTT project . Urban Water Footprint: a new approach for water management in urban areas

The URBAN_WFTT project (http://www.urban-wftp.eu/en/) is a Central Europe project focuses on local water management in urban areas in order to improve currently used technologies and to integrate innovative tools for monitoring and managing citizens' water use, water networks and wastewater treatment systems in order to determine economic, environmental and social benefits. To achieve these goals the Water Footprint approach represents an opportunity for better water management and use of water.

The project activities contribute to support environmentally friendly activities at the loal level in order to help the Municipalities in the definition of environmentally friendly policies, plans and strategies by quantifying the environmental benefits of the introduction of new technologies and

activities with the involvement of water services companies and relevant stakeholders, such as citizens. The project also promotes environmentally friendly technologies with the identification of innovative water saving and water treatment technologies in Urban Areas. Under this project was developed the **Urban water lab Innsbruck Lab.** The Innsbruck UWF Lab focuses on virtual water use and it concentrates on the end-consumers of virtual water, which is mostly the private individual. It is particularly important to start at young age to raise awareness about environmental friendly and sustainable water consumption. In this context it is most promising to achieve long-lasting changes in water consumption and behavioral pattern when working with teenagers. The Lab consists of 4 workshops with school students (age 16-18) with focus on: introducing the water footprint approach, presentation and interpretation of results by students, development of measures to improve the WFTP, how to best reduce the water footprint and evaluation and review about the measure implemented.
Energy
The SeapAlps Project: supporting alpine local authorities in the development and implementation of Sustainable Energy Action Plans (SEAPs). Within Seaoalps project (http://seap-alps.eu/hp2/Home.htm) a guideline for the implementation of Sustainable Energy Action Plans has been developed with a special focus on the characteristics of the Alpine Space communities: often small and medium cities with economies based on tourism that already today have been severely affected by climate change. Project partners from eleven Alpine regions have gathered their experience in drafting this methodology. The SEAPs are being implemented and evaluated in more than thirty pilot communities of different Alpine regions. In parallel, a training platform that can be accessed on the project website supports transfer of knowledge and capacity building at local level. The guidelines for cities and municipalities go beyond the field of climate protection by including local adaptation policies to climate change, thus providing a valuable contribution to the Alpine Space. **The ALPSTAR Project: Toward Carbon Neutral Alps - Make best Practice Minimum Standar** The ALPSTAR project (http://alpstar-project.eu) encouraged the capitalization, diffusion and implementation of proven good practice measures in reduction of climate change and preparation of cross-sectoral strategies and action plans toward carbon neutrality on regional and local level. The main specific objective were: to encourage and support exchanges of experiences, knowledge and know-how among pilot regions in order to facilitate their implementation and to capitalize and spread local strategies and good practices for the reduction of GHG emissions; to search for good practices in preparation and implementation of strategies, action plans and measures toward carbon neutrality and to make them become minimum standard; to promote integrative and participatory approach in development of cross-sectoral strategies and action plans and implementation of measures toward carbon neutrality; to empower local and regional administrative actors and planners to become facilitators of change; to encourage pooling, transfer and implementation of innovative and efficient good practices from and to other Alpine regions and beyond.

Air quality and human health
The ALPNAP Project: Living along a transit route air pollution, noise and health in the Alps The ALPNAP Project (http://www.alpnap.org) had the objectives of collecting and describe updated science-based methods to observe and predict air and noise pollution along trans-Alpine transport corridors and to assess the related effects on health and well-being. These methods can be used to assess the consequences of new transport infrastructures (roads and rail-ways) already in the planning phase or to design appropriate administrative or technological abatement measures against the violation of air pollution and noise limits also in consideration of climate and topographic variables. The results of the project, that are useful to identify vulnerable areas where adaptation measures are more needed, are published in a comprehensive and easy-to-read report to facilitate its use by environmental and transport managers. In the official website of the project a list of useful "adaptation links" is provided, including a number of Alpine climate and weather forecast services, online geo information and EU environmental organizations and agencies, that may be useful to design and implement an air quality adaptation strategy at subnational level. **Measures to improve the air quality on the Brenner corridor in Tyrol (Austria)** The Brenner corridor in Tyrol has experienced a considerable increase in road freight transport: in the last 20 years 2.0 million trucks/year are currently using the Brenner pass. 16.5% of all vehicles are Heavy-Duty Vehicles (HDV) and emit 54% of NO_x and 23% of PM_{10}; a high correlation exists between air pollution with NO_2 and the number of HDV. A plan of measures has been stipulated by the Land of Tyrol within their responsibilities and updated continually tackling a number of issues in several steps: - Traffic restrictions: night driving ban, ban of old motor classes Euro 0, 1, 2; higher night toll for HDV, driving ban for specific goods since May 2008 - Transport alternatives: promotion of transport alternatives with low emissions (e.g. rolling road, build of new rail infrastructure) - Harmonisation of traffic flow: speed limit during night since 1988, traffic management system, dynamic (traffic and pollution controlled) speed limit for passenger cars (100 km/h) at a distance of 90 km since 2007 - Harmonisation of traffic frames condition within the entire Alpine region at European level - (for more details visit www.tirol.gv.at and see also www.monitraf.org)
Mountain farming (agriculture and livestock)
The Alpwaterscarce Project: dealing with water scarcity in the Alps The main challenges of this project (www.alpwaterscarce.eu) was to create local Early Warning Systems against Water Scarcity in the Alps based on sound and perennial monitoring and modeling and anchored strongly and actively within a Stakeholder Forum linked across comparative and contrasting regions across the Alps. The Early Warning System is based on the linkage and improvement of field monitoring and assemblage of qualitative and quantitative data derived from anthropogenic water use in selected pilot regions in France, Italy, Austria, Slovenia and Switzerland. The aims are to implement water management at the short-term (annual) scale as well as the long-term (future scenarios) scale based on modeling under climate change and

anthropogenic scenarios. Among the outputs of the project, climate scenario guidelines and a set of Water-Scarce recommendations for adapting water management in the farming sector is provided in different languages at http://www.alpine-space.eu/projects/projects/detail/Alp-Water-%20Scarce/show/

Testing more drought-resistant crops in Rhône Alps (France)

From 2006-2009, scientist experimented with water efficient and drought-resistant crops in the Rhône-Alpes region. The "Chambre d'agriculture de la drome" facilitated the planting of meslin in the plain and mountain region. The objective was to diversify fodder resources to secure food supplies for animal herds. The pilot project found that meslin is a good grain to plant during water scarcity periods because it presents low water requirements and enhance the autonomy of farmers to avoid having to export grains in the winter and during drought periods.
Find further information only in French on:
http://rhonealpes.synagri.com/synagri/synagri.nsf/pages/AccueilRegion

Transports

State of the art on climate change impacts and vulnerabilities of trasports in Alpine countries

Information on the trends and future risks of climate change for European transports has improved recently due to several EU research projects focusing on climate change, extreme weather events and inland water transport. Even if not at local level, the EWENT project (http://ewent.vtt.fi/) assessed potential climate risk and average annual costs due to weather extremes for the current (1998–2010) and a future (2041–2070) time period. Costs comprise accident costs, time costs, infrastructure damage and maintenance, and effects on freight and logistics with regards to aviation, roads, river and rail transportation nodes in mountain areas. On the other hand, analogous researches were carried on within the WEATHER project (http://www.weather-project.eu/weather/index.php). The focus on alpine environments is performed through the evaluation of the physical impact of heavy snow events in alpine roads. The results differ slightly from those of the EWENT project because some factors like externalities regarding the cost of climate-induced transport accidents were omitted. Finally, ECCONET project (http://www.tmleuven.be/project/ecconet/home.htm) assessed the impact of climate change on inland waterway transport proposing also a set of possible adaptation measures. The project used the Rhine–Main–Danube corridor as a case study with special emphasis on low water river transports.

Good practices on Alpine transports: the Alpine Pearls network

Alpine Pearls (http://www.alpine-pearls.com/en/) promotes and communicates sustainable tourism with environmentally friendly soft mobility. The association's 24 members profit from the joint market activities and form a strong European tourism brand. Experiences are intensively shared amongst the pearls of the Alps. The activities for the members include e.g. joint marketing activities, mutual media relations, production of joint advertising media, co-operation with partners, events and public relations, etc.

The PARAmount Project: imProved Accessibility: Reliability and security of Alpine transport infrastructure related to mountainous hazards in a changing climate

PARAmount (www.paramount-project.eu) is an Alpine Space Programme aiming at improving hazard and risk management strategies for infrastructure protection. This goal was achieved by adapting existing and developing novel infrastructure-relevant tools, methods and procedures, especially with regard to the potential impact of climate change. Based on a thorough initial cross-sectoral state-of-the-art analysis, existing natural hazard management tools were adapted to the special requirements of transport infrastructure protection: Hazard early warning and decision support systems, as well as avalanche-, rock fall- and debris flow-simulation models were developed and implemented in a wide range of test beds throughout the Alpine Space, inter alia resulting in process- and infrastructure-specific risk maps.

Extreme events and natural hazards management

PLANALP: the adaptation strategy for natural hazards in the alpine space.
Following the devastating avalanches and floods of 1999, the Alpine Conference appointed a working group to discuss the development of common approaches to natural hazard prevention in the alpine space. Based on their recommendations the Platform on Natural Hazards, PLANALP, which involves 16-20 high-level experts delegated by the contracting parties of the Alpine Convention, was established at the VIII Alpine Conference in 2004. The PLANALP has published an alpine strategy for adaptation to climate change in the field of natural hazards. Based on an overview of climate change in the alpine region, its impacts on natural hazards and the consequences for risk management, this strategy defines a common vision for climate change adaptation and recommends adequate action options. Several examples from the alpine countries illustrate current good adaptation practice. The strategy can be downloaded at http://www.alpconv.org/it/organization/groups/WGHazards/Documents/PLANALP_Alpine_strategy.pdf

The AdaptAlp Project: Adaptation to Climate Change in the Alpine Space (2008-2011)
The project AdaptAlp (http://www.adaptalp.org) contributed to a growing body of scientific research on the effect of climate change within the Alpine region and how our societies can adapt to the increasing risk of natural disasters. The intent was to deepen this knowledge so that decision-makers can craft coherent policies and programs based on current and accurate information. AdaptAlp is the result of three years of research of collaboration and exchange between sixteen partners from six Alpine Space countries. AdaptAlp focused on three areas: climate change and water regime analysis; natural hazard mapping; risk management and risk prevention. The overall project goal was to generate a sound data basis for decision-makers and to put research into action.

The PermaNET Project: Permafrost Long-term Monitoring Network
The main aim of the PermaNET project (www.permanet-alpinespace.eu) was to compile data and facts about permafrost distribution and the thermal evolution of permafrost in a changing climate, creating one knowledge base and objectifying discussions in this field. This required bringing scientists together with stakeholders and decision-makers in territorial planning.
With the joint development of a common strategy for dealing with permafrost and related hazards under changing climatic conditions and the creation of an Alpine-wide monitoring network, the project aims at preventing natural hazards, at contributing to sustainable territorial development and at the implementation of good governance practices.

Tourism

Future natural snow reliability of sky areas in the Alpine Space: results at national level

According to the report "Climate change in the European Alps: adapting winter tourism and natural hazard management" (OECD, 2007) 609 out of around 666 Alpine ski areas can be considered as naturally snow-reliable. Almost 9% are hence operating under marginal natural conditions in terms of snow availability. Under the hypothesis of 1ºC warming, the percentage of snow-reliable ski areas in the entire Alpine arc will drop to almost 75% (500 sky areas), 61% with a 2º warming (404) and to 30% (near 202) with a 4ºC warming of the current climate (see table below).

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

Source: OECD, 2007: Present and future snow reliability of ski areas in the Alpine countries on a national level.

As revelled by the results of this research, the sensitivity of ski areas to changes in the line of natural snow reliability will differs from country to country, but also from locality to locality depending on the altitude range of the ski areas, exposure, slope and landscape characteristics. Hence, sensitive case-by-case studies are needed in order to avoid maladaptation and expensive and ineffective adaptation initiatives.

The ClimAlpTour Project: adapting alpine tourism to climate change

The ClimAlpTour project (http://www.climalptour.eu/content/) was focused on investigating and developing appropriate and tailored made strategies to tackle the negative impacts of climate change in Alpine tourism. The project has developed an analysis phase, collecting and processing data and information on not only on environment, but also on economy and social aspects of the challenges poses by climate change. A dataset integrating these three different sectors have been developed and relative data collected throughout the Alpine arch. This investigation allowed to compare the actual situations in the Alps, both for winter and summer tourism, pointing out categories and recurring features. 24 pilot case studies have been identified as special Alpine target areas where to implement climate change adaptation strategies. A specific impact assessment lead to understand the vulnerability index for the selected target areas. Social science methodology and tools were adopted in order to have correct information loops with the territories/stakeholders and a number of activities performed at the local scale. This lead to the understanding of some possible strategies to overcome possible future scenarios, which were shared with stakeholders and implemented. A Decision Supporting System tool (available at http://www.climalptour.eu/content/?q=node/146) was developed and applied in some local pilot cases. In parallel, an awareness raising campaign was conducted in order to spread out the opportunities provided and inform about the need of climate change adaptation.

Biodiversity and Ecosystems
The ECONNECT Project The ECONNECT project aimed at the enhancement of ecological connectivity across the Alpine range. The project involved International umbrella organisations linked to the Alpine Convention, scientific institutions and local implementation partners. All these entities have joined forces to demonstrate the need for connectivity across the Alps as well as exploring the best options for coordinated action and the development of innovative tools to promote ecological connectivity. Among the outputs of the project, there is a policy recommendation document (http://www.econnectproject.eu/cms/sites/default/files/Policy_Recommendation_printversion_en.pdf) lunched as part of the communication and knowledge transfer strategy. The document has the objective to inform policy makers and decision makers at all levels, from local to regional to trans-national, about key conclusions of the project. It is intended, among others, for government agencies and agencies at EU ministries. The purpose of the policy recommendations is to stimulate further development of and support for the ecological connectivity concept, as its implementation will result in enhanced effectiveness of programmes to conserve biodiversity both in cultural landscapes and in wilderness areas of the Alps, and the ecosystem services associated with it. **The SILMAS Project: Sustainable Instruments for Lakes Management** The SILMAS project aimed at pooling experience and know Alpine lake management. SILMAS aimed at exchange good practices and testing new methods, supply its partners with efficient tools for reaching goals of the frame directives (Water and Natura 2000) and the Alpine Convention. The main actions were: the creation of a virtual laboratory, to define current ecological state of the lakes and anticipate changes due to climatic and biological dynamics; the assessment of existing governance tools dealing with regulation of land/resources and conflicts solving, then testing decision-making instruments in different lakes sites; the production of information and education tools for sustainable lakes management and uses, dedicated to decision makers, stakeholders and the young public.
Spatial Planning
The CLISP Project: Climate Change Adaptation by Spatial Planning in the Alpine Space The CLISP Project (http://www.clisp.eu/content/?q=node/230) is a transnational European project funded by the Alpine Space Programme under the European Territorial Cooperation 2007-2013. From September 2008 until September 2011, 14 Project Partners from six different Alpine countries are tackling the challenges spatial development and spatial planning are facing due to climate change. CLISP is anchored in the belief that spatial planning has large steering capacity in containing vulnerability and increasing resilience of spatial development. However, the knowledge, procedures and tools required for fulfilling this key role in adaptation have still been widely lacking. CLISP tackles for the first time the challenges of climate change to spatial planning in a transnational effort within the Alpine Space and it is to be regarded as a strategic pilot project.

Cross-sectoral projects on adaptation
The KLIP Project: Climate Strategy for the Province of Tyrol (February 2013 – January 2014) This project will develop a climate strategy for the regional government of Tyrol including climate protection as well as adaptation for the period 2013 – 2020 and a road map for the period 2020 – 2030. In 5 work-packages, the following steps will be carried out: - Documentation of the current state of the impacts of climate change on the region and calculation of the CO2 and energy balance for all relevant sectors - Development of measures for climate protection for all sectors - Compilation of climate change adaptation measures for vulnerable sectors - Drafting a controlling and monitoring concept for the implementation of climate protection and adaptation measures. All of these actions will be developed in close cooperation with the regional government of Tyrol. **The C3-Alps Project: smart knowledge on climate change adaptation** C3-Alps is a transnational capitalisation project. Building on the results of previous projects and initiatives on adaptation to climate change in the Alps, C3-Alps seeks to synthesize, transfer, and implement in policy and practice the best available adaptation knowledge. By applying a knowledge transfer concept driven by the information and communication needs of target groups, the project optimizes the usability of available knowledge resources in an attempt to bridge the gap between the generation of adaptation knowledge and its application in real-world decision-making. C3-Alps supports bottom-up adaptation measures in Alpine regions and municipalities, contributes to the implementation of national adaptation strategies, and disseminates Alpine adaptation capital within the Alpine community and beyond.

Stage (ii)
Planning for adaptation

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 they need not only expert knowledge but also consistency with national adaptation strategies. Furthermore they may require that national authorities 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.

The main targets of an adaptation strategy are:

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

- 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 III)

Table III: 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

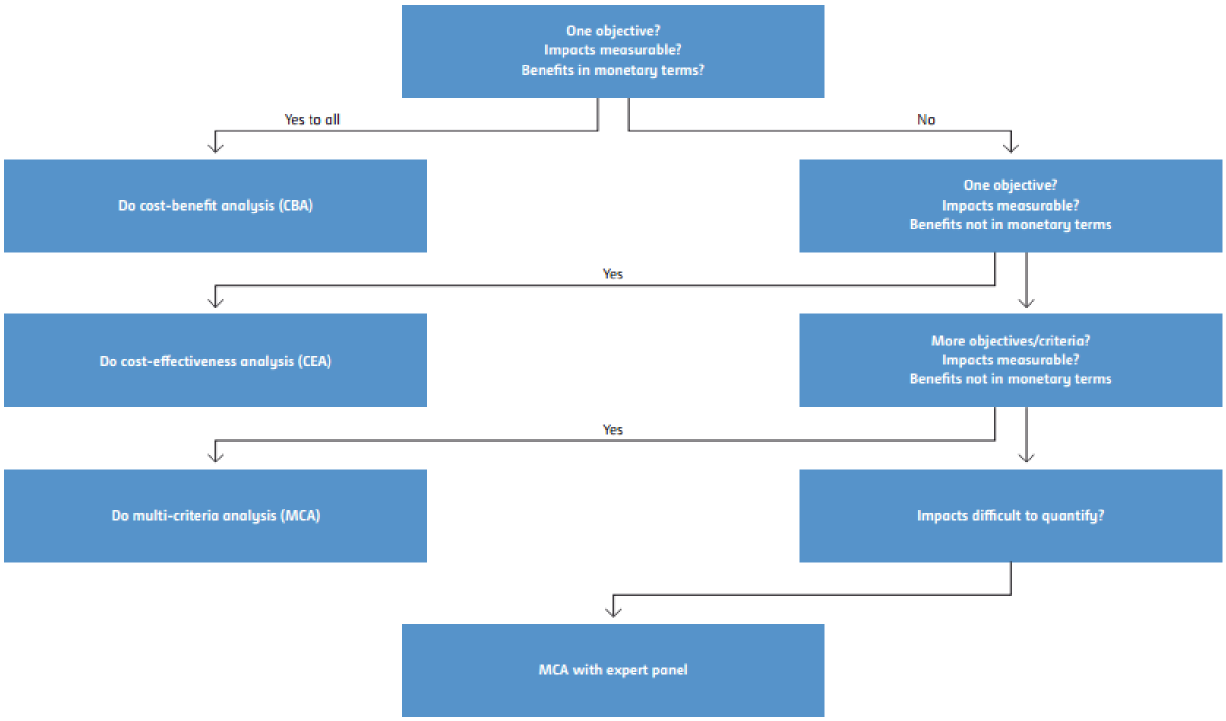
When current and projected impacts, vulnerability, risks and planned adaptation options have been assessed, targeted adaptation actions can be implemented.

The IPCC (AR4) defines adaptation costs as *"the costs of planning, preparing for, facilitating, and implementing adaptation measures, including transition costs,"* and defines benefits as *"the avoided damage costs or the accrued benefits following the adoption and implementation of adaptation measures"*.

Three main approaches have proven to be effective in assessing costs and benefits of adaptation options (UNFCCC 2011):

1. **Cost-Benefit Analysis (CBA)**
2. **Cost-Effectiveness Analysis (CEA)**
3. **Multi-Criteria Analysis (MCA)**

Figure IV: Decision tree of possible approaches for assessing the costs and benefits of adaptation options



Source: Adapted from BOYD R. and HUNT A. 2004. Costing the impacts of Climate Change in the UK: Overview Guidelines. UK Climate impacts Programme Technical Report.

1. Cost-Benefit Analysis (CBA)

Cost-benefit analysis (CBA) is often used to assess adaptation options when efficiency is the only decision-making criterium. 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. CBA provides a basis for prioritising possible adaptation measures. The benefit of this approach is that it compares diverse impacts using a single metrics.

Table IV: Steps of a Cost-Benefit Analysis

Steps of a Cost-Benefit Analysis	**Description**
1. Agree on the adaptation objective and identify potential adaptation options	An adaptation objective must be well defined and its attainment must be quantifiable in monetary terms
2. Establish a baseline	Define a baseline (situation without adaptation) and the project-line (situation with successful implementation of adaptation) to determine the costs and benefits by comparing the two situations

3. Quantify and aggregate the costs over specific time periods	Costs of an adaptation action include direct costs (e.g. investment and regulatory) and indirect costs (e.g. social welfare losses and transitional costs)
4. Quantify and aggregate the benefits over specific time periods	Benefits of an adaptation action include direct benefits and indirect benefits
5. Compare the aggregated costs and benefits	The bottom line for choosing an adaptation option is the comparison of monetized costs and benefits. They need to be discounted to be properly calculated. Three main options exist, including: the Net Present Value (NPV), the Benefit–Cost Ratio (BCR), and the Internal Rate of Return (IRR) [13]

A CBA can show a few distinctive characteristics and limits. It requires all benefits to be measured and expressed in monetary terms, does not address equity considerations related to the distribution of the costs and benefits of adaptation options across stakeholder groups and it must monetize categories of costs and benefits experienced at different times (need for discounting costs and benefits incurred in the future to compute their present value). A CBA makes possible to compare and aggregate different categories of benefits or costs into a single value.

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: thus CEA does not evaluate whether the measure is justified (e.g. by generating a certain benefit-cost ratio or internal rate of return-IRR). 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[14].

Table V: Steps of a Cost-Effectiveness Analysis

Steps of a Cost-Effectiveness Analysis	**Description**
1. Agree on the adaptation objective and identify potential adaptation options	An adaptation objective must be well defined and its attainment must be measurable (e.g. in terms of reduction of vulnerability, or increase in adaptive capacity / resilience)

13 More in detail, the three mentioned options can be described as follows. The NPV (Net Present Value) is the difference between present value of the benefits and present value of the costs. The NPV should be greater than zero for an option to be acceptable. NPVs can be used to prioritize the allocation of the funds. The BCR (benefit-cost ratio)is the ratio of the present value of the benefits to the present value of the costs. Benefits and costs are each discounted at a chosen discount rate. The benefit-cost ratio indicates the overall value for money of a project. If the ratio is greater than 1, the option is acceptable. BCR can also be used to prioritise the allocation of finite adaptation funding. The IRR (internal rate of return) is the discount rate that makes the NPV equal to zero. The higher an option's IRR, the more desirable it is.

14 For example, given the necessity for water, the aim of an assessment is not to find alternative adaptation options that might yield higher adaptation benefits, but to find those options that ensure sustainable water quality and quantity for vulnerable communities.

2. Establish a baseline	Define a baseline (situation without adaptation, actual or estimated) and a set of non-monetary indicators for evaluating and tracking benefits over time depending on the situation analysed (e.g. litres of water, etc.)
3. Quantify and aggregate the various costs	Costs of an adaptation action include direct costs (e.g. investment and regulatory) and indirect costs (e.g. social welfare losses and transitional costs) to be discounted to their present value at an agreed discount rate.
4. Determine the effectiveness	Benefits of an adaptation action depend on adaptation objectives and baseline (there can be a minimum goal to be achieved)
5. Compare the cost-effectiveness of the different options	The bottom line for choosing an adaptation option is the comparison of costs per unit of effectiveness of the adaptation option (e.g. € per litre of water). They need to be discounted to properly calculate their present value. *Overall cost-effectiveness ratio (CER)* Comparison of the cost per unit of effectiveness for each adaptation option (e.g. € per 1 litre of water). *Incremental cost-effectiveness ratio (ICER)* Difference in costs divided by the difference in effectiveness from comparing one adaptation option to the next most effective measure (or baseline-situation), analytically: $ICER = \frac{[Cost\ Option\ A - Cost\ Option\ B]}{[Effectiveness\ of\ A - Effectiveness\ of\ B]}$ *where A is the most effective policy measure, and B is the second most effective policy measure* As a result, option A should be preferred to option B only up to the point where the incremental cost effectiveness (ICER) of A is lower than ICER of B –when B has to be implemented.

An overall CEA is appropriate in cases where only one adaptation option will be implemented, which would be the option with the lowest cost-effectiveness ratio (least cost per unit of effectiveness). Where a single adaptation measure may not be sufficient, so that a combination of different options will constitute the adaptation policy, use of an incremental CEA is more appropriate.

The lowest incremental cost-effectiveness ratio indicates that policy A (the more effective measure) dominates policy B (the second most effective) in terms of cost-effectiveness. Basically, the gain in effectiveness from choosing A instead of B is high enough that it overcompensate for the eventually higher cost associated with implementing A. To maximase cost-effectiveness, adaptation planners should implement policy A until its marginal cost-effectiveness is lower than that of an alternative policy measure. There will be a certain quantity of policy A that will increase the cost enough to raise the value of cost-effectiveness ratio so that policy B will become preferable. In this sense, narrowly choosing a single option will rarely be the most cost-effective policy, and the preferred option will be a combination (i.e. choose A until when $ICER_A < ICER_B$, then choose B).

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. MCA essentially involves defining a framework to integrate different decision criteria in a quantitative analysis without assigning monetary values to all factors.
The robustness of an MCA result depends on the (un)certainty of the information regarding the selected criteria, the relative priorities given to various criteria (the weights or scores) and the extent to which the weights are commonly agreed upon by stakeholders. Sensitivity analysis can be used to check the robustness of the result for changes in scores and/or weights.

Table VI: Steps of a Multi Criteria Analysis

Steps of a Multi Criteria Analysis	
1. Agree on the adaptation objective and identify potential adaptation options.	In presence of more adaptation goals and criteria, a MCA can be conducted taking into consideration also other co-existing policies and goals (e.g. development policies, other political priorities). Objectives and options can be selected as under CBA and CEA.
2. Agree on the decision criteria	Criteria for the decision need to be clarified before the analysis is started. They are case-specific. Units of measurement (metrics) and span of possible scores have to be defined and shared with users / beneficiaries (possible criteria could be: urgency, importance, no-regret nature, co-benefits delivered, etc.).
3. Score the performance of each adaptation option against each of the criteria	May need a standardization (e.g. mathematical, statistical, etc.) of scores assigned under different criteria to a single metrics (unit) to compare and assemble the results under each criterion (e.g. all the resulting values score between 0 and 1, or 0 and 10, etc.).
4. Assign a weight to criteria to reflect priorities	Specific weights can be assigned to each of the considered dimensions; some aspects are deemed more important than others (priorities) because of well-justified motives that can be political, ethical, justice-based, etc. (e.g. measures positively affecting a larger number of individuals, or different levels of government can be preferred to less extensive ones).
5. Rank the options	The score for each option is calculated by multiplying the standardized scores with their weights. Weight-adjusted scores are then aggregated and compared to build up a rank order of adaptation options.

An MCA delivers a rank order of adaptation options and an overview of the weaknesses and strengths of each of the options. An MCA can be conducted in conjunction with other assessment approaches (e.g. CBA and CEA) to provide a more solid foundation for informed decision making.

MCA helps to select an adaptation option by outlining the various objectives of a composite policy program and the criteria to measure those objectives in a transparent manner. MCA can accommodate quantitative and qualitative information and helps to communicate the strengths and weaknesses of each adaptation option. In addition, MCA can entail direct stakeholder engagement by allowing the beneficiaries of the adaptation options to be involved in choosing them, which is crucial for creating ownership, responsibility and subsequent implementation of the adaptation measures.

The main difficulties associated with MCA include assigning weights, especially if the number of criteria is large and the criteria are very different in character, and standardizing scores (e.g. by building up synthetic indices), which leads to losing some information that could be valuable in later stages. Explicit statement of the weight assigned to each criterion can enhance public debate. Since it is not always easy to reach agreement among stakeholders on criteria and their relative importance, it is advisable to conduct a sensitivity analysis to determine if the ranking is sufficiently robust to withstand scrutiny.

2.3.2 Prioritization

Within the climate change adaptation process, the prioritization step has the aim to assess the main challenges and 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 to rank all the options needed.

The direct and indirect benefits of each action, as well as its costs, can register a significant variation depending on the viewpoints and stakeholders. Some adaptation options require also a change of behavior for the groups involved. Therefore, identification of priority options should be considered, evaluated and discussed with all stakeholders and implemented in a coordinated way. Some decision support tools that can be used included multi-criteria analysis, multi-objective analysis and consultation of expert panels. . Furthermore, any methodology should incorporate an assessment of impact and feasibility for the proposed adaptation options.

The essential criteria to implement the decision-making process, in order to select the priority adaptation options, are listed below:

- 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 they have to be taken in the short run. Other risks require a specific planning and interventions in the medium and long run. Therefore,

the timing assessment is an important aspect in order to help decision-makers in defining the action's agenda.

- 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. Many initiatives already under way at the regional level can help to reduce vulnerability to climate change. In this sense, priority should be given to those adaptation options that have a positive synergy with them.
- Cross-border implications. Some options may have negative consequences beyond regional borders. These options should be avoided, particularly where there are already potential impacts on natural or economic resources for neighborhood regions.
- Funding possibilities. Availability of funds to cover implementation costs, that may include existing funding streams in the region, co-financing by the central government or European funding as well as the possibility of steering private investment.

Stage (iii) Implementation of adaptation measures

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. The prioritization of the adaptation measures has to be based on transparent and clearly defined criteria. At the same time it must be kept in mind that the shortage of funding and financial incentives can undermine the willingness of stakeholders to take part to adaptation actions.

Looking at the success factors, a diffuse and shared political willingness among the policy-makers may support the development and implementation of climate change adaptation strategies and measures. On the other hand, a successful adaptation strategy requires a critical mass of motivated individuals from the relevant governmental and administrative bodies to be engaged in adaptation. To further motivate the strategy development, external or higher-level activities and international organizations (e.g. UNFCCC, IPCC, EU, Alpine Convention) are highly stimulating factors.

In order to enable local institutional levels 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 working at local level.

Coordination becomes a need at least at 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. In particular, it is advisable to include specific government levels (local, regional, federal, national and/or EU) on the basis of the specific adaptation problem and the regulative and socio-economic framework that is addressed.

Climate-resilience can be built by means of cost-effective adaptation measures (that may be 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).

Such a complex landscape calls for the application of a multilevel governance approach. The overview of key adaptation features below intends to characterize the multilevel governance for an adaptation approach at local level.

Climate impacts and vulnerabilities emerge in many ways at the regional and local levels, due to the diversity of bio-physical and socio-economic situations. In particular it is known how the degree of socio-economic development and the adaptive capacity of the interested areas determine the variability in the severity and nature of the impacts of climate change. This makes essential to take note of regional climate change impacts and regional adaptive capacities to frame local adaptation measures.

Moreover, the interconnectedness of different regions makes adaptation to climate change an inter-regional issue. For example, if a problem of water scarcity in a region in the European Alps is addressed by extracting more water from local rivers, downstream dwellers are likely to be affected by the decision. This challenge calls for inter-regional coordination of adaptation policies. To this purpose, the Alpine Convention, by addressing both conservation and development issues, supports transnational cooperation and the development of common frameworks through a series of initiatives, including its Natural Hazards Platform (PLANALP).

Adaptation to climate change is a multi-sectoral issue since it affects most economic sectors, but it is also cross-sectoral, due to the diversity 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; thus negative effects in some sectors can derive from an adaptation measure undertaken in one sector's interest. It is also to be noticed that the stakeholders involved can 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.

Often the authorities in charge of environmental protection do not hold administrative responsibilities within the boundaries of the environment affected by the phenomenon under inquiry. The same applies for authorities in charge of adaptation (when existing), a topic wherein pressures and responses cut vertically across different levels of decision-making interacting with each other within hierarchical structures.

For example, in water management, the European Commission has established the Water Framework Directive with the obligation to protect and restore the quality of waters across Europe (EC, 2010) and has issued a guidance document on adaptation to climate change in water management (EC, 2009b). National legislation was issued at the Member States' level, defining river basin management in their own contexts. Thus programmes and measures, including adaptation initiatives, will be implemented at that level.

Certainly the need for appropriate adaptation extends beyond the local and regional scale, is relevant at all levels of governance and cannot be the sole responsibility of any single institution (UNDP, 2010). Adaptation requires a critical mass of individuals from the relevant governmental and administrative bodies motivated to engage in climate change adaptation. As a conclusion, it seems essential to create a clear political willingness to take action that only can support the development and implementation of climate change adaptation strategies and measures.

Climate change affects in different ways a diverse range of actors and stakeholders (e.g. citizens, public authorities, scientists, businesses, NGOs) that should be actively engaged in adaptation. Different methods are available to involve stakeholders and address complex and uncertain problems, including joint-up actions, exchange of knowledge and expertise and mutual learning between different actors from government, business and civil society. The actors working together in adaptation can be engaged in mutual learning processes and discuss the respective role, power, authority and responsibility, as well as their multiple interests. This kind of approaches is still scarcely applied and new mechanisms are probably needed to allow learning and cooperation between actors and stakeholders from different fields and with different competencies.

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. It has also been observed how external or higher-level activities and international organisations (e.g. UNFCCC, EU, IPCC) are highly supportive factors of a sound strategy development.

In order to ensure a proper involvement of all levels of governance, it is crucial to develop strategic policy documents on adaptation (e.g. national or regional adaptation strategies) capable to convey a clear communication on the roles and responsibilities in adaptation for the different levels involved.
Some first interesting results are observable in some EU-funded cooperation projects (e.g. territorial cooperation/Interreg and research projects) that still need to be spread and fully capitalised within the policy-making communities of the involved countries. Information and data at different levels can be made available to and raise the awareness of decision-makers and the public through web portals (e.g. Climate-ADAPT combined with national and regional web portals) and indicate the need for better science-policy cooperation.

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

Local action	Regional action	National action	European action
Implementing action			
• 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	• 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	• 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	• 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

Source: EEA, 2012. Supporting action

Stage (iv) Monitoring and evaluation: the follow up of the adaptation policy

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 in different stages of the adaptation process . They are subjected to methodological challenges and often to large uncertainties. The "Impact Assessment to the European Commission's 2009 White Paper on Adaptation" describes the purpose and scope of indicators, as 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 and can be either quantitative or qualitative. The indicators are often based on a given metrics that requires, to be quantitative, proper units of measurement and thus allows 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.

According to a common classification (Harley et al., 2008.), it is possible to divide indicators in two main groups, according to the particular step of the adaptation process 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 chosen to select 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.

A number of good quality indicators on climate change impacts, vulnerability and risks relevant for Europe is now available at regional, national and EU (EEA Report No 12/2012) level[15]. Recently, specific indicators were also developed to track the uptake of adaptation action (UK Adaptation Sub-Committee)

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

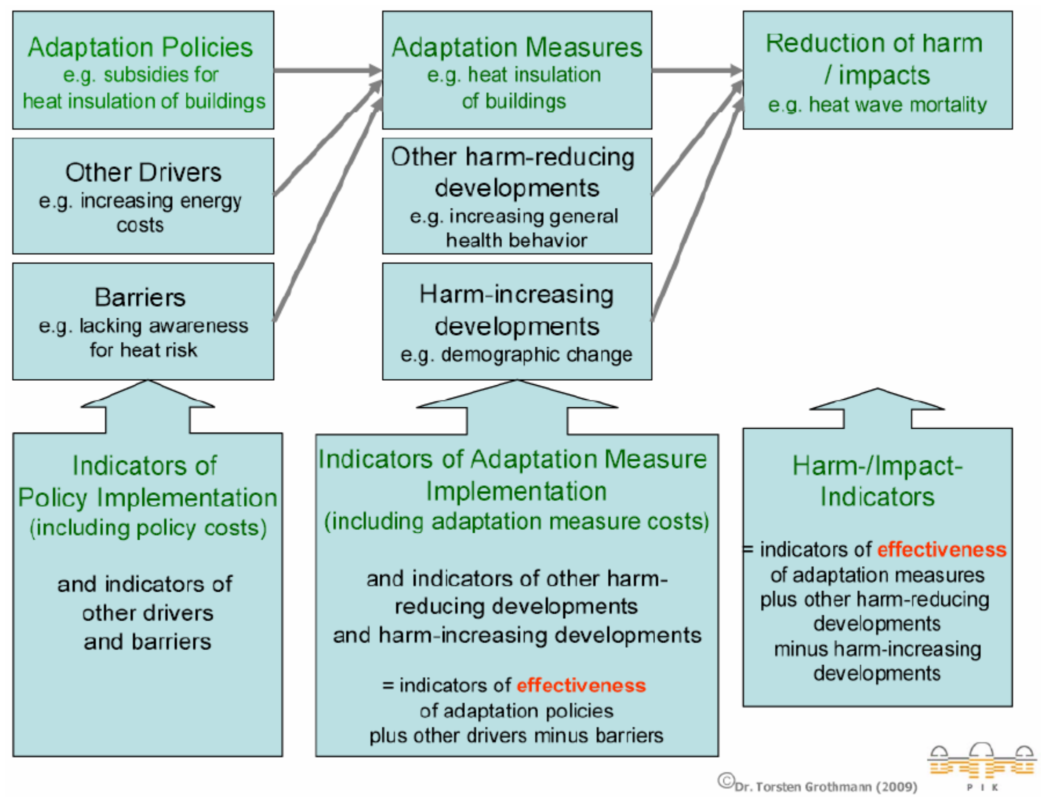
Type of indicator	**Main purpose**
Climate change (e.g. temperature, precipitation)	Understanding the causes of impacts of climate change
Climate change impacts (e.g. floods, droughts)	Understanding consequences of climate change and determining vulnerability to climate change
Social, economic, health, 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

Different indicators can be used to represent and track the progress of an adaptation strategy across its distinctive steps of designing policies, implementing measures and delivering outcomes (usually in terms of harm / impact reduction) as shown in the figure below.

15 For instance, in Germany a specific set of indicators for measuring progress towards meeting the objectives of the national adaptation strategy has been developed (Schonthaler et al. 2010)

Figure IV: Indicators to track the progress of an adaptation strategy across its distinctive steps of designing policies



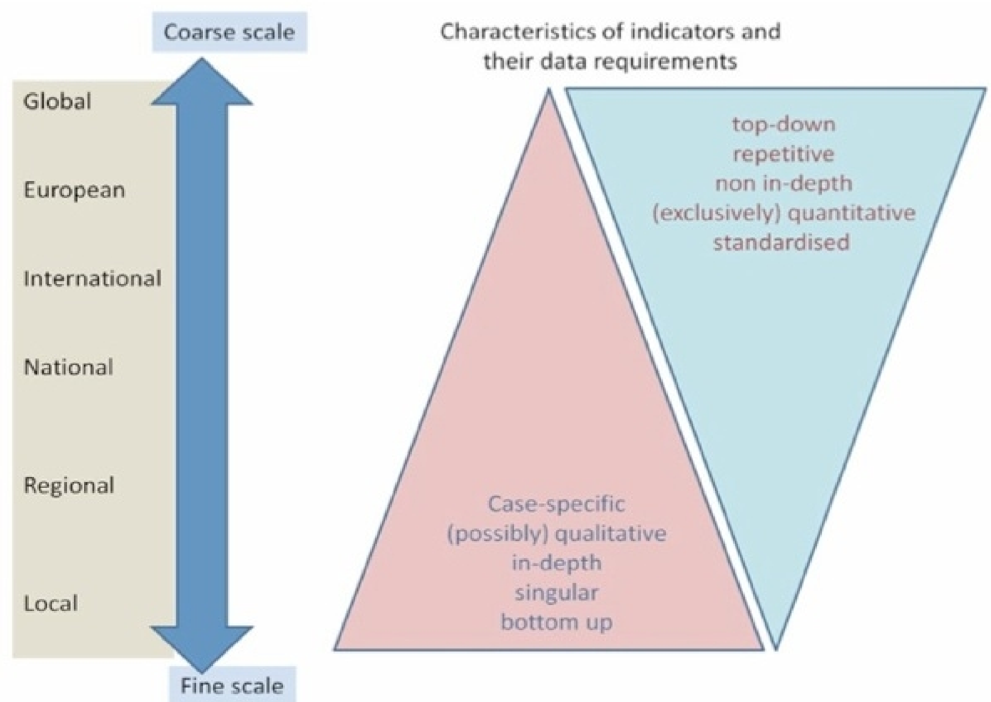
Source: ETC/ACC Technical Paper 2009/6

Since it is widely recognized that adaptation to climate change is, to a large extent, a local or national policy, 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, as far as possible, consistency in methodologies and data collection across countries. In the figure that follows a basic sample of regional level process-based indicators is provided, which need to be checked for its consistency to the specific region under inquiry.

Often limitations in data availability at coarser spatial scale call for the use of aggregated and standardised data by higher level authorities, usually provided consistently in the long-run and allowing for comparisons and update of the indicator values. Coarse-scale assessments can reveal the overall significance of climate change impacts, enable the comparison of regions and inform centralised policies (e.g. for financial allocation or other form of support).

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. Some data collection methods used (e.g. participatory approach) can only be applied locally (ETC/ACC Technical Paper 2010/12).

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



Source: ETC/ACC Technical Paper 2010/12

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

Regional/local process-based indicators

Sector	Indicator
General	- Use of scenarios to inform adaptation options. - Identification of cross-sectoral issues/concerns. - Production of local adaptation guidance. - Production of disaster management plans.
Agriculture	- Implementation of measures to reduce soil erosion and desertification. - Introduction of drought and heat resistant crops. - Uptake of insurance to cover weather extremes.
Biodiversity	- 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	- Mapping and control of disease vector species (e.g. mosquitoes). - Provision of climate control equipment for vulnerable people.

Tourism	Modification of recreational facilities to accommodate higher ambient temperatures.
Water	Construction of flood protection schemes.
Economy	Upgrade of transport infrastructure.

Regional/local outcome-based indicators

Sector	Indicator
Biodiversity	Reduction in degraded ecosystems.
Health	Reduction in deaths during heat waves.
Water	Reduction in water consumption.
Economy	Reduction in economic losses due to floods.

Source: ETC/ACC Technical Paper 2009/6

In the EU a number of indicator sets exist or are being developed for various policy purposes, but these initiatives do not yet explicitly take climate change impact, vulnerability and adaptation into account.

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. The reason why monitoring, evaluating and reviewing processes are started is to determine whether the strategy or plan delivers the intended benefits and/or has negative impacts, i.e. to check the effectiveness of the measures undertaken. Moreover, examining the effectiveness of adaptation support mechanisms can be helpful in order to evaluate adaptation funding, identify future priorities, ensure the effective allocation of scarce resources, allow a wiser allocation of public funding for accountability purposes (Fordet al., 2013).

Research was conducted to identify some key characteristics that define successful or effective adaptation and it has been focused on specific adaptation interventions or programs. 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. This means that 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. In this line, responsibilities need to have been assigned to different institutions, usually according to the expert judgment of an "ad hoc" Steering Group. Targets should be specific, measurable, achievable, realistic and time-framed (ICLEI, UNECE). As discussed above, indicators can be used to measure the success of the strategy. Other ways to measure progress include conducting public surveys, monitoring the number of visits to a climate change community website and monitoring the number of requests for climate change literature (ICLEI).

Three main typologies of systematic measures to assess various stages of adaptation exist, that are presented in the table below.

Table X: Typologies of systematic measures to assess stages of adaptation

Approach for adaptation tracking	Short Description	Indicators or criteria for evaluation
Measures of adaptation readiness	Evaluating "readiness" means assessing the strength and existence of governance structures and processes that determine the presumed ability (i.e., readiness) of government agencies to build support for action and effectively develop, implement, and monitor adaptation interventions.	Political leadership Institutional organisation Stakeholder involvement Climate change information Appropriate use of decision making techniques Consideration of barriers to adaptation Funding for adaptation Technology development and diffusion Adaptation research
Process-based approaches	Approach oriented to the need to conduct evaluation in the short-run. Focus on the process through which interventions are developed and implemented in pursuance of a desired outcome or objective. Applicability at a global scale is challenged by data and time requirements. Need for general indicators capturing key process components to assess current status of adaptations globally from which future progress could be tracked.	Effectiveness Efficiency Equity Legitimacy Flexibility Acceptability Mainstreaming Sustainability
Analysing policies and programmatic approaches	When outcomes of CCAP are difficult to measure (e.g. time lag between actions and results) a baseline can be defined out of current adaptation action, its adequacy can be assessed through adaptation reporting that is treated as a proxy for adaptation actions and compared to adaptation commitments and needs (types of action, scale, vulnerabilities responded to, stakeholder involvement, etc.). Descriptive and inferential statistics can be used to monitor, evaluate, and compare trends.	Individual ac tions/responses undertaken Stimulus motivating the response Who or what adapts Adaptation activities Adaptation outcomes Level of action Constraints to adaptation Facilitators of adaptation
Examining measures of changing vulnerability	Indirect or proxy measures of vulnerability reduction (diverse indices exist mainly for the national and global level) can also be used to infer successful adaptation, if used to determine a baseline to be used to evaluate and monitor adaptation success by comparison. Indices should not represent general socioeconomic development trends, where disentangling the role played by adaptation is problematic.	Monitoring of aggregate vulnerability indices in relation to adaptation Actions. Focusing on indicators capturing the determinants of vulnerability (incl. access to education, poverty, health, and inequality). Examining specific components of sensitivity and adaptive capacity (e.g. identifying regional shifts in land use in high-risk locations).

Source: adapted from Ford J.D. et al. 2013

However, implementing an adaptation strategy involves numerous stakeholders, sectors and communities working at a range of spatial scales and over differing periods of time. It is also essential to notice that autonomous and private adaptation will be occurring alongside planned efforts, with very effective outcomes that should be taken into account as well. Thus evaluation and review should follow the principles of participatory decision-making and seek to involve a wide range of stakeholders. Lessons learned and successes in adaptation can also be shared with other regions.

Still, monitoring and evaluation is the neglected phase in many adaptation strategies: adaptation indicators remain relatively poorly developed in most countries.

Even though a few approaches to monitor progress in adaptation (still mainly theoretical) 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 by which actions can be monitored, and limited standardization in approaches (Ford et al. 2013).

Nevertheless, this step is given growing attention since sharing lessons learnt and existing good practice in other areas or domains helps learning what works well (or not), in which circumstances and for what reasons. It is essential to assume a practice-oriented approach as well as a sense of purpose in making an evaluation exercise.

Table XI: Typology of approaches for adaptation tracking

	Tracking approaches	Characteristics	Data sources	Strengths	Limitations
Outcome-based	Outcome evaluation: *reduced negative climate change impacts*	• Track climate-related losses, mortality, and morbidity, over time and relation to adaptation. • Examine impacts of climatic hazard event before and after adaptation.	Natural hazard loss database (e.g. emergency events database)	• Quantification of adaptation progress and effettiveness • Metrics can be monitored over time • Availability of standardized global dataset of hazards losses and mortality across regions • Legitimacy with policy evaluation community	• Applicable only where outcomes are directly observable • Difficulty of inferring causality between outcome and adaptation • Potential for maladaptation not captured • Limited applicability to "soft" and mainstreamed adaptations • Does not measure outcomes from adapting to wider (nonevent-oriented) climate change
Preparedness process and policy-based	Adaptation readiness: *presence of key governance factor essential for effective and successful daptation*	• With regard to adaptation, evidence of: political leadership; institutional organization; stakeholder involvement; appropriate use of decision-making techniques; and consideration of barriers to adaptation, funding, technology development, and adaptation research.	• Speeches at Conference of the Parties meetings • Attendance at Conference of the Parties meetings • Leadership identified in UNFCCC National Communications or National Adaptation Programmes of Action • UNFCCC National Communications • National assessments	• Not dependent on outcomes being visible • Captures readiness for future action and ability to effectively implement adaptations	• Need to validate if readiness translates to action • Limited availability of readiness metrics
	Process-based approaches: *process through which adaptations are developed and implemented in pursuance of a desired outcome or objective*	• Comparison of adaptation characteristics and steps of development to theoretically and empirically derived characteristics of adaptation success and best practice	• National Adaptation Programmes of Action • Adaptation inventories	• Not dependent on outcomes being visible • Capture the key processes that are believed to underpin effective and successful adaptation	• Limited systematically collected data on process of adaptation development and implementation • Limited transferability across nations • Time intensive • Unproven link to adaptation success
	Analysing policies and programmatic approaches: *monitoring and comparison of reported adaptation actions and their characteristic s*	• Analysis of characteristics and comparison across regions by vulnerability categories, over time, and with respect to adaptation "obligations".	• UNFCC National Communications • National Adaptation Programmes of Action • Adaptation inventories • National adaptation assessments	• Not dependent on outcomes being visible • Systematic and quantitative analysis of progress • Comparability across nations • Suited for global application • Amenable for rapid assessment	• Success not directly measured • Results subject to reporting bias
	Examining Measures of changing vulnerability: *measurement of change in vulnerability in relation to adaptation*	• Monitor aggregate vulnerability indices in relation to adaptation actions • Focus on specific indicators which capture the generic determinants of vulnerability (e.g.	• Climate Change Vulnerability Index • Environmental Sustainability Index • Global Climate Risk Index • GAIN Index	• Not dependent on outcomes being visible • Readily available vulnerability indices globally • Amenable for rapid assessment	• Inability to capture determinants of vulnerability • Fundamental disagreement between indices on magnitude of vulnerability • Challenge of linking change in indices to adaptation

	access to education, poverty, health and inequality) • Examine specific components of sensitivity and adaptive capacity to climate change impacts	

Source: Ford, J. D., L. Berrang-Ford, A. Lesnikowski, M. Barrera, and S. J. Heymann. 2013

Cross cutting issues

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 (both applied and still in-progress) developed in the Alpine countries[16] 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.

Moreover, even if adaptation can theoretically be developed everywhere, there are some supporting and enabling factors that practice has shown as capable to ease the design and successful implementation of a plan within a specific region as well as the enforcement of adaptation strategies and measures that include:

- Legal frameworks which legitimate authorities to coordinate and develop climate change adaptation activities.
- Appropriate participation ensured and involvement of different institutions to support the acceptance of the plan.
- Availability of studies, reports and other expertise on climate change impacts, vulnerabilities, risks, and adaptive capacities.
- Schemes for monitoring and evaluation of climate change impacts and adaptation.

3.1 Dealing with cross-cutting issues: integration and mainstreaming

Adaptation to climate change is known to be a crucial cross-cutting issue. 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).

When the vulnerability of a society is assessed, it is easily recognised how its exposure to climate risk and its capacity to adapt are closely related to the nature and level of its economic and social development. As a consequence, adaptation plans cut across key economic sectors and many policy areas. When there is no adaptation policy, some measures are likely to be taken at the sector level and as a *de facto* response to climate risks, not being clearly perceived as interconnected.

16 “International Exchange "Governance of Climate Change Adaptation”, Ittigen, Switzerland, 3 April 2014

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.

It is worth noticing that strictly climate-oriented policies and laws (e.g. at the supranational level: UNFCCC, EU 2020, etc.) are not the only instruments to adopt principles being relevant to adaptation: other sectoral policies can prove very effective to address adaptation issues, too (e.g. vulnerability of specific ecosystems should be tackled also with adaptation policies that can help address another environmental problem such as biodiversity loss).

In our framework, the individual sectors described in *Chapter 2* might develop in different directions and seek specific targets that can be mutually contrasting. 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- and trans-disciplinary approaches that allow involve all affected actors.

Adaptation affects all levels of decision-making, all regions as well as most economic sectors; it needs to be structured as a cross-sectoral, multi-level and inter-regional activity bringing together actors with different knowledge, interests and values.

Integration among adaptation actions is therefore desirable. It can be achieved by adopting a cross-cutting approach that is aimed at involving different sectors, stakeholders and interest groups in adaptation planning. 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, and that can make participation a key success factor along the whole process.

Since decisions on adaptation influence different sectors of the economy and the society, ensuring a proper participation means involving policy makers and other stakeholders (both public and private).
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.

The participation approach has to take place since the early stages of the adaptation strategies and at first it is fundamental to identify the stakeholders to be involved in the participation process and define the potential instruments to use.

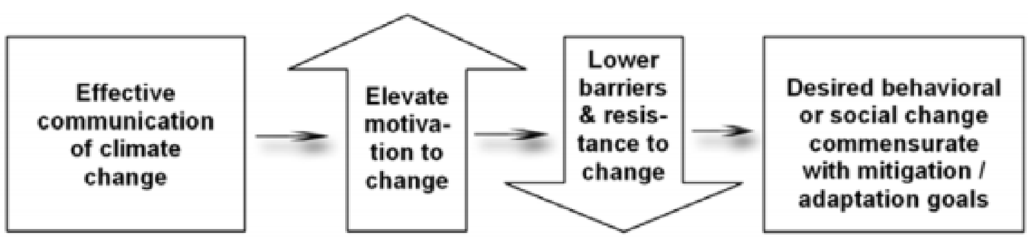
A well-framed participatory process has to be carefully planned and the most appropriate forms of participation assessed such as, for example, work tables, seminars, workshops or presentations. Workshops are a particular fruitful way of holding consultations and including the opinions and suggestions of groups and individuals that are not part of the core group drafting the policy document. The number of topics that can be covered in a one-day workshop is sometimes overestimated, however. Facilitators who have experience with similar tasks and are able to assess the content that can be covered in a workshop, should therefore be included.

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. Based on the interview responses, non-scientists should be enabled to appreciate opportunities for informal exchange between participants at such events. These meetings make it possible to get to know each other and to develop relationships of trust that enable all sides to ask questions they would otherwise fear would reveal inadequacy of their own knowledge. Such communication can be very valuable in learning each other's way of thinking, in finding common ground, and in identifying questions from those who need information, so that knowledge-producers can respond.

3.3 Communication and awareness raising

''Effective" climate change communication can be defined as 'any form of public engagement that actually facilitates an intended behavioural, organizational, political and social change consistent with identified mitigation or adaptation goals' (Moser 2006: 3)

Figure VII: The basic challenge of effective climate change communication



Source: Moser, 2006: 4

A few typical features of effective communication on climate change have been identified by researchers and can be used also when conveying messages on local adaptation strategies:

- 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 'people like me' have overcome." (Moser, 2010: 40)

- Messages are more exhaustive than the words or the information they convey: "Messages are accompanied by, and inseparable from, imagery, the tone of voice, and the emotions that are being evoked by pictures, symbols, color schemes, 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 being conveyed overtime, regardless of how the audience evolves in its understanding of climate change.

In order to identify success factors for communicating climate change, it is also important to be aware of the challenges that might occur and which could lead to a failure of communication.

Communication on climate change has also discovered that the mass media are no longer the most suitable communication instrument to implement change, raise awareness or reach a certain dialogue group. Simply informing and educating about climate change, as communication has focused on in the past, is no longer sufficient.

Previously, communication research had suggested that informing and educating individuals leads to action. However, this has been proven false. Recent research has shown, that the so called *"attitude – behavior gap"* shows a distinct break between individual's concern about climate change and the actual level of relevant behavior. Therefore, even if concern has been raised through providing primarily information, communication on climate change has to become more effective and not just informative and educative. In order to induce behavioral and societal change in favor of sustainable behavior and adaptation, communication is an essential tool.

In the past years, several campaigns on climate change present the issue as a major threat. The demand for a new and fairly positive vision has become very loud. New pictures of the future need to be drawn in the people's heads.

Communication has to focus to a higher extent 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 and exactly 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.

Financial constraints have been identified as one of the main barriers to adaptation (EU White Paper), since lack of funding and financial incentives can undermine the willingness of stakeholders to take adaptation action. Adaptation costs can represent a high cost for different regions, depending on the need for new infrastructure protection, the type of measures needed, or the variable degree of

vulnerability in different regions. Moreover, different regions may have a different capacity to cope with adaptation actions needed due to economic constraints.
In order to plan the amount of financial resources to be used for adaptation purposes, it can be useful to perform (at the appropriate level and making use of the estimates available at the EU and country level) an appraisal of adaptation costs for relevant policy areas in view of their inclusion in future financial decisions.

In this regard, and 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 DGs, additional needs for financial resources and staff for the implementation of the measures themselves 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. In these cases, the financial resources can derive in part from the EU mechanisms to reduce inequalities between its regions (as detailed in the EU White Paper).

3.4.2 The role of 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 alternative 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:

- Companies aim at value protection to ensure the resilience of physical assets and planning responses to maintain business as usual. Climate Change will affect the risks that companies are already facing. Therefore, companies are expected to ensure their long-term resilience, helping shareholders to understand the risk that climate change presents to their portfolios. Physical risks to fixed assets and infrastructure, impacts on supply chains, and shifting patterns in demand for goods and services could potentially also become material factors in the corporate credit risk assessment of banks.
- Climate change adaptation offers possibilities for value creation. Adaptive practices help suppliers, stakeholders, and customers adapt to a changing climate. Innovative solutions can, however, be also an important driver of future business and growth, also for the SME sector. The necessary investment in private infrastructure is expected to trigger additional investment and to create jobs. Unlocking this potential for value creation can additionally foster economic growth.

Optimising the use of insurance and other financial services and products could also be explored. It should be evaluated whether certain private actors/sectors (such as those providing public services, critical infrastructure) need to be covered by compulsory standard weather-related insurance. Insurance

and other financial products can be helpful to complement adaptation measures and play an important role as "risk sharing" instruments.
In cases where insurance is not available, for example for buildings located in flood plains, publicly supported insurance schemes may be required. Due to the cross-border effects of climate change, there may be benefits in promoting EU-wide insurance as opposed to national or regional schemes.

In any adaptation framework, consideration should be given to the role of specialized "Market Based Instruments" (MBIs) and public-private partnerships should be encouraged with a view to the sharing of investment, risk, reward and responsibilities between the public and private sector in the delivery of adaptation action. Examples of MBIs include incentive schemes for protecting ecosystem services or for projects enhancing the resilience of ecosystems and economic sectors in the form of Payments for Ecosystem Services (PES).

The possibility of using revenue generated from auctioning allowances under the Community greenhouse gas emission allowance trading system (the EU ETS) for adaptation purposes especially at the local level should be utilised. The revised Directive, governing the scheme provides that at least 50% of the revenue generated from auctioning allowances, should be used, inter alia, for adaptation in Member States and developing countries. This additional revenue will be crucial for sharing adaptation costs between the public and private sector.

3.4.3 External funding (EU and national sources)

External funding opportunities, mainly from the EU, can be a strong driver for regions to get involved in adaptation action. In countries where government budgets have been very limited in recent years, and awareness about climate impacts and adaptation needs is not very strong, it has been EU funding that has catalyzed many adaptation initiatives, including studies, pilot actions and planning efforts also for cross-border and transnational cooperation among regions.

In addition to national, regional and local level adaptation actions, countries or cities have also sought advice and support beyond their national borders by joining adaptation projects between several European countries or cities in different countries that seek to foster connections and exchange good practice between authorities, often in the frame of the EU Cohesion Policy.

Cohesion Policy is of particular relevance for regional adaptation, as many spending programmes target regions directly and are frequently prepared by regional authorities. Only if Member States include adaptation in the Cohesion Policy's regional financial instruments (e.g. Partnership Agreements and Operational Programmes) regions will be enabled to use Cohesion Policy's funds for developing and implementing adaptation measures.

In particular, cohesion policy's territorial cooperation instruments such as the Life+, ESPON and INTERREG programmes (as the ALPINE SPACE programme)have been widely used in north-west Europe and the Alps. The projects developed under these funding schemes differ in scope and focus as some of them are exclusively devoted to issues of adaptation, while others have a wider agenda in which adaptation to climate change plays an important role[17].

17 Details of transnational EU INTERREG projects are available on Climate-ADAPT at http://climate-adapt.eea.europa. eu/web/guest/transnational-regions, also the Climate Change Observatory for the Pyrenees (OPCC) provides examples of joint adaptation projects between several European countries or regions and cities in

3.4.4 EU financial instruments for adaptation

The EU finances adaptation to climate change in Europe through a range of instruments, aligned with the Europe 2020 Strategy towards smart, sustainable and inclusive growth. The Multiannual Financial Framework 2014-2020 will ensure that at least 20% of the European budget is climate-related expenditure. Other funding opportunities are provided by the European Investment Bank or the European Bank for Reconstruction and Development.

The European Social Fund (ESF) supports, among others, the shift towards a climate-resilient economy through reform of education and training systems, adaptation of skills and qualifications, up-skilling of the labor force, and the creation of new jobs.

The European Regional Development Fund (ERDF) promotes resilience to climate change and extreme weather events as well as European Territorial Cooperation (ETC), including cross-border co-operation of Member States on climate. The Common Agricultural Policy (CAP) is a core policy area of the EU aiming to ensure a fair standard of living for farmers and provide a stable and safe food supply at affordable prices. The European Agricultural Fund for Rural Development (EAFRD) supports also climate action in relation to forest area development, establishment of agro-forestry systems, investments improving the resilience and environmental value of forest ecosystems, organic farming, Natura 2000 and Water management.

Horizon 2020 will finance research and development on climate change adaptation. More than one third (35%) of its budget will address major concerns shared by all Europeans such as climate change.

The LIFE programme contributes to improving the implementation of EU environment and climate policy and legislation. The new LIFE instrument 2014-2020 will include a sub-programme focused on Climate Change and named “Climate Action”. Another major LIFE’s feature will be the "integrated projects" aimed at improving the implementation of climate policy on a larger territorial scale and to ensure coordinated mobilisation of other EU, national and private funds.

The sub-programme for Climate Action covers also 'Climate Change Adaptation' focusing on increasing resilience and 'Climate Governance and Information' on increasing awareness, communication, cooperation and dissemination on climate mitigation and adaptation. LIFE will support the development or implementation of national, regional and local adaptation strategies and lighthouse adaptation projects to address key cross-sectoral and cross-border projects, encouraging projects with a high innovation, demonstration, and transferability potential. Priority will also be given to green infrastructure and ecosystem-based approaches to adaptation, and projects aiming to promote innovative adaptation technologies and awareness raising on adaptation.

Climate adaptation is further mainstreamed into the European Union Solidarity Fund (EUSF), which responds to major natural disasters and expresses European solidarity to disaster-stricken regions in Europe.

different countries.

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.

A good starting point under the technical point of view can be the identification of common threats, based on mutual risk assessments. In policy terms, it is easier to start from those areas relevant to adaptation action in which there has been traditional trans-boundary cooperation unrelated to climate change (e.g. river basin management) involving managing authorities in the concerned countries and seek to involve them in the design of adaptation policies.

Cross-border cooperation, especially when based on large-scale activities and involving several actors, can help minimize the costs of adaptation and maximize its benefits by developing synergies in adaptation measures and integrating consequences for neighborhood jurisdictions. It is usually supported through EU funding. Mainstreaming of adaptation on EU level has facilitated policy and regulatory action on national level by incentivising the institutions to take action also through funding opportunities.

Alpine countries and regions already have experience of cross-border activities addressing climate change jointly developing adaptation responses (Alpine Space Programme). . Indirectly, adaptation already is supported by other more specific actions performed at the EU level, where policies participate in addressing some of the transboundary issues associated with climate change (e.g. Floods Directive and Water Framework Directive requiring transboundary cooperation in the water sector; European and pan-European early warning and detection systems for weather-driven natural disasters; European Flood Awareness System; European Forest Fire Information System; European Drought Observatory; EU Civil Protection Mechanism for effective prevention, preparedness and responsiveness to both natural and man-made disaster risks).

A transboundary initiative in the Alpine region is represented by the STRADA Project (Adaptation strategies to climate change for natural risk management in the transboundary Italy-Switzerland territory) that aims at developing adaptation strategies in the Italy-Switzerland transboundary territory, with the purpose of achieving a fit and sustainable spatial planning with special reference to the transboundary hydrosphere. Main fields of action include the management of water resources and hydro-geological hazards.

3.6 Ensuring stakeholder engagement

Adaptation is a process by which strategies to moderate, cope with and take advantage of the consequences of climatic events are enhanced, developed and implemented. 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.

Good governance criteria imply that it is advisable to involve stakeholders and other knowledge-bearers in the policy-drafting process. Some national examples of stakeholder engagement and management are available also in some Alpine countries, such as Germany (Rotter at al. 2013).

The term “stakeholder” in climate change studies usually refers to policy-makers, scientists, administrators, social and economic actors, communities interested or directly involved in the sectors most at risk. In this context, stakeholders can be brought together from both public and private sector to develop a joint understanding of the issues and to create adaptations. Certain variability is typical with regard to the range of stakeholders which are relevant for a peculiar adaptation strategy to be implemented in different situations or levels.

Analyzing the capacity of stakeholders to cope with and adapt to climatic events is fundamental to characterizing current and possible future vulnerability. Understanding the role of stakeholders in the decision-making process will assist in the implementation of adaptation policies. In short, stakeholders are central to the adaptation process. Among the stakeholders it is advisable to consult or actually include other or lower political levels, the private sector, the scientific community, NGOs or even the general public.

Consultation processes:

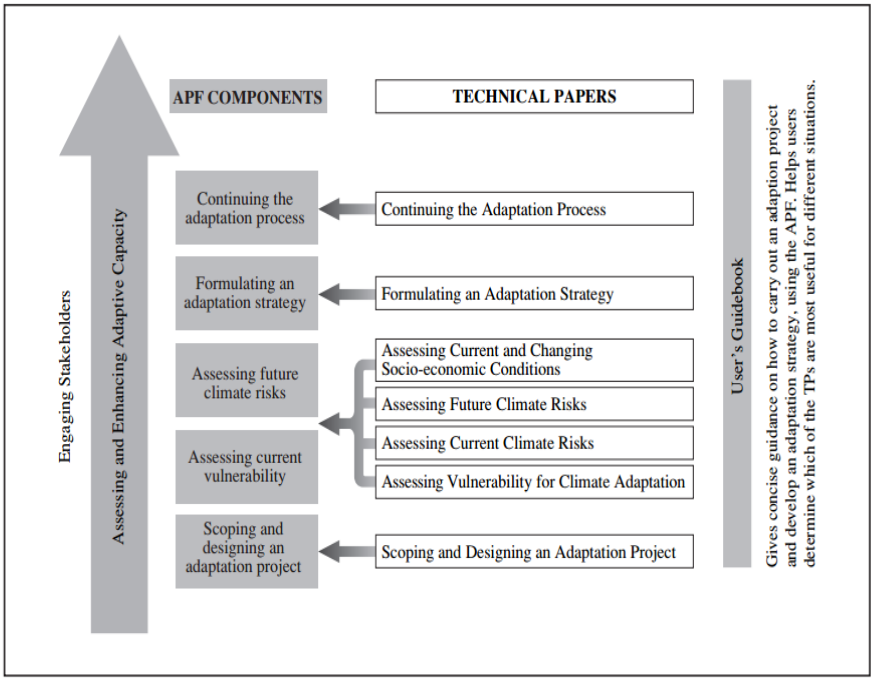
- may entail considerable extra work when feedback has to be responded to or possible changes to the plan have to be discussed and decided about;.
- are naturally time-consuming;
- allow the incorporation of additional (practical) knowledge that can increase the quality of the policy;
- highlight and delve into the values and needs of stakeholders.

The resulting policy is likely to have a higher profile, if it is publicly discussed before its official publication, since all the stakeholders (including institutions at different levels) and the civil society at large can identify with its content, and be more willing to implement the defined adaptation measures.

The involvement of stakeholders should continue along the whole adaptation process (as described under section 2, above) and across all its levels and phases.

Stakeholders have the current and past experience of coping with, and adapting to, climate variability and extremes. Their principal resource for responding to climate change impacts is 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 and experience of change and responses over time too.

Figure VIII: The Adaptation Policy Framework Process



Source: UNDP 2004

By listening to the views of others, stakeholders can build a shared understanding of the issues and decide which of the possible areas for action deserve priority. The process requires time to build trust between the groups and individuals involved, and can be empowering, as solutions are worked out collaboratively. A stakeholder process can encourage longer-term capacity development by developing pathways for coordinated action. Adaptive capacity is developed if people have time to strengthen networks, knowledge, resources and the willingness to find solutions.

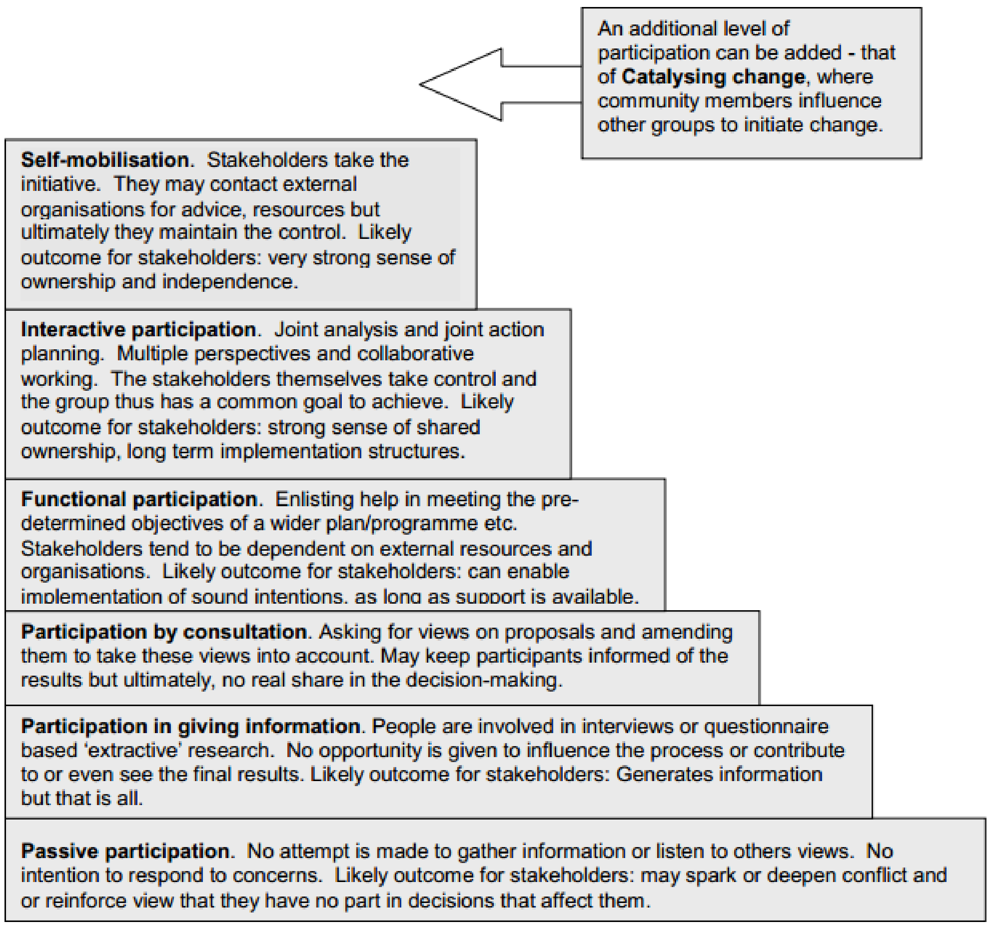
However, the process must be carefully designed and implemented in a professional manner, as stakeholder participation does not in itself guarantee equity, fairness or eventual buy-in.

Participatory processes that pay attention to good governance criteria tend to perform well and be capable of delivering benefits, such as the inclusion of stakeholder values and knowledge, and a motivating effect on implementation. Badly led, or merely pro-forma involvement processes can, by contrast, severely damage credibility and acceptance, and thus hinder policy performance.

Stakeholder engagement can be achieved by adopting a great number of approaches: there are combinations of tools and techniques well-suited to address a given situation, depending on the complexity of the issues to be discussed and the purpose of the engagement (both determined in the initial steps of the project where a careful evaluation of the time and resources available should be performed).

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). The different levels of participation can be illustrated using the "ladder of participation" outlined in the figure below.

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



Source: Conde and Lonsdale, 2005

Engagement closer to self-mobilization is not necessarily better because it is more participatory. Different levels of participation will be appropriate for different stages of the process and given the experience of the expert team that leads the process. However, the stakeholders need to understand how they are being involved, how the information they provide will be used and whether they have any power to influence decisions. Sometimes the engagement, though very participatory in itself, could not be effective because of a too constrained scope and of no opportunity for developing creative solutions.

When designing the engagement, it is also important to consider:

- The scope of the issues that stakeholders will participate in defining and solving (Thomas, 1996).
- 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.

Annex: A method for identifying and involve stakeholders in a regional adaptation process

A number of methods have been developed to identify and involve stakeholders in decision making processes. A few of them are inexpensive, but simplistic (e.g. “Snowball” consisting of asking a first group of stakeholders to identify other stakeholders on the basis of their opinion / perception), while others require a deeper degree of analysis and professionalism.

The majority of methods are based on some classification of stakeholders based on a set of *criteria* and are more suitable to address complex situations as the one of regional adaptation processes, where many actors of different types are generally to be involved.

Usually involving stakeholders is a *multi-step process* aimed at identifying a few categories of subjects that meet at least one of the following descriptions:

- *are affected by the impacts of climate change*
- *are affected by the adaptation measures implemented*
- *influence adaptation policies and measures since they are called to decide on or implement adaptation actions*
- *play a formal/informal role in the affected organisations*
- *play a formal/informal role in the hierarchy of the responsible institutions for the decisions on, or implementation of adaptation actions*
- *are actually relevant to the process of adaptation*
- *deliver concrete adaptation actions.*

The advanced techniques available rely on some recurring characteristics in adaptation policies, that have been gathered in the table that follows.

Table XII: Aspects to be considered in stakeholder identification / involvement in regional adaptation processes

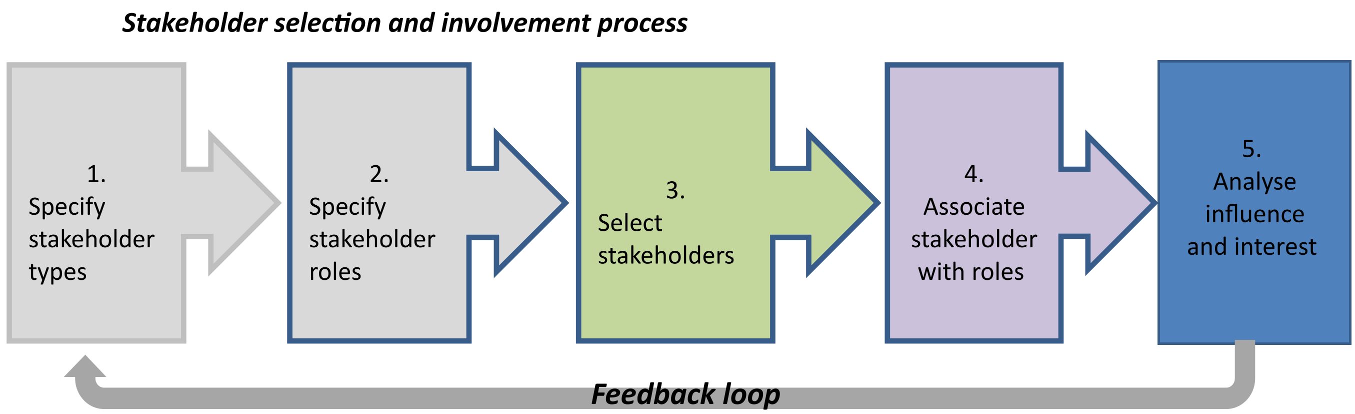
Characteristics in adaptation policies	Specifications
Dimensions	1. *Local*
	2. *Regional*
	3. *National*
	4. *Global*
Criteria	1. *Functional*
	2. *Geographical location*
	3. *Knowledge and abilities*
	4. *Hierarchical level*
Roles	Role of the stakeholder in relation to adaptation, often linked to the criteria and purpose of stakeholder identification, they may include:
	1. *Supporters*
	2. *Providers*
	3. *Disseminators*
	4. *Funders / Sponsors*
	5. *Experts*
	6. *Implementers*
	7. *Coordinators*

	8. *Responsible and/or decision makers* 9. *Regulators* 10. *Affected*
Interests	Stakeholders can bear peculiar interests in adaptation that may be affected by public policies and measures
• Influence	Sum of many different factors including: 1. *Legal hierarchy* 2. *Social status* 3. *Economic status* 4. *Political status*

Source: Ford et al. 2013

Five steps have been identified in a typical stakeholder identification process, which are presented below. There is a feedback loop to be considered that tracks back from the last steps to the preceding ones and makes a few adjustments possible across the whole process.

Figure X:.The 5 steps of a stakeholder selection and involvement process



Source: adapted from Ford et al. 2013

Step 1. Specify stakeholder types

Stakeholder types have to be identified on the basis of an inventory of subjects based on criteria. They can be then attributed to a particular geographical *dimension*, varying from local to global level. It is worth noticing how also high-level stakeholders can play a substantial role in a regional/local adaptation process due to their influence, knowledge base, political power, *de facto* influential role on large audiences. The result of this step should be a list of well-identified subjects.

Table XIII: Selection criteria for stakeholder types with actual examples and dimensions.

Selection criteria		**Selection dimension**	
Functional	Local: municipalities, water, waste, energy and housing, building	Regional: CABs, regional government and cooperative bodies,	National/global: sectoral authorities (e.g. National Board of Housing,

	and construction, companies, insurance companies, citizens	local government, federations and municipal federations	Building and Planning, MSB, National Food Administration, Board of Health and Welfare)
Geographical location	Municipalities, vulnerable groups, property owners, local business and private companies	SGI, CABs, local river groups	SGI, water authorities
Knowledge and abilities	Consultants, citizens	Trade and interest organizations, colleges and universities	SMHI, SGI, MSB, SEPA, Board of Housing, Energy Agency, Mapping, Cadastral and Land Registration Authority, etc., trade and interest organizations, colleges and universities, IPPC
Hierarchical level	Municipalities, individuals	Decision-makers, CABs etc.	The parliament and the government, national authorities, the EU

Source: Ford et al. 2013

Table XIV: Criteria for identifying stakeholder types and short description. All can be linked to a particular dimension

Criteria for selection	**Definition**	
Functional (F)	*Stakeholders formally responsible for adaptation (decision makers/implementing actors; actors affected by decisions on adaptation actions): due to their function they affect change, or are affected by the response.*	**Dimension *(Global/National/Regional/Local)***
Geographical location (G)	*Actors with no function for adaptation can become relevant because of geographical exposure to climate change (e.g. municipalities). Geographical focus can be important too (e.g. water basin authorities). They can be relevant for their adaptive capacity, that can depend on wise climate change policies but also on independent factors (socio-economic, demographic statuses, etc.)*	
Knowledge and abilities (K)	*Actors with certain knowledge and skills related to adaptation or climate change risks and system, or more general regional knowledge*	
Hierarchical level (H)	*Enables the identification of decision makers and other de facto influential stakeholders which hinder/ facilitate adaptation*	

Source: Ford et al. 2013

Step 2. Specify stakeholder roles

Adaptation demands specific roles for actors participating in the process. Theoretically each adaptation policy or action could require specific roles that are context-specific; nevertheless some standard roles exist for climate adaptation which are reported in the table below and may serve as a reference for local adaptation processes. The roles of the stakeholders can be matched with the criteria used for identifying the stakeholders. The result of this step should be a list (eventually adjusted) of standard roles for the area under inquiry.

Table XV: Standard stakeholder roles and their matching with criteria for defining their type

Stakeholder role	Example / definition	criteria
Supporters	Stakeholders who prepare and support adaptation through advice and guidance, evaluation of adaptation, etc.	F
Providers	Stakeholders who provide research, knowledge and information on climate change causes, impacts, vulnerabilities and adaptation, etc.	K
Disseminators	Those who disseminate knowledge and information	K
Funders / sponsors	Funders of adaptation measures and / or climate-related research	F
Experts	Local experts on specific local conditions, climate experts on the climate system and impacts of climate change and /or practical and technical solutions	F / K / G / H
Implementers	Stakeholders responsible for implementing, adaptation measures	F
Coordinators	Stakeholders that coordinate other actors, research or adaptation strategies in general	F / K
Responsible and / or decision-makers	Stakeholders that have an explicit responsibility for climate policies, climate adaptation or activities that are affected by climate change, such as long-term planning or sensitive sectors	F / H
Regulators	Initiators or implementers of new legislation, as well as changes in norms and standards	F / H
Affected	Stakeholders exposed and / or vulnerable to climate impacts or the responses	G / K

Source: Ford et al. 2013

Step 3. Select stakeholders

This step encompasses the assessment made in the previous ones. In particular, it is essential to make reference to a well-identified adaptation initiative, process or action.
A sample of some possible questions that can be asked as a preliminary step to the selection of the stakeholders to be involved in the participatory process is presented below.

- *Which are the main issues with the adaptation initiative under inquiry? (e.g. water related risks)*
- *Which is the geographical scope of the region where the adaptation initiative will be implemented? (e.g. administrative region, region with borders not overlapping to administrative borders, valley, etc.)*
- *Which are the responsible institutions for setting up adaptation policies and measures? (e.g. water basin authorities, regional governments, national Ministries, etc.)*

- *Which is the hierarchical position of each of the responsible or involved institutions?*
- *Which are the bodies and actors actually involved in implementing adaptation measures? (e.g. municipalities and specific departments, individual citizens, property owners, farmers, companies, etc.)*

Each question can be related to one of the criteria for identifying the stakeholder types. A cross-analysis can reveal which types are more relevant for a specific adaptation process (function, location, knowledge, hierarchy).
The result of this step should be a list of stakeholders to be considered when a particular participation process is enacted, where stakeholder types as well as roles are clearly identified.

Step 4. Associate stakeholders with roles

Once stakeholders have been selected on a regional or local basis, a correspondence can be constructed between the specific actors identified and the list of standardized roles in adaptation presented above.
Such an exercise can be performed through focus groups or brainstorming sessions. As a result it should be possible to visualize a rich quantity of information concerning the stakeholders involved in the process, in particular all the details gathered across the whole stakeholder identification process (see some examples reported in the table XVI).

Table XVI: Association of stakeholder characteristics collected through the identification / involvement process

Stakeholder name	Selection criterion	Dimension	Role
Municipality x in the region	Geographical / Hierarchical	Local	Implementer Regulator
Farmer in the region	Geographical / Functional	Local	Affected
EC- DG Climate Energy	Functional / Hierarchical	Global	Decision-maker Supporter Facilitator

Source: Ford et al. 2013

Step 5. Analyse stakeholder influence and interest.

Effective implementation of adaptation measures depends on stakeholder influence on the adaptation process and interest in seeing the adaptation in place.

Unfortunately there is no universal rule to determine the identity and real involvement of regional actors, institutions and individual subjects in the adaptation process. Nevertheless, participatory exercises (such as a brainstorming session of a core-group of stakeholders) help identify a wider group of stakeholders (often referred to as *stakeholder landscape*), their capacities and relevance for adaptation on a perceptive and knowledge-basis.

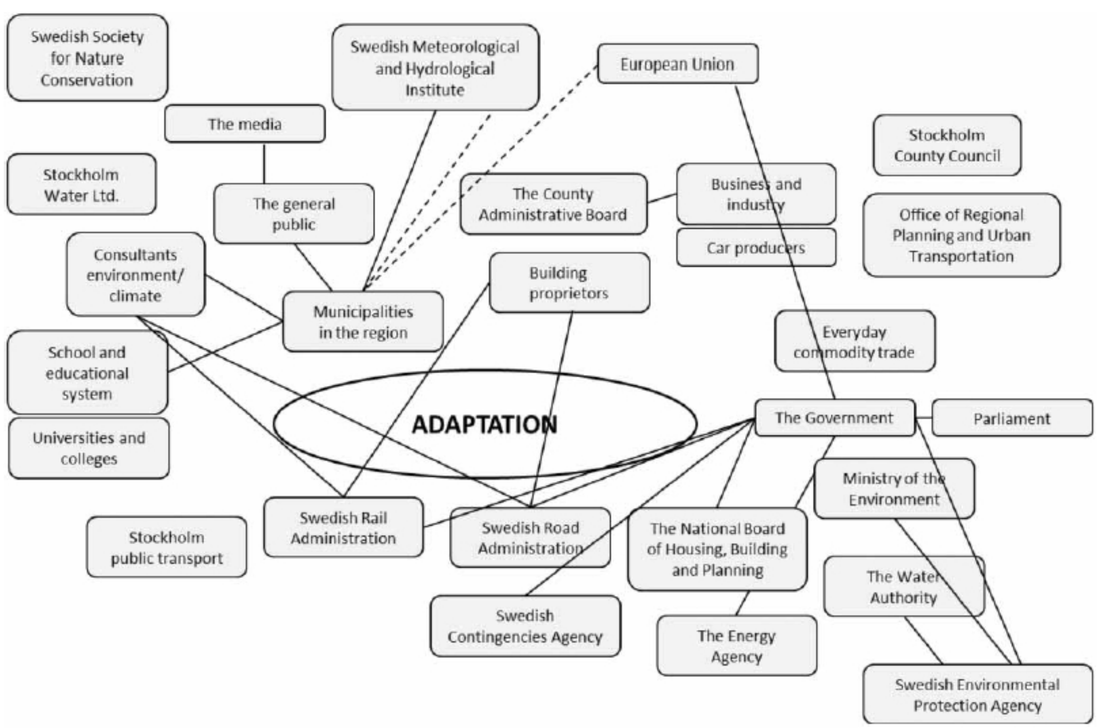
When relevance and capacities are to be assessed for specific stakeholders, it is important to consider all the dimensions of stakeholders recalled above (from local to global) since some actors can play a limited role in implementing actual adaptation measures on-site, but can exert a significant influence on the decision to enact an adaptation policy. Similarly other stakeholders can have the capacity to openly support an adaptation policy, e.g. by delivering expertise/professional services or financial resources (e.g. the EC DG Climate and Energy does not implement site-specific adaptation actions but can be very influential concerning the decision to start the implementation of an adaptation plan because of both its political influence and financial capacity). Usually the most influential stakeholders have many linkages to the other stakeholders included in the resulting stakeholder map (see an example below).

A relevant stakeholder within an adaptation process will:

- Be classified as of a certain *type* out of the four available criteria (some types are likely to statistically prevail over the other possible ones)
- Be characterized by a certain *influence* on a set of other stakeholders (the number as well as the intensity of a stakeholder's relationships matter)
- Hold a specific *interest* in the adaptation process, an adaptation measures

Since a specific focus on relationships among stakeholders was not considered in the previous steps, new entities are likely to be identified on the basis of local or regional knowledge and experience, and the resulting *stakeholder landscape* will be enlarged.

Figure XI: Graphical representation of a stakeholder landscape and mutual linkages



Source: Ford et al. 2013

Recommendations and limits of the approach

Mapping and involving stakeholders in participatory processes in the field of adaptation to climate change shows a few peculiar features that deserve to be singled out:

1. Due to its regional dimension, adaptation is the result of a set of different policies and measures and involves stakeholders from many organisations dispersed on a region;
2. The region where adaptation policies and measures will be applied needs to be well-defined taking note of a set of criteria including physical, cultural, social and economic aspects as well as stakeholder perceptions on regional boundaries being relevant for adaptation purposes;
3. Adaptation is a long-term process where changes may arise in the stakeholder landscape, roles and responsibilities, thus the composition of the stakeholder landscape needs to be revisited throughout the process;
4. Adaptation / resilience can be achieved through different methods and with different engagement of stakeholders (adaptive capacity can be unevenly distributed among stakeholders within a region);
5. Action on adaptation often depends on the perception of the impacts of climate change combined with other factors by the actors to be involved;
6. Adaptation takes place to a large extent at the private / individual level and it is implemented by actors often not present in the formal policy process wherein they should be involved. Therefore, these actors may be unknown to decision makers promoting adaptation policies and measures (often adaptation focuses on institutional – administrative stakeholders);
7. Biased selection of participants in the adaptation process is possible as a result of lack of motivation, time and resources of the selected stakeholders: dissemination of climate change adaptation knowledge, supply of reasons for motivation in the first steps of the process and transparency on the selection process can alleviate the problem.

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”.

In order to have a case of *maladaptation*, an ineffective policy addressing adaptation issues is thus needed. Therefore maladaptation basically 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 (typically also actions increasing emissions or creating damages in sectors independently from any climate-related considerations are classified as maladaptive, as the list reported below should clarify).

The main problem with the failures classified as maladaptation is that it is complex to predict the nature and timing of the inaccuracy that tend to vary according to a case by case logic. However, a few common causes of maladaptation have been broadly identified in two categories of issues.

1. Some actions that may benefit a particular group, or sector, at a particular time may prove to be maladaptive to those same groups or sectors in future climates or to other groups or sectors in existing climates.

2. The presence and complexity of multiple interactions and feedbacks between systems and sectors can be difficult to account for, and may lead to collect inadequate or inaccurate information for developing effective adaptive responses and strategies, that risk to be maladaptive (Scheraga et al. 2003; Satterthwaite et al., 2009; Pittock, 2011).

In practice, several actions can be classified as maladaptation – namely actions that, relative to more suitable alternatives:

- *Increase emissions of greenhouse gases:* the best known example is the increased use of air conditioners in response to the health impacts of heat-waves. The problem with energy-intensive adaptation actions is that, while solving current needs, they create a positive feedback by increasing emissions of greenhouse gases, thereby increasing the extent and costs of further adaptation actions required in the future.

- *Disproportionately burden the most vulnerable people:* adaptation actions are maladaptive if, in meeting the needs of one sector or group, they increase the vulnerability of those most at risk, such as minority groups or low-income households. Some idea of justice is certainly needed in order to determine the most deserving or affected groups within a population, as well as when a burden is to be seen as “disproportionate”: many criteria can be applied to make such an evaluation.

- *Have higher opportunity costs:* approaches may be maladaptive if their economic, social, or environmental costs are high relative to alternatives. The use of the techniques for assessing costs and benefits of adaptation actions can help understand the impact of each alternative and reduce the risk of incurring in maladaptation. Certainly identifying alternatives and their costs results in an additional burden to policy makers and independent adapters.

- *Reduce incentives to adapt:* if adaptation actions reduce incentives to adapt, for example by encouraging unnecessary dependence on others, stimulating rent-seeking behaviour, or penalising early actors, then such actions are maladaptive. Giving citizens too much a sense of safety may dramatically reduce their awareness and willingness to adapt, inducing maladaptation.

- *Set paths that limit the choices available to future generations:* a major issue typically found with large infrastructural developments is the way they commit capital and institutions to trajectories that are difficult to change in the future. Whilst in the past large infrastructure projects may have had some success, in the future such path-dependent responses may lead to decreased flexibility to respond to unforeseen changes in climatic, environmental, economic and social conditions. At least in extreme cases, heavy infrastructural investments should be treated as sunk costs – i.e. retrospective costs that have already been incurred and cannot be recovered.

- *Transfer vulnerability to a neighboring area or country:* sometimes vulnerability is reduced by taking improper action that simply transfers the risk to a neighbor. In this case globally, the overall risk has not been reduced, but simply transferred from a place to another. For instance, in case of lack of water resources, using water from a basin that is flowing to different valleys located in more countries or regions may reduce water availability in the other locations served by the same basin. Such a practice can affect the quality of international relations among countries or regions. The ideal case presented shows the need to establish lasting cooperations in the field of management of environmental and natural resources especially when confronted with pure public, or quasi-public goods[18]

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. Conflicts and tensions between different policy areas can be a major cause of maladaptation. Sometimes people and decision makers can be aware of a climate related risk, nevertheless they can be willing to take that risk (or they may have limited choice) given their current circumstances – where the need for economic growth can be felt as a priority (IPCC SREX 2012, section 4.2.2).
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.

Unfortunately there is no universal method to avoid maladaptation, especially because knowledge about the consequences of measures is often uncertain (especially in the long run). Each decision on adaptation needs to be addressed "*per se*". However, the five fallacies identified above, together with the methodologies for prioritizing adaptation options can provide some guidance on how to minimize the risk of incurring in maladaptation episodes.

18 In economics, "pure public goods" are goods that are perfectly non-rivalrous in consumption and non-excludable. Only few goods meet both of these requirements. Examples of pure public goods include flood control systems, street lighting and national defence. For instance, a flood control system cannot be confined to those who have paid for the service. Impure or quasi-public goods are goods that satisfy the two public good conditions (non-rival and non-excludable) to some extent, but not fully.

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Glossary

Glossary

Term	Definition
Adaptation	The IPCC defines adaptation as 'adjustment in natural or human systems in response to actual or expected climatic stimuli or their effects, which moderates harm or exploits beneficial opportunities.' Adaptation can also be thought of as the on-going process of managing changing climate risks.
Adaptation options	Adaptation options are concrete ways in which programmes and projects can build in resilience to climate change. Some options directly target climate change adaptation, some are management actions with adaptation as a complementary or side-objective.
Adaptive capacity	The ability of a system to adjust to climate change (including climate variability and extremes), to moderate potential damages, to take advantage of opportunities, or to cope with the consequences.
Climate	Usually defined as the 'average weather', or more rigorously, as the statistical description in terms of the mean and variability of relevant quantities over a period of time. These quantities are most often surface variables such as temperature, precipitation, and wind.
Climate change	The IPCC defines this generally as '...any change in climate over time, whether due to natural variability or as a result of human activity.' This usage differs from that in the United Nations Framework Convention on Climate Change (UNFCCC), which defines 'climate change' specifically in relation to human influence as: 'a change of climate which is attributed directly or indirectly to human activity that alters the composition of the global atmosphere and which is in addition to natural climate variability observed over comparable time periods'.
Climate proofing	In contrast to mainstreaming, climate proofing refers to the process of cross-checking that all elements of a programme and its implementation, including specific measures and projects, address climate change issues. This involves ensuring that: - Funding is resilient to future climate impacts; and - The carbon intensity of funding is reduced to the extent possible.
Mainstreaming	Mainstreaming of climate change adaptation focuses on the integration of climate concerns and responses into relevant policies, plans and programmes at different levels of governance.
Maladaptation	Planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long term.
Sensitivity	The degree to which a system, receptor or exposure unit would be affected, either adversely or beneficially, by a particular change in climate or climate-related variable.
Vulnerability	The extent to which a system is susceptible to, or unable to cope with, adverse effects of climate change, including climate variability and extremes. It depends not only on a system's sensitivity but also on its adaptive capacity.

Source: Glossary from EC (2013), Study of Adaptation Activities at Regional Level in the EU