Alpine strategy for adaptation to climate change in the field of natural hazards

Developed by the Platform on Natural Hazards of the Alpine Convention PLANALP

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Authors

Platform on Natural Hazards of the Alpine Convention:
Thomas Probst (Switzerland)
Wanda Wicki (Switzerland)
Andreas Zischg (Italy)
Andreas Pichler (Austria)

Good Practice Examples:
Austria: Rudolf Hornich, Maria Patek
France: François Gillet, Cécile Rousseau
Germany: Erich Eichenseer, Andreas Rimböck
Italy: Andrea Bianchini, Gianluigi Giannella, Eutizio Vittori
Liechtenstein: Stephan Wohlwend
Slovenia: Jože Papež, Milica Slokar
Switzerland: Andreas Götz, Claudia Guggisberg
Transnational: Thomas Probst, Cécile Rousseau, Andreas Zischg

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National Platform on Natural Hazard
planat@bafu.admin.ch
www.planat.ch > Infomaterial

Permanent Secretariat of the Alpine Convention
info@alpconv.org
www.alpconv.org

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Foreword

Avalanches, rockfall and floods have occurred in the alpine space since time immemorial. Many efforts have been made in the past to protect people and infrastructure there from natural disasters. However, with rising temperatures, shrinking glaciers and melting permafrost, we must anticipate the exacerbation of existing risks and emergence of new ones, such as glacial lake outburst floods. Even if we intensify the national and international commitments to the reduction of greenhouse gas emissions, the climate is already changing and the scenarios predict even greater alterations.

Adaptation to the impacts of climate change is, therefore, a new but common challenge for all countries in the alpine space, and being prepared for the avoidance and reduction of future risks is gaining in significance in terms of sustainable development. The fact that climate change does not stop at national borders makes international cooperation essential, especially in relation to natural hazards in the Alps.

With this document, the Platform on Natural Hazards of the Alpine Convention (PLANALP), which has been successfully promoting integrated risk management since 2004, provides the first alpine-wide framework for climate change adaptation in the field of natural hazards. The strategic goals and recommendations follow an integrated, foresight-based and participatory approach and lay the foundations for efficient risk management solutions under changing climate conditions. The first steps in the implementation of these goals have already been taken and are illustrated using good practice examples from the alpine countries. These measures highlight the potential synergies of the cross-border exchange.

I would like to thank PLANALP for this essential contribution to climate change adaptation in the alpine space and to the cooperation between the alpine countries in the field of natural hazards and risk management. Given that the process of adaptation to climate change is still in its early stages, I would also like to encourage all of the involved actors to intensify the dialogue so as to pave the way for a climate-proof future for the Alps.

Doris Leuthard
Federal Councillor, Head of the Federal Department of the Environment, Transport, Energy and Communications (Switzerland)

Preamble

Platform on Natural Hazards of the Alpine Convention PLANALP

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 VIIIth Alpine Conference in 2004.

PLANALP's mandate covers both the formulation of strategic concepts for integrated natural hazard and risk management and the coordinated implementation of subsequent measures. Within this framework, PLANALP develops approaches for the integrated reduction of natural hazards, identifies best practice and intensifies the cross-border exchange of knowledge and experience. It cooperates closely with the relevant international and national institutions in the fields involved.

Since its establishment, the chair of PLANALP has been held by Switzerland. An administrative secretariat, affiliated to the Swiss National Platform for Natural Hazards (PLANAT) and hosted by the Swiss Federal Office for the Environment (FOEN), provides assistance and support to PLANALP.

The Alps are particularly vulnerable to climate change. Increasing temperatures and changing precipitation patterns are expected to impact on the alpine environment, economy and society in various ways. In order to enable the sustainable development of the alpine space in the context of climate change, both mitigation and adaptation efforts are required.

To this end, the contracting parties of the Alpine Convention adopted the action plan on climate change in the Alps at the Xth Alpine Conference in Evian, France in 2009. The action plan aims to make the Alps an exemplary territory for both the reduction of greenhouse gas emissions and adaptation to the impacts of climate change on water resources and biodiversity, mountain forests and farming, tourism, settlements and infrastructure.

One of the most noticeable and threatening consequences of climate change in the Alps is the amplification of natural hazard potential. Hence, the XIth Alpine Conference in Brdo, Slovenia in March 2011 commissioned the Platform on Natural Hazards PLANALP (see left) with the development of a specific adaptation strategy for the alpine space.

With this document, PLANALP fulfils this mandate and presents the 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, which are illustrated by good practice examples from the alpine countries.

The strategy establishes the framework for future cooperation and coordination between the alpine countries in terms of adapting natural hazard and risk management to changing climatic conditions. Moreover, it contributes substantially to the implementation of the action plan on climate change in the Alps. With its clear focus on natural hazards, however, by its very nature, the strategy can only cover one of many fields affected by climate change.

Background: Climate change, natural hazards and adaptation in the alpine space

The climate is changing – particularly in the Alps

The global and regional climate has a strong dynamic component and has always undergone change for natural reasons. Adapting to these changes is an ongoing challenge for any society. However, the 4th Assessment Report of the Intergovernmental Panel on Climate Change (IPCC 2007) showed that, nowadays, substantial change is being caused by anthropogenic greenhouse gas emissions and the subsequent man-made global warming. It is anticipated that correlated adverse effects will impact on our societies and environment far faster than former natural climate variability.

Figure 1 – Expected mean temperature changes (°C) in winter (December-February) and summer (June-August) for the period 2071-2100 relative to 1971-2000. Climate projections based on a multi-model ensemble with the medium emission scenario A1B; "low / central / high estimate" = 10% percentile / median / 90% percentile. (Krahe & Nilson 2011, Nilson et al. 2012)

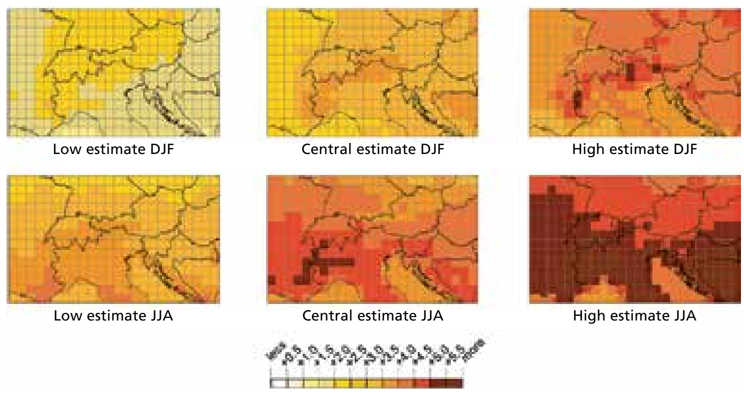
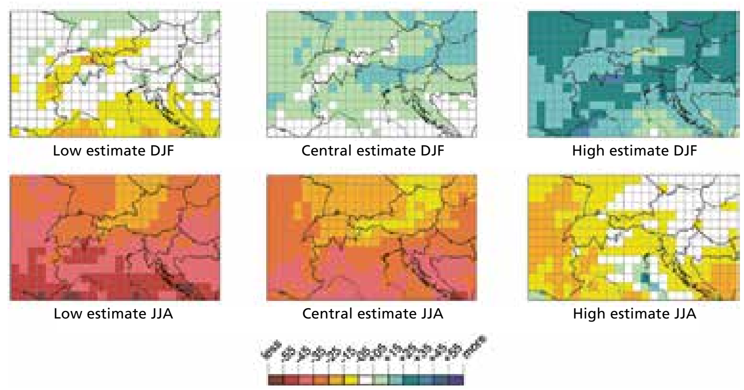


Figure 2 – Expected changes in mean seasonal precipitation (%) in winter (December-February) and summer (June-August) for the period 2071-2100 relative to 1971-2000. Climate projections based on a multi-model ensemble with the medium emission scenario A1B; "low / central / high estimate" = 10% percentile / median / 90% percentile. (Krahe & Nilson 2011, Nilson et al. 2012)



The alpine space faced an exceptionally high temperature increase of approximately 2°C between the late 19th and early 21st centuries. This is more than twice the average warming rate of the northern hemisphere. The development of precipitation has been less homogeneous; however a slight trend towards increasing precipitation in the northern alpine region and a decrease in the south has been recorded (EEA 2009). Some climate change impacts are already being clearly observed, such as distribution shifts in plant species, changes in the hydrological cycle, permafrost thawing, and glacier retreat (e.g. Korck et al. 2011, EEA 2009, KLIWA 2009, BMU 2008, OcCC / ProClim 2007, Lebensministerium 2006, Mair et al. 2011).

Climate change scenarios expect further pronounced warming as well as a change in precipitation patterns. An ensemble of 14 selected regional climate models compared by the EU project AdaptAlp (Adaptation to climate change in the alpine space) on the basis of a "medium" greenhouse gas emission scenario ("A1B"), shows a temperature increase of approximately 1.5°C by 2050 and 3.5°C by 2100 (compared with average for 1971-2000, central estimates). Towards the end of the 21st century, the central estimates for mean precipitation show an increase in the order of 15% in winter (up to 25% in some areas of the Central Alps) and a decrease of around 15% in summer (up to 45% in some mediterranean regions; Krahe & Nilson 2011, Nilson et al. 2012). Even if the general trends are undisputed, the range of possible developments for different emission scenarios, regional variations (Figure 1, Figure 2, Annex) and underlying modelling uncertainties must be taken into account.

Due to the variety and severity of the potential adverse impacts, the EU White Paper on Adaptation names mountain areas and, in particular, the Alps as among the areas most vulnerable to climate change in Europe (EC 2009). Natural hazards play an outstanding role in this context: the OECD identified the increasing exposure of settlements and infrastructure to natural hazards as the primary source of vulnerability along with increasing losses in winter tourism due to reduced snow cover (OECD 2007).

Expected impacts on natural hazards

There is consensus among scientists that continued climate change will alter the natural hazard patterns in the alpine space. 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; some places could even benefit from favourable potential, such as the expansion of forests with protective functions, in the long run.

Due to this complex heterogeneity and due to current technical and scientific limitations (e.g. uncertainties in climate models and knowledge gaps concerning impacts and vulnerability), the generalisation and simplification of the effects of climate change on natural hazards over large areas or even the entire alpine space is not appropriate and must be avoided in order to prevent the drawing of unsuitable conclusions for risk management.

This document focuses on alpine natural hazards particularly influenced by meteorology, i.e. floods, debris flows, landslides, rockfalls and avalanches (as these are the hazards that PLANALP deals with), and forest fires, which also pose an increasing threat. For these hazards, the following general trends can be probably attributed to climate change – with the aforementioned limitations and the possibility of diverging situations at local level to be taken into account (ClimChAlp Partnership 2008, if not indicated differently):

Floods: An increase in the intensity and frequency of floods has been detected in some regions of the Alps. An increase in winter floods and summer low waters is expected in future, as well as an earlier flood peak due to snow melting.

Debris flows: In recent years, debris flows have tended to originate at higher altitudes in some parts of the Alps and a decrease has been observed in some medium altitude areas. The increase in the amount of material available close to glaciers and the evolution of heavy precipitation patterns could, in turn, prompt local increases in the evolution of debris flow activity.

Glacial hazards: Loss of stability of the hanging glaciers and the increase in the number and size of glacial lakes as a consequence of glacier retreat and ice temperature rise appear to be the two main consequences of climate change in the context of glacial hazards. The risk of outburst floods arises not only from glacial lakes but also from emerging intraglacial cavities filled with water (Vincent et al. 2010).

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.

Forest fires: More frequent and intense heat waves and droughts will mean a further increase in the probability of forest fires. This must be expected not only for forests on the southern side of the Alps and in dry valleys, but also as a new phenomenon also on the northern side (OcCC / ProClim 2007).

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.

Consequences for risk management

Because of the continuous changes in our natural, societal and economic systems, future-oriented and sustainable natural hazard and risk management needs permanent adjustment. Because it has always been and will always be sensitive to a wide range of natural hazards, keeping all actors up-to-date in the methods for adapting risk management practice to new requirements is a key task in the alpine space, in particular.

Disastrous natural events are common phenomena in the Alps which make people and societies repeatedly aware that they must live with the associated risks. The devastating floods, storms, avalanches and mass movements of recent decades have prompted a shift towards "living with natural hazards and risks" and resulted in the emergence of the concept of integrated risk management in dealing with natural hazards in a wider sense (see Figure 3). This concept is based on the holistic understanding and consideration of the risks posed by natural hazards and incorporates risk analysis, risk evaluation and risk reduction, and risk management in a narrower sense.

Integrated risk management incorporates all measures that contribute to the reduction of damage caused by natural hazards (Korck et al. 2011). The idea of "living with risks" is also reflected today in life-cycle based protection strategies and in the adoption of precaution principles in natural hazard management through the consideration of social responsibility, the investment in education approaches and the further harmonisation of technical standards and codes.

However, recent years have repeatedly witnessed natural disasters throughout the Alps, e.g. the catastrophic floods of 1999, 2002, 2005, 2007 and 2010 and the exceptional avalanche winter of 1999, which caused enormous damage and losses in some areas. Even if the contribution of climate change to these events is rather unclear in many cases, it must be assumed that the intensity and frequency of extreme events and natural hazards is likely to increase in future. However, due to the technical limitations in climate change modelling, the lack of regional / local scenarios and the resulting uncertainties in relation to impact assessment, it is impossible to predict the concrete consequences for the local level in detail at present.

Hence, taking climate change and the uncertainties about extreme events into account in hazard and risk management is a challenging task – not only for practitioners and researchers, but also for policy and decision makers. This situation is not facilitated by the fact that the alpine countries have different safety levels and concepts in place, which are implied in protection strategies and influence the preferred adaptation options.

Thus, the adaptation measures already being implemented today are restricted to noticeable impacts triggered by increasing temperatures, i.e. glacier hazards (e.g. glacier lake outburst floods) and permafrost degradation (e.g. accelerated rockfall activities). However, these few examples can only be found in the highest regions of the Alps, which are most sensitive to warming (Mair et al. 2011, Greminger & Zischg 2011).

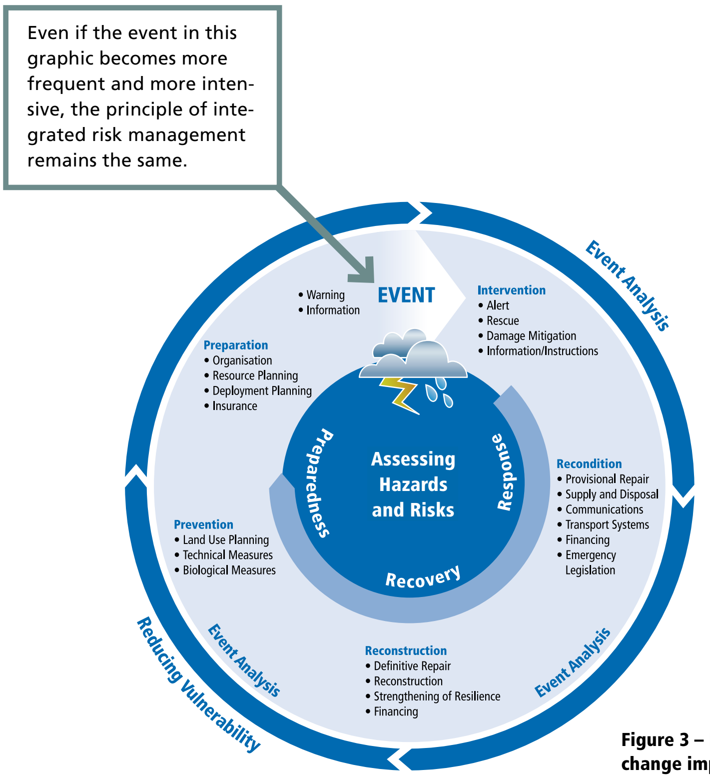


Figure 3 – Integrated risk management cycle taking climate change impacts into account. (Greminger & Zischg 2011)

From awareness to action: Adaptation strategies in the alpine countries

Owing to the well documented evidence of and increasing concern about climate change in recent years, there is now greater public awareness of the need for a collective and cooperative effort to reduce greenhouse gas emissions. However, even significant action cannot prevent but only mitigate the effects of climate change effects. Adaptation to the inevitable impacts is, therefore, vital. This is particularly true for the highly sensitive and vulnerable alpine space. Hence, the Alpine Convention's action plan on climate change in the Alps, which was adopted in 2009, is dedicated to both climate change mitigation and adaptation.

In order to meet the new challenges arising as a result of climate change, the alpine countries have started to initiate comprehensive National Adaptation Strategies (see Table 1). Natural hazards play an important role in these strategies. France and Germany adopted their strategies in 2006 and 2008 and have already created action plans for the implementation of concrete adaptation action. The other alpine countries are well on their way to the implementation of national adaptation strategies. In addition to national strategies, some regions already finalised or are in the course of developing adaptation strategies at province, federal state (Bundesland) and cantonal level.

The development of adaptation strategies depends on the nature and magnitude of observed and expected impacts, the assessment of current and future vulnerability, and the capacity for adaptation in the different countries. The states are adopting diverse approaches, which reflect their political and cultural framework conditions, their appraisals of the risks posed by climate change, and their ideas in relation to the key questions of how to finance adaptation and how to allocate responsibilities in an adequate vertical and horizontal manner.

Both the national and regional adaptation strategies adopt a cross-sectoral approach and cover a variety of fields affected by climate change. Hence, although the issue of natural hazards is only one of many areas dealt with in the strategies, it is, nonetheless, a vital one. The natural hazard content of the strategies is focused on improving the capacity to prepare and respond to climate-change-related hazards and on managing climate-change-related risks. By and large, they follow the guiding principles of sustainability, flexibility, robustness, precaution, subsidiarity, proportionality and integration, focus on no-regret and "co-benefit" options, and share common basic objectives, such as providing a basis for decision making on all levels and across all relevant sectors and creating and raising the awareness of stakeholders.

Table 1 – Overview of adaptation strategies across the alpine space.

State	National adaptation strategy	Action Plan	Natural hazards key sector?	Regional adaptation strategies [1]
Austria	expected 2012	expected 2012	yes	not yet predictable
France	2006	2011	yes	Rhône-Alpes and Provence-Alpes-Côte d'Azur expected 2012
Germany	2008	2011	partly	Bavaria (2009)
Italy	expected 2013	Action Plans against desertification, droughts and forest fires and for irrigation, health and water resources management	yes	[2]
Liechtenstein	-	-	-	-
Slovenia	expected 2012 [3]	expected 2013	partly [3]	not yet predictable
Switzerland	2012	expected 2013	yes	Uri (2011)

Note: All available documents are listed in the references. The scenarios used for the adaptation strategies are shown in the annex (page 20).

[1] Within the perimeter of the Alpine Convention.

[2] No regional adaptation strategies but consideration of climate change in rural development plans and river basin management plans possible.

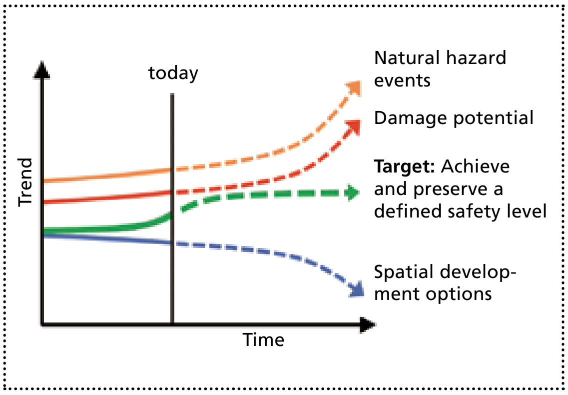
[3] The "Strategy for the transition of Slovenia to a low carbon society by 2050" (expected 2012) also covers aspects of adaptation and, in this context also, adaptation in the area of natural hazards. Further relevant documents in the context of climate change and natural hazards are the Resolution on the National Security Strategy of the Republic of Slovenia, the Resolution on the National Programme of Protection against Natural and other Disasters and the corresponding Plan of Implementation.

Goals for risk management in the Alps under changing climatic conditions

The alpine space has been prone to natural hazards since time immemorial. Despite enduring efforts and extensive public investments by alpine countries in reducing the region's susceptibility to natural hazards, the human and economic losses caused by disasters have grown significantly in recent decades. In this context, climate change and the related increase in natural hazard frequency and intensity is one of many factors. Another factor that is growing in significance is the continuous decline in the availability of spatial development options, which leads to the spatial concentration of settlements and infrastructure – often in endangered areas. Taking into account that economic development, regional growth and social welfare depend crucially on the level of safety from natural hazards, these trends and, their combination in particular, limit the attractiveness and competitiveness of the alpine space.

Thus, safety can be understood as a fundamental precondition for the sustainable development of the alpine space. 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 (see Figure 4). To this end, the integrated natural hazard approach to risk management is the most appropriate, and its elements do not change even when the worst case climate change scenarios are taken into account. Integrated risk management must also consider climate-proof solutions that at least maintain the current level of safety and, where necessary, simultaneously reduce residual risk with the help of new organisational, planning and construction measures. As a part of this process, even more attention must be paid to "imagining the unthinkable" (PLANAT / PLANALP 2010).

Figure 4 – Adaptation goal for the alpine space. (PLANAT)



Recommendations for integrated climate-proof risk management and good practice examples

Natural hazard and risk management in the alpine space faces manifold challenges posed by climate change. The goal of adequate safety levels in the alpine countries under changing climate conditions calls for integrated and climate-proof risk management, which fully exploits the potential of prevention, preparation, intervention, reconditioning and reconstruction in a sustainable and coordinated way. The need for action is a given for policy, administration, practice and research, and for all territorial levels from transnational to local.

The following sub-chapters describe **ten recommendations** for integrated climate-proof risk management in the alpine space:

- Prepare for emergency intervention
- Review the climate change fitness of existing structural protection measures
- Set up and optimise long-term monitoring and warning
- Anticipate and deal with new risks
- Adapt hazard and risk mapping to a changing climate
- Enhance coordination between spatial planning and risk management
- Establish a risk culture and initiate risk dialogue
- Strengthen individual preparedness and precaution
- Improve the knowledge base and transfer to practice
- Maintain and improve the functionality of protection forests

Specific aspects of these recommendations are illustrated by good practice examples from the alpine countries.

Prepare for emergency intervention

In order to prepare for, cope with and recover from natural disasters, the skills, processes and resources required by public and private civil protection organisations must be strengthened. It is particularly necessary to prepare adequate emergency management plans and to train emergency and rescue services. Furthermore, the population must also be sensitised to emergencies and interventions.

EXERCISE DIKE (GERMANY)

Background. Former flood events showed how important it is to have well-trained personnel to defend protective structures during a hazard event. The help of numerous other actors is also required. Such help is even more effective, if the actors in question are familiar with the tasks involved and have an idea of the overall context of their work. Mistakes can cause serious consequences as can dike failures, which must also be avoided in the special situation that arises during a hazard event.

Implementation. Around 42'000 inhabitants live within the flood-risk area in the lower Mangfall valley. The damage potential exceeds EUR 1 billion. A major sustainable protection master plan was developed for the management of the risks involved. In addition to technical flood protection and flood retention in plains, further precautions are inevitable. In this context the State Office for Water Management Rosenheim constructed an exercise dike at the drill ground of the local fire brigade to facilitate practical training. Realistic damage could be simulated through the use of adjustable water pipes. The relief units receive instruction on identifying situations, assessing them properly and making use of the necessary auxiliary material. In the course of these exercises the experts from the water resources administration cooperate with the commandants of the fire brigades, who can then use the facilities with their teams.

www.wwa-ro.bayern.de

Figure 5 – Dyke defence: Exercise course on the fire brigade training ground in Rosenheim. (State Office for Water Management Rosenheim)

Review the climate change fitness of existing structural protection measures

Numerous natural hazard protection structures have been constructed in the alpine countries in recent decades. In order to maintain the safety levels achieved so far, the availability of up-to-date information about the condition of these structures and their functionality and operability under changing climate conditions is essential. Thus, the status of structural protection measures must be reviewed critically as a basis for maintenance and reconstruction concepts.

WLK.DIGITAL: THE AUSTRIAN TORRENT AND AVALANCHE CADASTRE (AUSTRIA)

Background. A lot of structures providing protection against natural hazards have been built in the Austrian Alps since the 19th century. Once completed, these structures are generally subject to extreme environmental conditions and loads, hence the rate of ageing and wear is high and the life-time of the structures is limited. The anticipated impacts of climate change are likely to amplify the current pressure on protective structures. In order to obtain and share up-to-date information about the condition of these structures, their functionality and operability, the digital Austrian Torrent and Avalanche Cadastre (WLK.digital) has been extended to become a register of countermeasures.

Implementation. The Austrian Forest Technical Service of Torrent and Avalanche Control's "WLK.digital" system is a GIS and web-based nationwide information tool that includes data and basic information essential for the planning, implementation and maintenance of hazard protection structures. By incorporating a spatially-referenced register of countermeasures, the results of the periodic monitoring of protection works, e.g. control minutes, damage catalogues, or functionality assessments, can be used for maintenance and inspection planning with a view to attaining precise and efficient maintenance management and optimising life-cycle costs. This tool supports not only the Austrian Forest Technical Service of Torrent and Avalanche Control but also facilitates information exchange with the municipalities, authorities and organisations responsible for emergency planning, for example.

www.lebensministerium.at > Forst > Schutz vor Naturgefahren > Wildbach- und Lawinenverbauung

CONSISTENT CONSIDERATION OF EXCESS LOAD FOR FLOOD PROTECTION MEASURES (LIECHTENSTEIN)

Background. The more frequent and heavier precipitation to be expected as a result of climate change is likely to result in the exceeding of the load capacity of flood protection structures becoming a more common event. If the possibility of excess load was not taken into account in the design and construction of such structures, this may give rise to multiple risks. For this reason, overload is consistently taken into account in all new or renovated flood protection measures recently carried out in Liechtenstein.

Implementation. All slope watercourses in the Rhine valley are drained by the Liechtenstein inland canal and the water is transported by the canal through the entire country. The already insufficient drainage capacity of the inland canal and the expected increase in extreme events as a result of climate change necessitated the creation of retention areas to accommodate the peak discharge. One of these new retention basis consists of a controlled outlet structure. In the case of insufficient capacity in the retention basin and the outlet structure, spillway edges were created in an area of the dyke with a lower height. These prevent a dyke burst in the event of the flooding of the dyke and hence the increased flood risk to the downstream settlement area. The consistent consideration of the case of excess load, which only involves minimal additional costs, in all newly constructed and renovated flood protection structures in Liechtenstein significantly reduces the risk of flooding.

Figure 6 – Detail of WLK.digital, showing the location of different protection measures (e.g. retention basins, countermeasures, avalanche protection, forest-ecological measures etc.) in the central Tyrolean region. (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft)

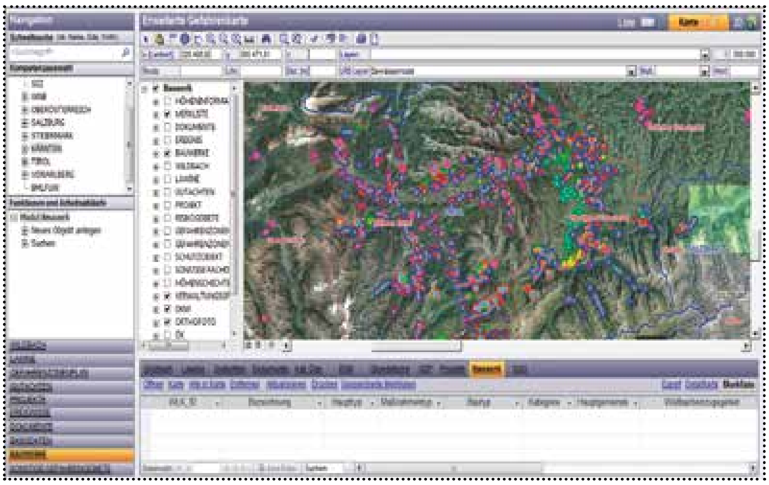


Figure 7 – Säga retention basin with controlled outlet structure and provision for the case of excess load for the controlled flooding of the dyke. (Amt für Wald, Natur und Landschaft)

Set up and optimise long-term monitoring and warning

With regard to climate change, the disposition for natural hazard processes is not only influenced directly by increasing temperatures and changing precipitation patterns, but also by subsequent alterations of environmental parameters such as the altitudinal shift of temperature regimes. As such modifications extend over longer time periods, they are scarcely – or not at all – perceptible. Hence, it is indispensable that we monitor natural hazard processes permanently, identify areas with increasing risks and install or improve warning systems. This provides also the basis for planning and emergency preparedness.

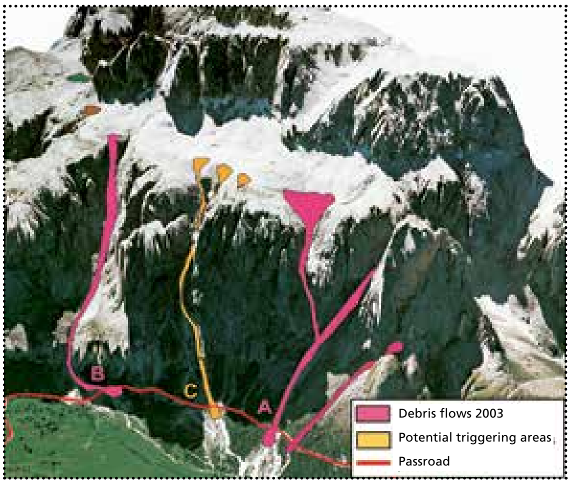
INSTALLATION OF A MONITORING SYSTEM FOR EARLY RECOGNITION OF PERMAFROST-RELATED HAZARDS (ITALY)

Background. Climate change alters the thermal regime of mountain permafrost. Depending on the local situation, this can result in the increasing flow velocity of rockglaciers, the destabilisation of rockwalls and frozen slopes, slope movements, increasing rockfall frequency and soil subsidence processes. The changes in permafrost conditions occur over a long period and are spatially variable. It is important to know the locations, in which melting permafrost increases existing risks or where new risk can arise.

Implementation. These demands can only be met by combining different approaches. In 2005, the autonomous province of Bolzano started to monitor the impact of environmental changes on mountain permafrost areas systematically, and developed an information basis for the assessment of natural hazards related to permafrost. Different methods of permafrost detection and mapping were combined. An inventory of rockglaciers was compiled on the basis of information derived from orthophotos and the laserscan digital elevation model for the entire province. Multi-temporal analyses were used to establish an inventory of slope movements in mountain permafrost areas by means of satellite-based radarinterferometry (DiffSAR) using data starting from 1993. A permafrost distribution map was created on the basis of the inventory and a permafrost distribution model. This map provided the basis for the analysis of potential hazards triggered in permafrost areas and an overlay of the hazard index maps with the exposed infrastructure by means of a GIS. The identified critical situations were analysed in detail and are monitored with a special focus on increasing risks.

www.aineva.it

Figure 8 – Rockglacier as source of debris flow processes. (Mussner 2009)



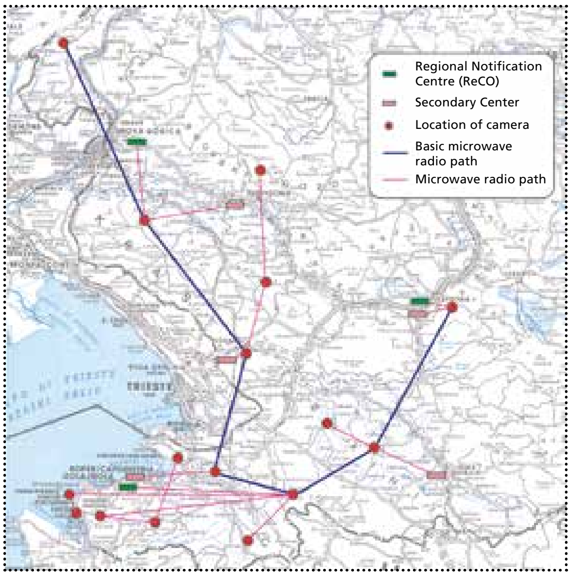
SYSTEM FOR THE VIDEO SURVEILLANCE OF THE SLOVENE KARST AREA (SLOVENIA)

Background. More frequent and intense heat waves due to climate change increase the probability of forest fires, which could aggravate problems with torrents and erosion. The fact that the Slovene Karst area is very prone to fires prompted the initiation of the project "Video surveillance Karst", which involved the installation of a fast and efficient system of disaster monitoring, notification and warning.

Implementation. The Administration of the Republic of Slovenia for Civil Protection and Disaster Relief (URSZR) established a video surveillance system with 14 cameras enabling the real-time observation of the most remote areas in western Slovenia (covering an area of 5'878 km^2). The system is operational even in low visibility conditions. The system enables the identification of forest fires, the rapid response, monitoring of their development and the efficient routing of intervention forces. Intervention costs are reduced and damage limited as a result.

www.urszr.si
www.sos112.si

Figure 9 – Monitoring system. Location of cameras and observed forest fires. (Administration of the Republic of Slovenia for Civil Protection and Disaster Relief)



IMPLEMENTATION OF A FLOOD FORECASTING SYSTEM ON THE RIVERS SAVA AND SOČA AND THE HYDROALARM SYSTEM (SLOVENIA)

Background. The high costs resulting from flood damage in Slovenia necessitated the implementation of an efficient early warning system. Hence, the Environmental Agency of the Republic of Slovenia (ARSO) is implementing the BOBER (Better Observation for Better Environmental Response) project, which aims to achieve the accurate forecasting of extreme hydrological phenomena.

Implementation. The first step towards obtaining reliable forecasts involved the integration of all available information in terms of real time data, including water level, discharge and rainfall data, along with meteorological models. Two hydrological / hydrodynamic models for the Sava and Soča rivers (covering about 64 per cent of Slovenia's catchments) were then developed. The new system was equipped with a user-friendly platform for real-time operation and flood forecasting. The forecast results are visualised using web pages based on Google maps. An application developed for mobile phones completes the dissemination capability of the system. Flood warnings are released to the public using the hydroalarm system. The forecasting system has already proven its worth. During the flood of September 2010, which occurred while the system was in its testing phase, it was used to support early warning messages and to direct civil protection forces to the right places in good time, thereby saving numerous lives and considerable costs.

www.arso.gov.si

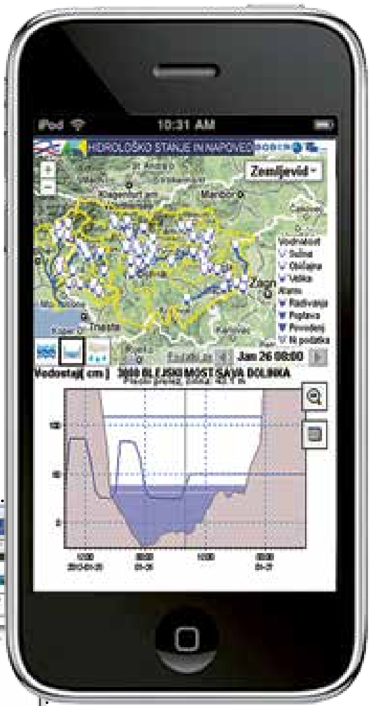
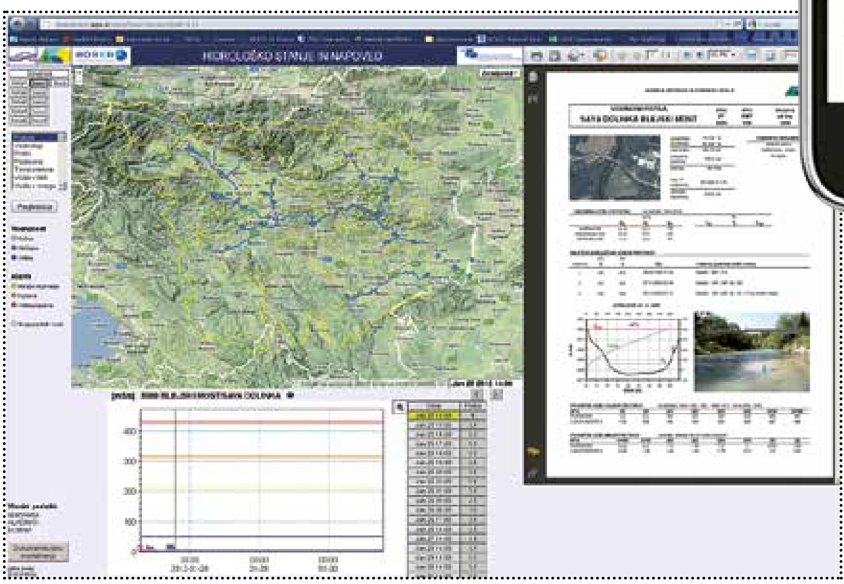


Figure 10 – Flood forecasting intranet home page.
(Environmental Agency of the Republic of Slovenia)



Anticipate and deal with new risks

The impacts of climate change can destabilise alpine environments directly and indirectly. Potential new risks must be recognised before they culminate in disastrous events. Therefore, particular attention must be paid to the identification of new risks and the integrated planning and implementation of adequate measures. These measures must be adaptable to altering hazard situations, with climate change as one of many potential factors of influence.

SYSTEMATIC ANALYSIS AND MONITORING OF NEWLY ARISING GLACIAL AND PERIGLACIAL HAZARDS IN AOSTA VALLEY (ITALY)

Background. Increasing glacier shrinkage has been observed all over the Alps in recent decades. Despite their location at a considerable distance from the inhabited areas, recently deglaciated areas can alter the characteristics of mountain torrents. The deglaciation can lead to an increase in unconsolidated materials, which can be eroded and transported downstream. Furthermore, the appearance of new lakes in these areas could provide sources of outburst flood events.

Implementation. The autonomous region of Valle d'Aosta has developed an inventory of proglacial lakes which represent potential sources of outburst floods. This inventory will be updated periodically. The deglaciated areas and potential hazards related to periglacial and glacial areas were identified for the entire region. Hazard processes that are triggered in these areas and settlements and infrastructure of interest were identified and their evolution is being monitored. The relevant changes in a monitored hazard situation are reported periodically. If these systematic and repeated analyses result in new findings, risk management practice will be adapted.

www.fondazionemontagnasicura.org

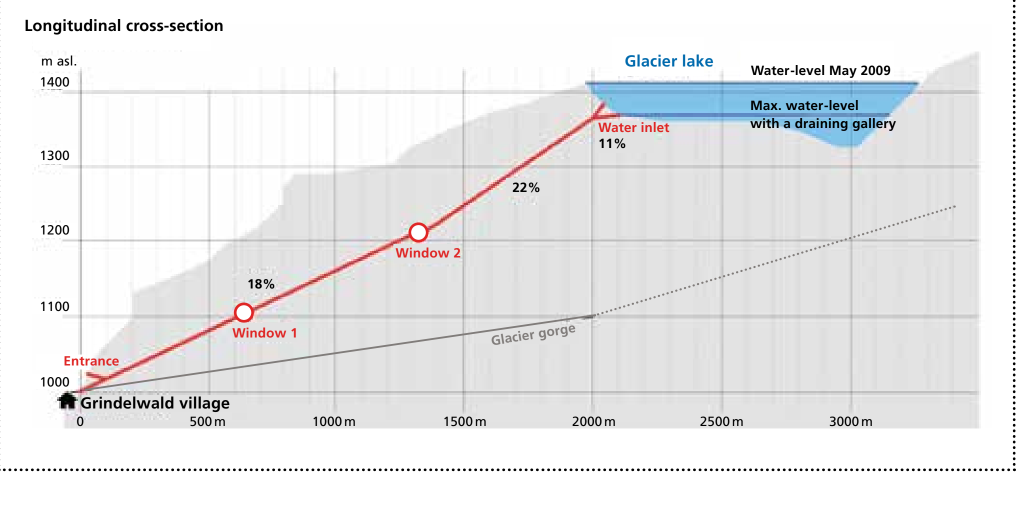
DRAINAGE GALLERY FOR GRINDELWALD GLACIAL LAKE (SWITZERLAND)

Background. Due to the rising temperatures and associated retreat of the glacier in 2005, a lake formed for the first time on the tongue of the Lower Grindelwald Glacier in the Bernese Oberland. Accelerated growth during the following years would lead – in the case of an unregulated and abrupt outburst of the glacial lake – to increased danger of flooding that would affect the population along the river Lütschine from Grindelwald as far as Interlaken. An artificial drainage gallery was constructed to alleviate this threat.

Implementation. The drainage gallery prevents the uncontrolled rise of the water level through the creation of an artificial discharge hole below the natural debris threshold. Starting at the entrance to the glacier gorge, the gallery ascends 2 km through the mountain flank to reach the glacial lake. The position of the upper entrance has been engineered to a height, at which the volume of the lake basin cannot exceed 500'000 m^3. It is assumed that an outburst involving this volume of water would not be able to cause severe damage along the river Lütschine. Periodical lowering of the entrance is planned to take the annual advance of the lake bottom due to the melting of more ice into account. In addition to these engineering measures, permanent surveillance of the glacial lake, an alert system and an emergency plan have been developed. Should the need arise, a series of other reasonable measures will be initiated immediately (e.g. closing of hiking trails and the train station in the area, evacuation of the camping site).

www.gletschersee.ch

Figure 11 – Drainage gallery on the tongue of the Lower Grindelwald Glacier. (Oberingenieurkreis I, Tiefbauamt des Kantons Bern)



Adapt hazard and risk mapping to a changing climate

Hazard and risk maps make natural hazards perceptible and provide an essential basis for integrated risk management. In order to maintain hazard and risk mapping at state-of-the-art level, it is critically important that all relevant alterations in natural and man-made systems be taken into account. To this end, the maps must be updated periodically (as required, for example, by the EU Floods Directive) and ideally incorporate improved and regionalised climate change projections and related potential impacts.

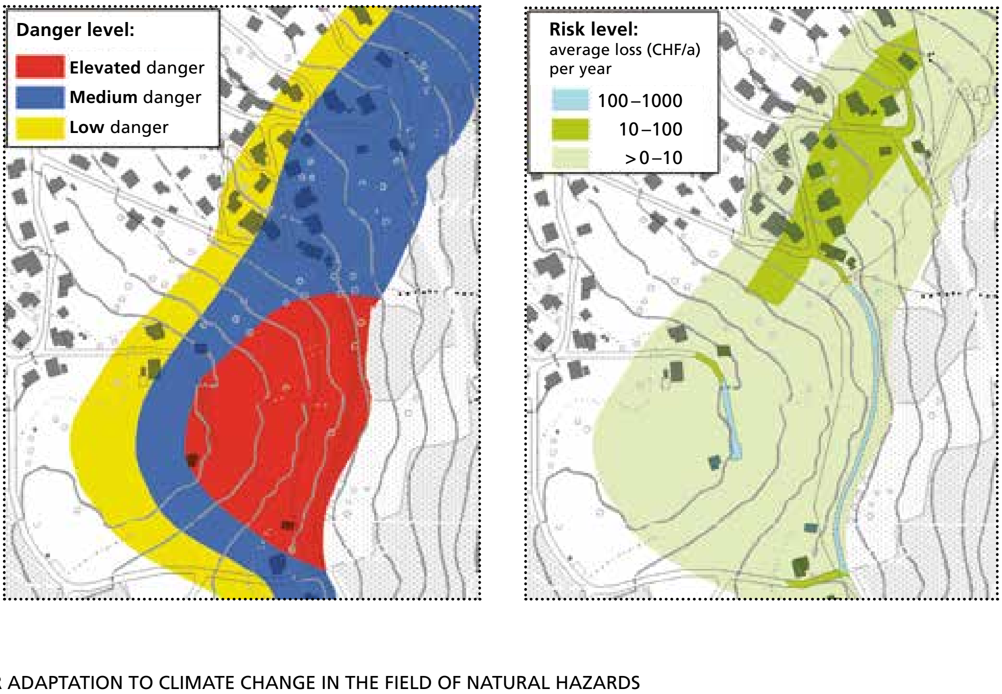
COUNTRYWIDE HAZARD AND RISK MAPS (LIECHTENSTEIN)

Background. In accordance with the Forest Act, the process for the compilation of comprehensive nationwide hazard maps for water, avalanches, rockfalls and landslides started in 1995. This task was completed in 2001.

Implementation. Thanks to the comprehensive hazard maps, information, which is particularly valuable in the context of climate change, is also available for remote areas. These hazard maps are checked for their correctness and updated as required, particularly in the aftermath of storm events. This ensures that climate-change-related information is taken into account in the hazard maps. In addition to the timeliness of the hazard maps, their implementation is also crucial. Hence the hazard maps must be publicly accessible and incorporated into municipal use and development plans, and the construction bans and regulations derived from them must be implemented consistently. This is the only way that a further increase in the risks that exist in hazard areas can be prevented. The hazard maps also form the basis for risk maps which have been compiled for all settlement areas. These risk maps enable, first, the implementation of measures in locations where the risks are highest and, second, the prioritisation of measures on the basis of their efficiency.

http://www.gdi.llv.li > Naturgefahrenkarte

Figure 12 – Examples of landslide hazard and risk maps for the same area.
Elevated danger does not necessarily coincide with high-risk. (Amt für Wald, Natur und Landschaft)



Enhance coordination between spatial planning and risk management

The limited nature of the space available in the alpine region gives rise to a variety of different and often competing demands, e.g. for settlements, infrastructure, tourism and natural hazard prevention. Climate change impacts can increase the vulnerability of spatial structures and further aggravate spatial conflicts. In order to find sustainable solutions, better coordination between spatial planning and risk management is vital. Potential changes in risk situations must be taken into account, particularly in regional and local planning, with all concerned sectors and actors being involved in the planning processes.

GUIDE FOR ASSESSING THE CLIMATE CHANGE FITNESS OF SPATIAL PLANNING (TRANSNATIONAL)

Background. Adaptation to climate change is quite a new issue for spatial planning. Hence, the pilot project CLISP (Climate Change adaptation by Spatial Planning in the alpine space), which involves with 14 partners from the alpine space, focused on the forthcoming challenges in this area and developed initial approaches for "climate-proof" spatial development.

Implementation. The CLISP partnership developed a guide for spatial planners for assessing the climate change fitness of spatial planning. This tool is applicable to the different spatial planning systems in the alpine countries and to national, regional and local levels. Its core elements were tested successfully in model regions during the project. The guide is designed as a practical self-assessment tool for spatial planning authorities. It offers an easily understood, step-by-step approach to reviewing whether the planning instruments in place are able to cope with the expected impacts of climate change and, if necessary, to identify appropriate enhancement options. The approach enables the identification of strengths and weaknesses in the performance of adaptation and the analysis of further action requirements. Progressing through all four steps also raises the awareness of policy makers and stakeholders for climate change adaptation. The complete assessment on a basic level involves around two to three weeks' work. Depending on the aspired degree of detail, the availability of climate change impact studies and other input information, and the extent of stakeholder involvement, the assessment could take several months.

www.clisp.eu

RESETTLEMENT BRIENZ (SWITZERLAND)

Background. Devastating hazard events were rather rare in Switzerland in the mid-20th century. As a result, knowledge about potential danger disappeared into oblivion. Hence, the use of hazard-exposed areas intensified and settlements moved closer to rivers and torrents. A fatal debris flow occurred in the Glyssibach torrent in August 2005. In this case, a landslide in the catchment area of the torrent was partly responsible for the generation of large volumes of debris-flow material. Approximately 70'000 m^3 of debris was transported into the populated area (village of Brienz) in the course of the event. Two people were killed and 28 houses were destroyed completely, or in part. With the increase in both the frequency and intensity of severe hazard events as a result of climate change, a shift is needed from a technical to a sustainable solution.

Implementation. After the 2005 event, the aim was to avoid major damage and the transportation of debris-flow material into the populated area. The question emerged as to whether the destroyed buildings should be rebuilt or not. The solution implemented after the debris flow event at the Glyssibach torrent aimed, first and foremost, to protect people within buildings and to avoid structural damage to buildings. An analysis of the event recommended a combination of several measures. Upstream of the villages, a diversion currently under construction will channel the majority of the debris into a detention space. The remaining debris will be guided into a substantially enlarged corridor through the village into the lake. The construction of the aforementioned corridor alongside to the existing stream prevented the reconstruction of ten houses near the old stream. Resettlement on this scale due to natural hazard protection is unique in Switzerland. The reconstruction of damaged buildings outside of the corridor included measures for their protection. The solution for the Glyssibach torrent is based on local conditions and combines technical measures and spatial planning. The risk situation and its potential changes were taken into account through the allocation of more space for the Glyssibach torrent. The 2005 event clearly demonstrated that extreme events must be borne in mind in the assessment of hazards and risks.

Figure 13 – The four steps in the assessment of the climate change fitness of spatial planning instruments. (Pütz et al. 2011)

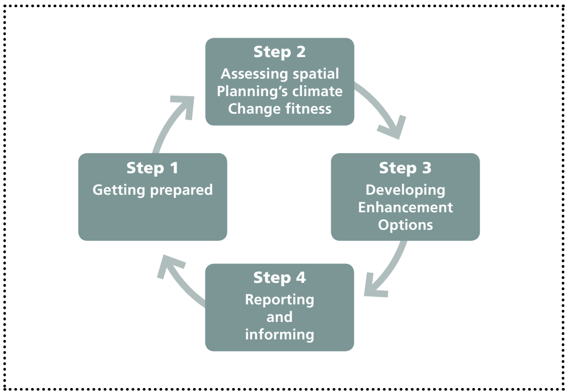


Figure 14 – Glyssibach, Brienz. (Swiss Air Force)

Establish a risk culture and initiate risk dialogue

Risk-appropriate decision-making and planning of measures requires a shift from pure protection against hazards to a culture of risk. This requires a variety of actions ranging from awareness raising, targeted communication and information exchange to education and training across all territorial levels and all concerned sectors. The risk dialogue, involving actors from the fields of policy, the administration, business, insurance and the population, must be promoted as an efficient way of building such capacity.

ACTION PLAN ON RISK DIALOGUE (SWITZERLAND)

Background. The Swiss National Platform for Natural Hazards (PLANAT) is an extra-parliamentary commission that focuses on dealing with natural hazards in Switzerland at the strategic level. In this capacity, PLANAT has been focusing on risk communication and awareness-building for a number of years. The findings obtained from the various studies show that risk communication certainly takes place in Switzerland and numerous instruments are available, however, there are also many redundancies and a lack of coordination of the involved actors.

Implementation. In order to close the identified gaps relating to coordination and the availability of the necessary instruments, PLANAT developed a general concept for an action plan on risk dialogue. The responsibilities and interfaces, as well as instruments for the actors involved, are defined on the basis of eight individual projects in the following fields of action:

- Existing know-how is bundled and accessible.
- Practical support is provided, particularly through training and the provision of auxiliary devices for best risk-dialogue practice.
- Tasks and responsibilities are clarified for all relevant actors.
- Opportunities are created for exchange on the topic of risk communication.
- The population is made aware of natural hazards.

With respect to methodology, attention shall be consistently paid to the direct integration of future users. The focus is on the municipal level, where the dialogue with the population will actually be carried out. The practical goals of these projects are the creation of an efficient internet platform for the exchange of know-how between experts and the general population, practical risk communication tools for the involved actors and further education modules in the area of risk communication for specialists and representatives of authorities. Once the studies have been completed, leadership in the various areas will be handed over to the relevant actors.

www.planat.ch > Risikodialog

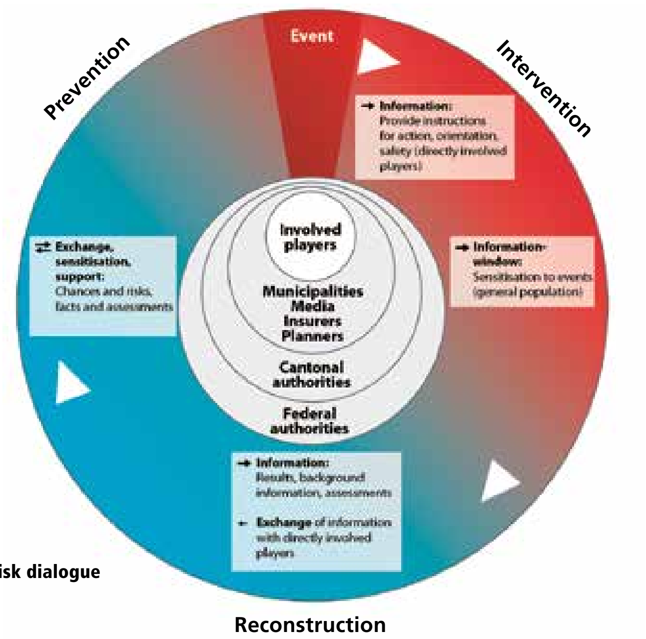


Figure 15 – Overview of PLANAT risk dialogue and involved actors. (PLANAT)

Strengthen individual preparedness and precaution

The population is not yet sufficiently committed to taking personal responsibility for risk precaution. Efforts have to be made to increase public awareness, to make people understand the need for risk management as a collaborative task better and to generate the corresponding commitment. Furthermore, the risks facing individuals and their material assets can be reduced through local structural protection, e.g. adapted building design and the establishment of cooperative structures and public-private partnerships.

PLANNING AND CONSTRUCTION OF BUILDINGS THREATENED BY NATURAL HAZARDS IN ACCORDANCE WITH "LOCAL STRUCTURAL PROTECTION – A PRACTICAL GUIDELINE" (AUSTRIA)

Background. Due to increased settlement activities in Austrian mountain regions and the scarcity of areas suitable for development, settlements have been extended into areas at risk from natural hazards. Conventional protection concepts in catchment areas, along channel systems or tracks, and at fans provide protection to a certain degree, however they guarantee neither reliability nor complete safety. In accordance with the principal of strengthening individual preparedness and precaution, structural precaution provides considerable opportunities for fundamentally reducing the vulnerability of individual buildings and / or interiors.

Implementation. In order to support the public, in general, and building owners and mayors, in particular, a brochure entitled "Living with natural hazards" has been published. The brochure – the outcome of cooperation between spatial planers, natural hazard experts, architects and civil engineering experts – provides knowledge and practical advice on how to reinforce and protect structures and interiors under threat natural hazard(s). The information applies not only to the construction of new buildings but also to the adaptation of existing ones. The advice is complemented by information about hazard maps, recommended behaviour in emergencies, contact information for authorities and individuals and links to further information about natural hazards in Austria.

www.lebensministerium.at

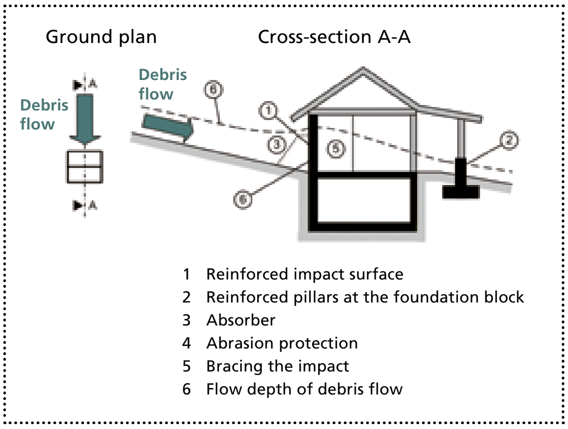
WATER COOPERATIVES (AUSTRIA)

Background. As understood in Austria, in accordance with the Water Act of 1959, a water board or water cooperative is a legal body composed of individuals, municipalities, companies etc. with a variety of tasks, including the sharing of the (financial) risk associated with water-related hazards at a specific site – mainly valleys and regions. Each member contributes financially to a common fund, which is intended for use in the development of mitigation or prevention measures. The idea behind this is to share the financial burden, e.g. to develop protection measures in a torrent / river with all of the people / organisations that anticipate a given safety level in a valley / region – regardless of whether they are directly affected by natural hazards or not.

Implementation. A number of water boards or water cooperatives currently exist in Austria (some of which are over 100 years old, e.g. the Schmittenbach, Zell am See, Salzburg water board), however it is not yet a common cooperative structure throughout the Austrian country. With regard to torrent and avalanche-related hazards, the highest number of water boards can be found in the province of Salzburg (approx. 260) and include approximately 230'000 households. The level of the contributions made to the common fund by each member is formalized using a points-based system which reflects the degree of exposure of a given property and / or building. Due to this "direct" involvement of the members of a water board in natural hazard management, a high level of identification with the "products" of protection strategies can be observed and this, in turn, supports maintenance and further mitigation measures in the areas in question.

www.wg-schmittenbach.at (for example)

Figure 16 – Examples of local structural protection measures against debris flow. (Suda & Rudolf-Miklau 2012)



Improve the knowledge base and transfer into practice

The concrete implications of climate change on natural hazard processes are not precisely foreseeable on the small scale. Substantial efforts must be made to improve the scientific basis, provide regionally and locally differentiated information, and transfer this knowledge into tailor-made approaches for the respective target groups. Cost-benefit analyses of adaptation options help to prioritise measures and support adequate decision-making under uncertain conditions. The exchange and cooperation between the alpine countries promises clear added value in all these respects.

CLIMATOLOGICAL STUDY OF AVALANCHES OVER THE LAST 50 YEARS IN THE FRENCH ALPS (FRANCE)

Background. The climatic impact on avalanche activity and its future evolution in terms of possible changes in the frequency and intensity of both ordinary and extreme events is difficult to quantify and remains poorly understood. This makes climate change difficult to take into account for risk management purposes.

Implementation. The ECANA project (Etude Climatologique de l'Activité Avalancheuse Naturelle) has been in process for two years. The aim of the project is to develop statistical modelling in the context of the avalanche-climate link and to provide useful information about the long term evolution of avalanche hazards. IRSTEA (ex Cemagref) provides the daily avalanche records from the exceptional French avalanche chronicle (Enquête Permanente sur les Avalanches). Both refined snow and weather data and snowpack instability indexes are issued by a model chain of Météo France. Regression models were constructed to represent the interannual variability of avalanche activity using a combination of relevant snow and weather parameters on different spatial (the French alpine massifs) and temporal (seasons) scales. In the second phase of the project (from February 2012), the impact of climate change on avalanche activity will be evaluated by combining the regression models obtained from the results of Météo France model simulations generated using climate warming scenarios. It will provide potentially very useful information for long-term avalanche hazard assessment in land-use planning, which continues to be carried out within the debatable assumption of the stationary nature of avalanche processes.

Eckert et al. 2012

PERMANET PROJECT 2008–2011: LONG-TERM PERMAFROST MONITORING NETWORK (TRANSNATIONAL)

Background. Permafrost is highly sensitive to climatic changes. Permafrost degradation and related natural hazards affect traffic routes, tourism areas, settlements and infrastructure. However, some years ago, the data available on permafrost were spatially inconsistent and there was no map of the distribution of permafrost in the entire alpine region. Furthermore, the relevance of subsurface ice content in rock-glaciers and scree slopes for the hydrologic regime of alpine watersheds in the context of water resources management was unknown. A common strategy for tackling these emerging impacts of climate change on risk prevention and territorial development did not exist. Decision makers and stakeholders needed to be provided with such information to manage the consequences of climate change impacts on permafrost and the resulting natural hazards.

Implementation. The overall objective of this project was to make a significant contribution towards the mitigation of natural hazards related to permafrost and manage their consequences with specific regard to climate change impacts. To this end a common strategy for dealing with permafrost and related hazards under changing climatic conditions was developed collaboratively and an alpine-wide monitoring network established. The PermaNET project further aimed to contribute to sustainable territorial development and the implementation of good governance practices by supporting the development of regional and local adaptation strategies by providing decision-makers and local authorities with a decision-base and strategies for dealing with these factors in their work. The spatially distributed gaps in the permafrost data would be closed and a consistent permafrost map and database for the entire alpine region developed.

Monitoring outputs. The interdisciplinary and integrated approach to collating the existing knowledge about permafrost in the European Alps resulted in many valuable products that can be used in natural hazard management practice and in territorial planning. The main outputs of the PermaNET project are an alpine space permafrost monitoring network and related handbooks, an inventory of permafrost evidence, a map of permafrost distribution in the Alps, and guidelines for the consideration of permafrost in risk management.

www.permanet-alpinespace.eu

Maintain and improve the functionality of protection forests

In the long term, increasing temperatures, more frequent and intense droughts and spreading pests and diseases will affect protection forests with tree species which cannot adapt to such conditions. As protection forests play a key role in mitigating the risks posed by natural hazards, their stability and functionality have to be maintained and, if required, improved. Resilient protection forests require site-specific adaptive management solutions, which can include improving forest stand structures, fostering adapted species mixtures, promoting natural regeneration, preventing forest fires or controlling pests and diseases.

MOUNTAIN FOREST INITIATIVE (GERMANY)

Background. In 2007, Bavaria launched the "Climatic Program Bavaria 2020" which includes different measures for the reduction of greenhouse gas emissions, adaptation to climate change and the intensification of research and development. A special set of measures known as the "Mountain Forest Initiative" (Bergwaldoffensive, BWO), focuses on the adaptation of the alpine forests in Bavaria to climate change.

Implementation. The central aim of the BWO is to stabilise and sustainably adapt the alpine mountain forests to climate change. For this purpose, 30 projects were identified in areas with special climatic risks. Integrated master plans were developed for these projects, which include different silvicultural measures like thinning, planting and natural regeneration, the construction of forest roads, and hunting and pasture management for the reduction of browsing damage. A large number of owners are usually affected by the projects. Thus, the pilot measures are planned and initiated in agreement with the land owners and local stakeholders. This strong focus on participation renders the process transparent – a crucial factor for the success of the projects. Other important elements of the BWO include improving the supply of suitable tree seeds for the alpine region in Bavaria, strengthening applied research and generating new basic information for the management of alpine forests. For example, a digital map of forest soils in the northern Alps was generated as basis for restoration and forecasts by the WINALP project (Waldinformationssystem Nordalpen) in cooperation with partners from Austria (Tyrol, Salzburg).

www.forst.bayern.de
www.hswt.de
http://arcgisserver.hswt.de/Winalp

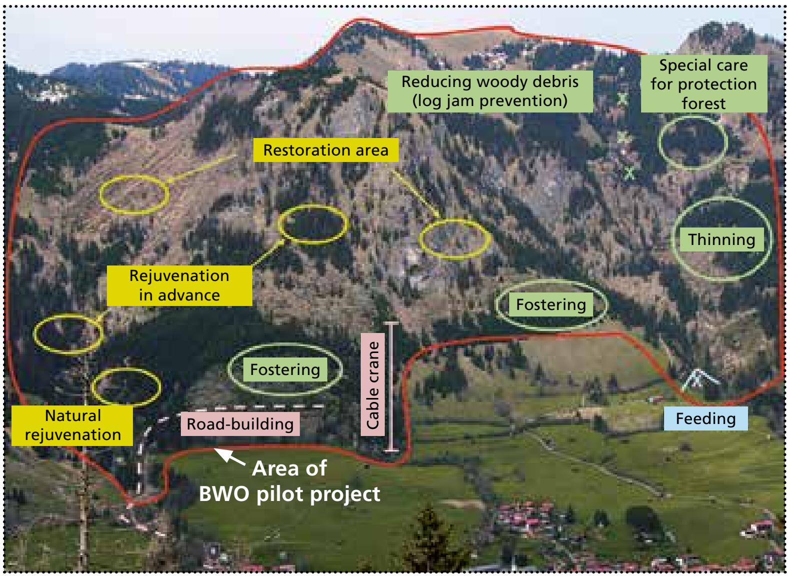


Figure 17 – Example of measure combination within a Mountain Forest Initiative Area. (Bavarian State Institute of Forestry)

Annex: Climate change scenarios used for national and regional adaptation strategies and adaptation work

State	Title and basis	Emission scenarios used	Time scale	Reference period	Expected mean temperature changes	Expected mean precipitation changes
Austria	reclip:century (Loibl et al. 2011)	A1B, B1 (A2 will be added in the next step)	2050 (next step: 2100)	1971-2000	Spring: +1.0°C to +1.2°C (more distinct in the east) Summer: +1.0°C to +2.5°C (but scenarios disagree) Autumn: +1.7°C to +2.3°C (higher increase in the west and south, divergent in north) Winter: +1.6°C to +2.2°C (more in the east)	Spring: constant to light decreases Summer: little decrease (more distinct in the south) Autumn: little decrease (more distinct in the south, south-east and eastern Alps) Winter: +8% to +13% (less in the south and west)
France	ARPEGE-Climat (Météo France) LMDZ (Institut Pierre-Simon Laplace)	A2, B2	2030 2050 2100	1980-1999, 1970-1999	Annual mean 2030/2050: +0.5°C to +1.5°C Annual mean 2100: +2.0°C to +3.5°C	2050 (summer decrease): -10% 2090 (summer decrease): -30% Spring: less distinct decrease Winter and autumn: uncertain
Germany	REMO CLM WETTREG STAR	A1B, A2, B1	2021-2050 2071-2100	1961-1990	2021-2050: +1.0°C to +2.2°C 2071-2100: +2.0°C to +4.0°C Winter: +3.5°C to +4.0°C	2021-2050: Summer: -5% to -25% Winter: 0% to +25% 2071-2100: Summer: -15% to -40% Winter: 0% to +55%
Bavaria	WETTREG 2006	A1B, A2, B1	2021-2050	1971-2000	Summer: +0.7°C Winter: +0.9°C	Bavaria north: summer: -7% winter: +6% Bavaria south: summer: -7% winter: +3%
Italy	AdaptAlp scenario (Krahe & Nilson 2011, Nilson et al. 2012) [1] Basis: EU project ENSEMBLES	A1B	2021-2050 2071-2100	1971-2000	2021-2050: Summer: +1°C to +1.5°C Winter: +1.5°C to +2.0°C (central Alps), +3.0°C (north-eastern Alps) 2071-2100: +3.5°C	2071-2100: Summer: -10% to -25% Winter: +10%
Slovenia	Scenario used in adaptation strategy of agriculture and forestry (Ministry for Environment and Spatial Planning 2008) [2] Basis: EU project PRUDENCE	A2	2071-2100	1961-1990	Spring: +3.3°C Summer: +5.0°C Autumn: +4.2°C Winter: +3.5°C	Spring: +8% Summer: -17% Autumn: -2% Winter: +20%
Switzerland	CH2050 (OcCC / ProClim 2007) Basis: EU project PRUDENCE	A2, B2	2050	1961-1990	CH north: summer: +2.7°C winter: +1.8°C CH south: summer: +2.8°C winter: +1.8°C	CH north: summer: -17% winter: +8% CH south: summer: -19%, winter: +11%
Uri	Uses the Swiss scenario (CH2050 / CH north)					

Note: All indicated temperature and precipitation changes are median or mean values.

(1) The scenario results of the EU project AdaptAlp are used for the Italian Alps

(2) This scenario is also used for the upcoming "Strategy for the transition of Slovenia to a low carbon society by 2050".

Glossary*

Hazard – The temporal probability that an event of a given intensity involves a certain area during a specific time interval. Hazard includes latent conditions representing a future threat for man and the environment and is generally expressed in terms of annual probability. (AdaptAlp)

Integrated risk management – Holistic approach to reducing the damage caused by natural hazards which embraces all sources, pathways and receptors of risk and considers combinations of structural and non-structural solutions. (AdaptAlp combined with FLOODsite)

Reconstruction, restoration – Actions carried out following a hazard event in order to restore the areas involved to the pre-event living conditions, with particular regard to risk reduction. This generally consists of two main phases: an initial phase consists of the restoration, even if only temporary, of the most important infrastructure during and immediately after the event; a second phase consists of reconstruction of an undetermined duration that must be planned and concerns all affected structures and infrastructure. (AdaptAlp)

Risk – Probability multiplied by consequence; with consequence being an impact such as economic, social or environmental damage / improvement that may result from a natural hazard. Theoretically, the consequence can be both positive and negative. (FLOODsite)

Residual risk – Residual risk is the risk remaining when all protective measures have been implemented and is closely related to the question as to which risks are acceptable to individuals and society. (AdaptAlp)

Risk analysis – A methodology for objectively determining risk by analysing and combining probabilities and consequences. (FLOODsite)

Risk assessment – Comprises understanding, evaluating and interpreting the perceptions of risk and societal tolerances of risk as a basis for informing decisions and actions in the risk management process. (FLOODsite)

Risk dialogue – Risk dialogue should help to inform authorities, politicians and society about the need for a concerted preventive effort. It is fundamental to risk-appropriate decision-making when planning safety measures and when prioritising investments. A sound risk dialogue also enables participative decision-making processes. In addition, it is an opportunity for proper consideration of climate scenarios and their potential consequences. (AdaptAlp)

Risk management – The entire process of risk analysis, risk assessment, options appraisal and the implementation of risk management measures (FLOODsite)

Vulnerability (with regard to climate change) – Vulnerability is the degree to which a system is susceptible to, and unable to cope with, adverse effects of climate change. Vulnerability is a function of the character, magnitude, and rate of climate change and variation to which a system is exposed, its sensitivity, and its adaptive capacity. (IPCC)

* The definitions are taken from the AdaptAlp Final Report (Korck et al. 2011), the FLOODsite Consortium Report "Language of Risk" (Gouldby & Samuels 2005) and the IPCC Glossary of the 4th Assessment Report (IPCC 2007).

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