DETEC
Department of the Environment, Transport, Energy
and Communications

Bundesamt für Raumentwicklung
Office fédéral du développement territorial
Ufficio federale dello sviluppo territoriale
Federal Office for Spatial Development

Natural hazards and the Alpine Convention

Event analysis and recommendations

Imprint

Published by
Federal Office for Spatial Development (ARE).
Department of the Environment, Transport, Energy
and Communications (DETEC).

Production
ARE Information Staff Unit, Rudolf Menzi

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and Landscape (SAEFL).
The report was commissioned by the Alpine Conference
(Conference of Contracting Parties to the Alpine Convention)
and compiled by a working group with representatives from all
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Distributed by
SFBL, Distribution of Publications, CH-3003 Berne,
Fax: +41 (0)31 325 50 58,
www.bbl.admin.ch/bundespublikationen,
Article No: 812.034.eng (d, f, i, rg)

also available in German, French, Italian and Slovenian

12.2003

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1 Background and starting point

After the catastrophic floods of 1999 and 2000, which affected almost the entire European Alpine region, the Alpine Conference commissioned an internal working group to analyze the events. The purpose of the working group's report was to recommend measures that would provide more effective protection against natural hazards in the region.

The Alpine Conference of 30/31 October 2000, which was chaired by Moritz Leuenberger, a member of the Swiss Parliament, unanimously took note of the *Bericht zum Lawinenwinter 1998/1999* («Report on the Avalanche Winter of 1998/1999»). Attention was drawn to the fact that the Conference considered the report as containing important information for increasing the awareness of the population and visitors in the Alpine region of the risks posed by avalanches. In the same resolution, the Alpine Conference extended the mandate of the Avalanche Working Group to include the areas of «floods, debris flows and landslides» (cf. Annex).

Figure 1:
Intact watershed areas: one of the conditions necessary for sucessful protection against natural hazards.

2 Fulfilling the mandate and reporting

The aim for the future in the Alpine region is to provide better protection to human life and material assets against floods, debris flows and landslides in accordance with internationally comparable safety standards. This necessitates, *inter alia*, the provision of resources for more intensive cross-border co-operation.

Cross-border syntheses and reports on disastrous natural events with an international focus take considerably more time to compile than individual country reports. Thus, the presentation of this report, which was originally planned for 2001, had to be postponed.

As demonstrated by the disastrous events of 11–13 August 2002 in Austria and Bavaria and the storm damage of November 2002 in the Italian and Swiss Alps, given current organizational structures, resources and procedures, the presentation of up-to-date internationally co-ordinated reports to the Alpine Conferences is either impossible or only possible to a very limited extent. This is particularly true if such reports are constantly overtaken by current natural events.

The main reason for the delay is the fact that within the area covered by the Alpine Convention, there is currently no institutionalized network of authorities responsible for natural hazards which extends beyond national borders. Correspondingly, no additional capacities and financial resources are provided for the completion of mandates in the context of the requirements of the Alpine Convention.

Thus, the question arises as to the objectives that should be adopted by this kind of report in the future. One thing is certain: such reports are useful if the words are followed up by deeds and the resources necessary for intensified international co-operation are made available.

The objectives of the report

The aim of this report is to highlight the need for cross-border action in different areas so as to provide more effective protection in the future to human life and material assets against floods, debris flows and landslides. This action shall be based on the experience gained in the context of the storm events of 1999 and 2000 in the area covered by the Alpine Convention.

The following objectives were adopted in the compilation of this report – in the following order of priority:

- to demonstrate the possibilities for the improvement of future cross-border co-operation for the protection of man and his material assets at administrative level within the area covered by the Alpine convention;
- to raise political awareness of the possibilities that exist for the improvement of protection against natural hazards, such as floods, debris flows and landslides.

Thus, the core concern is to ensure comparable levels of cross-border protection against natural hazards in the Alpine region.

The basis of the report

The main basis for the report was provided by the individual country reports of the Alpine Convention states, i.e. Germany (Bavaria), France, Italy, Liechtenstein, Austria, Switzerland and Slovenia. The Principality of Monaco was not affected by the storm events in question. Furthermore, any available guidelines, recommendations and other publications from the individual countries were taken into account.

The country reports were compiled on the basis of a prescribed report structure, which could be observed to a greater or lesser extent by the report writers. Thus, a conscious decision was made not to harmonize the country reports retrospectively.

The differences with regard to the scale of the damage and the lessons learned in the individual countries do not allow us to draw any general conclusions with respect to the quality and quantity of prevention work carried out in the Alpine countries.

Figure 2:
The example of Rottachstrasse road in Kempten, where the floods in spring 1999 also affected parts of Bavaria, gives us an idea of the vehemence with which nature reclaimed its space. Fortunately, there was major environmental damage arising from groundwater contamination.

3 The storm events of recent years: 1999 and 2000, in particular

In 1999 and 2000, heavy precipitation falling on already saturated ground in most Alpine countries resulted in an accumulation of debris flows, landslides and floods, some of which were devastating. The repeated natural disasters claimed a total of 73 lives and gave rise to material damage and follow-up costs total of more than 7 billions of Euro.

At Whitsun 1999, the cumulative effect of heavy precipitation falling on ecosystems which were already water-saturated as a result of heavy snow cover gave rise to extensive flooding and unconfined debris flows in Germany (Bavaria), Austria, Switzerland and the Principality of Liechtenstein.

In summer and autumn 2000, extreme precipitation events in conjunction with the already exhausted water absorption capacities of the soil, vegetation and water bodies again triggered floods, debris flows and landslides. In this instance, the countries affected were Germany (Bavaria), Italy, the Principality of Liechtenstein, Austria, Switzerland, Slovenia and to a far lesser extent the French Alps.

For example, on 14 October 2000, after days of intensive rain, the Gondo slope in the Simplon area of the Swiss canton of Valais began to slide. Mud and debris plunged into the valley sweeping everything in their path along with them, i.e. trees, roads and houses. Fourteen people met their deaths in the masses of mud and debris and a large part of the village in the canton of Valais on the Italian-Swiss border was completely destroyed.

Debris flows, landslides, torrents and valley rivers breaking their banks claimed dozens of lives in the entire European Alpine region and caused extensive life-threatening damage. Along with the Swiss canton of Valais, the Valle d'Aosta valley in Northern Italy was the most severely affected area.

Solidarity with the victims

The populations in the affected countries demonstrated their solidarity by providing rapid help with the clean-up operations carried out by the fire brigade, army and civil defence and through generous financial donations to private aid organizations. The ministers who participated in the Alpine Conference of 30/31 October 2000 in Lucerne also expressed their solidarity with the affected regions.

Table 1: Overview of the number of victims and material damage caused by storms in 1999 and 2000 (not including the damage caused by hurricane Lothar).

Countries	Number of victims	Material damage in (million) Euro
Germany	5	250
France		80
Italy	44	5700
Liechtenstein		80
Austria		440
Slovenia		10
Switzerland	24	1000
Monaco		
Total (estimated)		7560

Debris flows, landslides and floods claimed a total of 73 lives and gave rise to estimated material damage in excess of EUR 7 billion – including the indirect effects on the economy (cf. Table 1). The only reliable figures available concern the death toll. Due to the lack or approximate nature of the available data, it is only possible to estimate the cost of the material damage incurred.

Consequences, climate change and its harbingers

The fact that the cost of the damage arising from natural disasters is rising due to increasingly intensive land use is not the only issue that provides food for thought here. The fact that extreme storm events are clearly occurring more frequently than in previous decades is also extremely worrying. The question arises as to whether the phenomenon at play here is merely a regular recurrence of natural weather phenomena or whether it already signals the consequences of anthropogenic climate change. The fact that an accumulation of extreme natural events in the Alpine countries also gave rise to death and destruction in the 19th century makes it more difficult to provide conclusive scientific evidence of a causal link between anthropomorphic influences and climate change.

The consequences of climate change represent a major challenge for the new millennium. The current level of insight into climate processes would suggest that climate warming can involve an increase in the potential for heavy precipitation and extreme wind speeds. These extreme meteorological phenomena may be particularly significant in the context of the southern slopes of the Alps, however floods in winter and in transition periods could also increase in intensity. The influence of climate change on summer storms and wind storms is still uncertain, however. Today, climate research assumes that shifts leading to extreme weather events will first become manifest at global and continental level. Furthermore, it assumes that it will not be possible to conclusively prove the existence of an altered climate-induced risk of extreme meteorological events at national level in the near future as the number of such events will be insufficient to enable the demonstration of such shifts with sufficient statistical certainty.

Today, the main danger lies in the fact that the gaps that exist in the complex argumentation proving the links between human influences and ongoing climate change are often more strongly emphasized in the general debate than indications of a causal link between the two that actually exist.

For this reason, instead of rapid and consistent action being taken to protect the environment, there has been a rather hesitant adoption of effective measures. This is the case despite the fact that research has provided sufficient indicators to substantiate environment-policy and sustainability-oriented arguments which legitimize the rapid reduction of the burdens on the environment. Furthermore, in view of the long-term effects, complete and conclusive proof from climate and environmental research will come too late to enable the implementation of the kind of precautions that would provide speedy relief and assistance.

Thus, for the above-mentioned reasons, the following two-pronged approach is recommended:

- A more intensive and targeted consideration of the principles of sustainable development which will reduce anthropogenic pollution and conserve non-renewable resources.
- The promotion of preventive measures to minimize the damage caused by climate change.

The creation of ever-expanding access to the Alpine region has a significant role to play in this context. Thanks to the construction of roads, railway tunnels, road tunnels, bridges, funiculars, avalanche barriers, rock fall protection systems and barriers that provide protection against the forces of nature and assist in the straightening and damming of watercourses, new settlements, recreational areas and transport axes have been created in areas that were previously considered as high risk. It is impossible to provide complete protection for these structures in extreme storm conditions. Thus, a residual risk to human life and material assets must always be reckoned with. The situation is further intensified by increasing soil sealing due to the constant extension of settlement areas as this gives rise to increases in peak flows.

4 The main conclusions of the country reports

In order to protect human life and material assets, society must adapt its use of land in a better way to existing natural hazards and, where possible, avoid using areas that are at risk from such hazards. Effective hazard maps are also essential in enabling the timely identification of risks. These are two important conclusions arising from the country reports.

The most important insights from the damage caused by natural events in Germany, France, Italy, Liechtenstein, Austria, Switzerland and Slovenia in 1999 and 2000, in particular, are presented below. The main emphasis is on the conclusions drawn with respect to preventive work that needs to be done in the future to protect human life and material values against floods, debris flows and landslides.

The conclusions drawn from the most recent events in 2001 and 2002 support the insights already gained from the events in 1999 and 2000.

4.1 Germany (Bavaria)

The storm at Whitsun 1999 claimed five lives in Bavaria. Around 40'000 hectares (ha) of land were flooded, of which 2200 ha were located in a settlement area with 5650 buildings; the resulting damage gave rise to costs totalling almost EUR 250 million.

The hydrological evaluation of the storm event revealed that the design flood (HQ100) had been exceeded significantly in all areas of southern Bavaria that suffered extensive damage. The flood peaks exceeded the dimensioning of the protection systems – in some cases extensively.

In terms of the management of the disaster, around 30'000 personnel from the fire brigades, technical relief organizations, voluntary organizations, police, army and the Federal Border Police were deployed.

The management concept provided by the Bavarian disaster legislation passed the test as no organizational or structural deficits came to light. The general computer-based disaster planning also performed well.

Scope for improvement was identified in the following problem areas and corresponding action has already been taken:

- Immediate dissemination of warning reports to the relevant disaster protection authorities;
- Provision of additional information to the general public through the broadcast media, print media, loud-speaker announcements and personal contact, and provision of systematic information about natural hazards in the form of information sheets to be made available outside of concrete hazard situations;
- Timely dissemination of information to the general public with concrete instructions concerning, for example, the securing of oil tanks, the clearing out of houses and evacuation of the lower floors of houses and buildings.

Contamination of ground water supplies did not occur on a scale worthy of consideration. The supply of clean drinking water was guaranteed in all locations at all times. Microbiological limit values in samples from 42 water supply plants were exceeded. Supplies from six of the affected plants were subsequently discontinued. In the other 36 plants, the drinking water was disinfected using chlorine or instructions were issued to the public to boil tap water.

A total of 421 ha of ground was contaminated; of this 294 ha suffered an insignificant to very low level of contamination, 53 ha suffered an average level of contamination and 74 ha was severely or extensively contaminated by oil. Concrete clean-up measures for the treatment, removal or monitoring of contamination were required for an area of around 37 ha. It was originally expected that the contamination would affect a far more extensive area. It is presumed that the leaked oil collected and deposited with the fast-flowing flood in sinks and ditches.

As sample measurements of the contaminated areas have shown, soil has a very high natural capacity for breaking down oil contamination. This process can be significantly accelerated by means of simple measures such as ploughing.

Figure 3:
Dam failure near Flecken on 22.05.1999. Lack of open space, increased soil sealing, extreme precipitation and non-risk-appropriate land use repeatedly result in major material damage and, at worst, the loss of human life when rivers and streams are forced to make space for themselves.

Much of the material and environmental damage was caused by leaked heating oil. Thus, the Bavarian environment ministry has issued an information sheet on the requirements for the handling of substances that are harmful to water in flood areas. The safety of oil storage systems has been further improved through the introduction of the testing of heating-oil storage containers in flood areas by independent authorized experts.

Conclusions for future work in the area of prevention

The programme *Nachhaltiger Hochwasserschutz in Bayern – Aktionsprogramm 2020* (Sustainable flood protection in Bavaria – Programme of Action 2020) is the backbone of Bavarian flood protection policy. It is based on the following three main principles:

- promotion of natural water retention;
- technical flood protection;
- extensive flood precautions.

The definition of flood areas for the purpose of the protection of retention areas and the banning of development is particularly important.

There is a particular need for action in areas which were previously defined as development areas in the development master planning, but for which no right to build exists in the form of authorized construction plans or other urban planning statutes. However, in cases in which a right to build exists, if no buildings have been constructed, existing construction plans can be changed or reformulated, taking the right to indemnification into account.

Prior to the Whitsun flood, Bavaria had already initiated projects to improve the assessment of natural hazards and damage potential with the intention of tailoring land use to the existing risks in a better way.

Furthermore, the perception of natural disasters by society and society's risk behaviour are being analyzed by research projects. The insights gained in this research will be used to promote awareness of the risks embodied by natural hazards. It is hoped that this will lead to an improved risk dialogue with the general public.

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4.2 France

Unlike the other Alpine countries, i.e. Germany, Italy, Austria and Switzerland, the French Alpine regions largely escaped the extreme flooding and landslide events of 1999 and 2000 and the extensive havoc they wreaked.

This was not the case during the avalanche winter of 1999, The only exceptions in the year 2000 were the landslides that occurred in the Alpes-Maritimes and Alpes-de-Haute-Provence regions in November, which claimed the life of one victim, caused injury to two individuals and caused some material damage. Residents also had to be evacuated from their homes and roads were blocked.

Based on the Spatial Planning Law of 1995, «Plans for the Prevention of Predictable Natural Risks» (*plans de prévention des risques naturels prévisibles – PPR*) are currently being compiled. These plans provide the basis for the targeted deployment of prevention, intervention and rehabilitation instruments. Approximately 3000 municipalities already have such plans and this number is to be increased to 5000 by the year 2005.

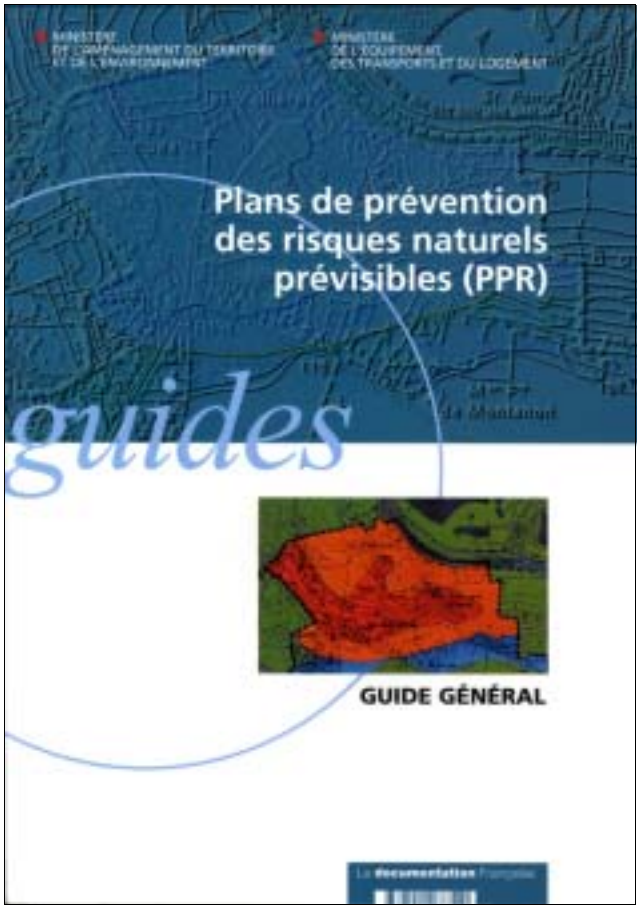

Figure 4:
In France risk-appropriate land use is based on the guideline: Plans de prévention des risques naturels prévisibles (PPR) – Guide général.

The following projects have been launched to improve knowledge about the protection of human life and material assets against natural hazards and the practical application of this knowledge:

- Compilation of a register of protection structures and simultaneous evaluation of the protection capacities of existing structures
- Internet-based computerized documentation of current technology for protection against natural hazards for practitioners
- Documentation of the current status of anchoring technology

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4.3 Italy

The catchment area of the river Po was affected particularly severely by the heavy flooding that devastated northern Italy in autumn 2000. In this region alone, there were 44 fatalities and around 32'000 people had to be evacuated from their homes. The estimated cost of the damage to property totalled EUR 5.7 billion.

Damage management

The disaster was managed through the extensive deployment and involvement of the entire civil defence system. Rehabilitation was immediately initiated with the help of the special funding made available by the state.

When the flooding in October and November 2000 finally spread to all of northern Italy, a state of emergency was declared in the following regions: Valle d'Aosta, Piedmont, Lombardy, Veneto, Friuli-Venezia Giulia, Autonomous Province of Trento, Autonomous Province of Bolzano, Liguria, Emilia-Romagna and Tuscany. The planning of emergency measures and damage containment measures, rehabilitation, the securing of damaged infrastructure and reduction of hydrogeological risks, which comes under regional competencies, was carried as part of the process for the implementation of regional planning and allocation of state funding.

The events leading to the damage coincided with the completion of the soil conservation planning phase, thus the authorities in the watershed areas with responsibility for natural hazards had hazard maps at their disposal which provided information about slide, flooding and avalanche risks. For various reasons, a comparison of the «seriously damaged» municipalities with those specified in the map as potentially at risk from flooding and slide activity did not show any significant correlation. For example, damage was recorded in areas for which no major risk was predicted in the hazard maps. One reason for this is, no doubt, the fact that the extensive spatial

variability in the intensity of the precipitation resulted in significant differences in the scope of damage in the affected regions. An analysis of the accuracy of the predictions which takes all of the area's influencing factors into account could probably provide the corresponding answers.

Figure 5:
Casetti, district of Locana (17.10.2000). The storm in October 2000 had disastrous consequences in the Valle d'Aosta.

Conclusions for future work in the area of prevention

The large number of victims and municipalities affected by the floods, the enormous cost of the damage to infrastructure and the national economic implications all bear witness to the extreme scale of the damage suffered in the affected areas. The disaster years 1999 and 2000 demonstrated once again how vulnerable the affected areas are to hydrogeological hazards. For this reason, recent state provisions which lend a new impetus to preventive efforts for the avoidance of and protection against natural hazards and risk-appropriate land-use management are particularly valuable.

The land use policy which targets the protection of the population, property and productive activities is being implemented in the framework of the hydrogeologically based land-use planning for watershed areas. The following conditions must be incorporated here:

- Precise data must be available concerning the relevant natural hazards (physical, natural, anthropogenic etc.) in the area to be evaluated. On the basis of this data, it is possible to specify where and when the disposition for potential landslides, flooding and avalanches exists.
- Land use must be regulated, in particular in areas at risk from the above-mentioned phenomena. This is to be achieved through regulatory measures (ban on new buildings, ban on certain activities etc.) and/or promotional measures (financial support for the conversion of disadvantageous uses, resettlement payments etc.). Effective risk reduction is to be targeted by means of this approach.
- Creation of emergency plans for civil defence.
- Priority-based planning and implemention of technical measures for the protection of human life and material assets.

These tasks are financed by the state and a reserve fund is provided for urgent emergency measures which can be defined and planned by the regions on the basis of the hydrogeological spatial plans (PAI).

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4.4 Principality of Liechtenstein

Thanks to numerous targeted interventions, it was possible to prevent extensive floods and the corresponding consequences in terms of damage to human life and material assets at Whitsun 1999 and in August 2000.

The high ground water level – combined with the exceptionally high water levels in the receiving streams – resulted in the flooding of the basements of many buildings. The limits of the municipal drainage system were exceeded. Extraordinary heavy precipitation gave rise to a tense and potentially hazardous situation in July and August 2000, in particular. Protection measures, such as the deliberate flooding of agricultural land during the flood events, helped to prevent more extensive damage in settlement areas.

Due to geological conditions, the soils, which consist of argillaceous slate and recent decomposition products, are relatively unstable. Depending on land use, the extreme saturation of the soil had a strong influence on the site stability and hence, also, on the accumulation of damage. Unconfined debris flows were triggered – in particular on steep slopes used for grazing and to a greater extent than in forest areas where comparable conditions prevailed. The lowland valley communities were affected by this main landslide phenomenon in 1999 on a scale that had not be previously experienced. Fortunately, however, the resulting damage was not extensive.

As a result of the intensive precipitation and the saturation of the sliding bodies, an acceleration of the unstable deep slides could be observed throughout the country as revealed by permanently installed monitoring system.

Scope of the damage and financial consequences

The rehabilitation of the flood protection systems, which were subject to excessive strain in 1999 and 2000, probably cost around EUR 4 million, i.e. twice the annual budget for normal flood protection.

The damage caused by the unconfined debris flows gave rise to intensive clean-up operations costing around EUR 1 million. The cost of the clean-up in 2000 was just

under Mio € 0.5 which represents a total of 40% of the ongoing spending on hazard prevention work.

In view of the accumulation of damage arising from natural events in recent years and the associated burden on the public finances, the country saw itself forced to revise its practice of financing uncovered basic damage. While previously, private property owners could largely recoup their losses thanks to the generous support provided by the state, the state now only contributes to a third of the costs incurred in the repair of uninsurable damage on private property. A prerequisite for the granting of this support is that the relevant municipality also contributes at least one third of the costs.

Figure 6:
An acceleration of unstable deep slides could be observed as a result of the intensive precipitation in the hilly terrain. More unconfined debris flows were triggered on steep slopes used for grazing than on comparable forested slopes.

Conclusions for future work in the area of prevention

- The successive concentration of pasture areas in more productive and accessible locations combined with the simultaneous extension and stabilization of the protection forest – measures undertaken as part of the development of the mountain region from the late 1960s – paid off. The damaging events of 1999 and 2000 demonstrate that this process must be continued. Thus, in the year 2000, instead of concentrating on expensive clean-up activities, the emphasis was placed on the strategy of reforestation of unstable pasture land that is prone to slipping. The uncertain future of the mountain economy and the general decline in the numbers of animals being grazed on the Alpine pastures facilitated the adoption of further steps in the direction of land use which is appropriate for the location and also provides better protection against erosion. The fact that the slide activity was significantly more extensive on agriculturally used land than in the forested areas should lend the necessary impetus to these efforts.

- Neither the local chronicles nor elderly local inhabitants refer to previous slide phenomena on Mount Eschnerberg. Thus, the newly compiled hazard maps had to be updated again as a result of the landslides observed in 1999.
- The performance of the receiving streams must be tested and quantified in the interest of flood protection. This applies in particular to the flood safety of the main receiving streams, and particular attention needs to be paid to the interaction between the level of the Rhine ground water and the levels of the receiving streams. The optimum bed position of the Rhine can be established with the help of this data.

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4.5 Austria

Excluding the consequences of the storms in Voralberg, 107 events giving rise to material damage were recorded in Austria in 1999 and a further 155 cases in 2000. In 1999 alone, the area affected by flooding totalled almost 7000 hectares, with 13 m^3 of river wash being deposited and *inter alia* 348 buildings damaged. The total cost of the damage incurred was around EUR 220 million. Fortunately, no lives were lost as a result of the events.

Analysis of the causes and limits of flood protection

The scale of the repeated flood events in recent years is aggravated, in particular, by the intensive settlement pressure in the vicinity of the hazard zones and areas at risk, and through the loss of natural river wash and flood retention areas as a result of competing interests in the area of land use. The increasing sealing of the soil with transport infrastructure and buildings and the resulting intensification of surface run-off also plays a crucial role here.

As the year 2002 also showed, it was possible to avoid damage on a far greater scale thanks to structural flood mitigation systems, such as torrent and avalanche barriers, and through the measures implemented by the Federal Department of Hydraulic Engineering.

However, there are economic and technical limits to what can be achieved by means of flood protection measures. In places in which run-off exceeded the normal design basis of a 100 year event, damage occurred despite the effect of the existing barrier systems. In view of the revealed limits of active protection measures, it needs to be acknowledged that Austria faces an ongoing residual risk in the mountain regions in terms of the threat posed by natural hazards to settlement areas and the cultivated landscape. This risk can only be reduced through the adoption of

passive protection measures and the targeted control of land use in the threatened areas.

Figure 7:
Due to lack of space, the Pfenningbach stream in Puchberg broke its banks and caused significant damage to property. Extensive settlement pressure resulted in a reduction in drainage capacity and natural bed wash and flood retention areas with the inevitable consequences.

Conclusions for future work in the area of prevention

The aim is to establish comprehensive co-operation between the state and the regions (*Laender*) in the areas of activity of relevance to sustainable flood protection.

Focus on Hazard zone plans

From risk analysis to risk evaluation and risk management, prevention requires comprehensive hazard zone plans in all municipalities at risk. For this reason, a focus was set on hazard zone planning in the context of the forestry service and the construction and maintenance of mountain torrent and avalanche barriers with the aim of making the data on all municipalities with mountain torrent and/or avalanche catchment areas available in digital form by 2010 at the latest.

Spatial development plans

Close co-operation with spatial planning processes in the regions and the incorporation of the corresponding measures in the relevant national legislation are intended to ensure that the zoning of construction land in areas at risk from natural hazards will not be possible in the future. The province or *Land* of Lower Austria set a particularly positive example here with its amendment of the Spatial Planning Law of 1999 which stipulates that yellow zones can no longer be released for zoning as construction land.

No buildings in areas under threat from natural hazards

Year after year, areas along and around water bodies that are at risk from flooding are rezoned as development land and built on. This increases the potential for damage during flood events hugely. For this reason, areas in the vicinity of water bodies should be kept free from buildings through the adoption of the necessary spatial planning and zoning measures. The water management sector (Federal Water Engineering Authority (BWV) and Torrent and Avalanche Control authority (WLV)) makes suitable planning bases available to the spatial planning sector through the definition of hazard zones and flood drainage areas.

No cutbacks in the area of ecological flood protection

The disastrous flood events must not result in the neglect of ecological objectives in the context of structural flood mitigation. Natural water engineering which networks water bodies with their surrounding areas, improves water retention and thus attenuates flood peaks in the course of small-scale and average events. River revitalization projects have never caused an increase in flood damage.

Incorporation of past experience into future planning

Flood protection structures in settlement areas are generally calculated on the basis of 100 year event. This limit was exceed in some rivers in 2002. Thus the re-evaluation of the measurement criteria is a matter of urgency. Once the immediate measures have been implemented and the most urgent repairs to flood protection structures completed, more integrated planning instruments, for example water monitoring concepts and regional studies, need to be developed in co-operation with other authorities in the areas of spatial planning, road construction, agriculture etc.

A residual risk remains

In the case of extreme flows which exceed existing capacities, disasters can also occur in the presence of functioning flood protection systems. The affected populations need to develop a greater awareness of this residual risk. This necessitates the increased use of warning and alarm plans in the case of floods and the provision of better information about individual prevention options open to private property owners.

Event documentation

The detailed analysis of disastrous events, the monitoring of catchment areas and the systematic recording of event data represent the most important sources of information for the assessment of hazards and the planning of future protection measures. Thus, it is aimed to improve the options for the financing of such monitoring programmes in the framework of the amendment of the legislation on the promotion of hydraulic engineering structures (*Wasserbautenförderungsgesetz*).

Research and technological development

The disastrous flood events demonstrated the significant need that exists to further the development of technological measures for protection against natural hazards. Future research should focus on the further development of early warning systems and simulation models. Information is lacking, in particular, in the area of runoff and the transportation of river wash and regarding the dynamics of rock fall, flowing and powder avalanches. It is also aimed to improve flood forecasting (weather radar), electronic support for planning processes, the development of warning and alarm plans and the design and safety of protection structures.

Interdisciplinary co-ordination

A new section entitled «Protection against Natural Hazards» with the task of co-ordinating co-operation between sections has been set up in the Austrian Federal Ministry for Agriculture, Forestry, Environment and Water Management. This office has also proved particularly valuable as a coordinating body and lynchpin in the context of the often short-term tasks that arise in connection with flood events. It is intended to intensify co-operation with the other actors involved in disaster protection in the future. The nation-wide co-operation of all of the authorities involved is to be improved by means of the following measures: closer co-operation

between the Torrent and Avalanche Control division and the Federal Water Engineering Authority, increased coordination of the prevention and protection aims with spatial planning processes, regular involvement of torrent and avalanche control experts in crisis committees and in the co-ordination of disaster operations, exchange of the relevant data.

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4.6 Switzerland

The storm events of 1999 and 2000 claimed a total of 24 lives in Switzerland, not including the 20 victims of the canyoning accident in Saxetenbach (Bernese Oberland). The cost of the damage arising from these events totalled around EUR 1 billion.

The thaw of February 1999 gave rise to flood damage in the cantons of Aargau and Basel-Landschaft, in particular. The storms mainly involved floods on Ascension Day, in May and at Whitsun. Almost all of the lakes in the Alpine foothills and their affluents and drainage areas were affected by extensive flooding. The damage was mainly concentrated in the lower basin of Lake Thun, in the city of Berne, along Lake Konstanz (in particular the lower lakeshore), in the Fricktal valley and in the Rheintal valley in St Gall.

In the year 2000, the storms mainly involved the floods in the canton of Valais on 14/15 October. The local authority areas of Gondo, Baltschieder and Stalden-Neubrück were the main areas affected by the damage. The canton of Ticino, where Lake Maggiore reached a level last recorded in 1868, was also affected. Less extensive damage was also caused in the cantons of Vaud and Berne.

Figure 8:
Baltschieder in the canton of Valais, October 2000. If it does not have enough room and there is no retention capacity, the torrent will simply take the space it requires. Despite the extensive damage to housing, fortunately, there were no fatalities.

Conclusions for future work in the area of prevention

- The storm events confirmed the validity of the integrated planning of protection concepts which was adopted after the storms of 1993.
- In view of the extremely large volumes of water, the different causes of damage, the restricted spatial situation and eventual effects on residents and buildings both upstream and downstream, it will be difficult to provide sufficient technical protection against such natural events. Given that the storm damage involved is not of an everyday nature, efforts to ensure greater safety face economic, ecological and social limits.
- The testing of existing protection structures and their effectiveness is intended to serve as a planning basis for a modernization programme which will take the current hazard situation into account.
- In future, hydraulic engineering protection concepts must also take extreme events into account. Damage cannot be avoided by means of hydraulic engineering measures alone; risk-appropriate land use in the affected areas is also necessary. In the case of the flood water level of the lakes, the slow rise of the lake water level and the slow dynamics of the forces enables those affected to react correctly in serious situations. Similarly, the protection of objects and suitable building practices make it possible to adopt effective precautionary measures. If these safety measures are implemented as part of the remedying of the damage, the additional costs are insignificant as compared with the exclusive rehabilitation costs.

- Lake water levels should be regulated using floodgates after winters with heavy snow falls so that the filling up of the lakes is delayed. The effectiveness of this kind of management declines with the increase in the scale of the storm events. In view of the different interests at play and the lack of long-term predictions, the scope for action here is temporally restricted.
- The desire to avoid damage should not result in the unrealistic restriction of uses, which would be impossible to implement in practice. Thus, for example, the use of attractive locations on Lake Langen in Locarno or Ascona is legitimate. Users must, however, be aware of the fact that their land may be flooded from time to time. Thus, buildings must be designed in such a way that the damage arising in such cases is tolerable. These principles apply not only to public buildings, but also to private structures. Unfortunately, previous experience shows that the will to implement individual precautions is weak as people feel they can rely on the generous support of insurance companies. However, the combination of minor structural adaptations and preparatory temporary measures – for example the raising of lakeshores or river banks using timber beams or sand bags – has proven worthwhile.
- Just as in nature, floods do not arise due to a single factor, in damage prevention, it is necessary to adopt a tailored combination of spatial-planning use restrictions, protection structures, object protection measures and organizational precautions implemented by the emergency services in the context of emergency planning.
- Hazard maps also provide an important basis for the adoption of individual precautions (object protection) and the passing on of risks to the insurance companies.
- In future, integrated risk management should be made more cost effective through the balanced and equal consideration of all possible measures – for example at spatial planning, construction and organizational level – in interaction with prevention, intervention and rehabilitation.
- The risk dialogue between experts, the administration, politicians and potential stakeholders will be intensified under the slogan «From hazard avoidance to a culture of risk» (*Von der Gefahrenabwehr zur Risikokultur*).

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4.7 Slovenia

As compared with 1999, a normal year with respect to meteorological events, in 2000 heavy storms broke over Slovenia in the summer and the west of the country

also suffered heavy precipitation in October and November. Thus, the volume of rain in the Julian Alps exceeded the average rainfall for the previous 30 years by 250%. The maximum daily values twice exceeded 200 mm in November. The area had been affected by a strong earthquake two years earlier which had probably caused the destabilization of some slopes. These factors were the main causes of several landslides.

Figure 9:
In the Slovenian village of Log pod Mangartom, the biggest landslide in 2000 claimed seven lives and gave rise to damage that threatened the livelihoods of the local population.

Disastrous landslide

The biggest landslide for 100 years in Slovenia took place in the village of Log pod Mangartom near the Italian border in November 2000. The material started to move at an altitude of around 1600 m and did not stop until it had slid a distance of 1000 m down the slope. The consequences included the loss of seven lives – the victims were buried under the masses of soil or swept away by them – six houses were destroyed and 13 damaged, two small hydro-electric power plants were buried in debris and several bridges were destroyed. Over 700'000 m³ of material reached the valley and a 300-metre stretch of the road leading to Italy via the Predil Pass were destroyed. An entire village of 140 people and 400 residents further below in the valley had to be evacuated.

Protection measures undertaken

In view of the extreme volumes of precipitation, landslides and local flooding were to be expected in this area. Thus, the civil emergency service together with the national weather service issued several warnings and the municipalities activated groups from the civil emergency service to assist.

After the disaster, a civil rescue system was set up on a local basis with the support of similar national organizations. The headquarters was set up within a few days

and the rescue services proved well organized and efficient. Certain problems arose during the evacuation of the village as not all inhabitants were willing to leave.

As more precipitation was expected, the authorities established a 24-hour monitoring network along the course of the landslide.

Due to the high volumes of precipitation, two more landslides occurred in the year 2000 which did not, however, cause any damage. In one case, several farms were threatened by over three million m³ of material slowly sliding down a valley. The landslide had started in 1990 but stopped for years and was reactivated by the heavy rainfall. The state made enormous efforts to prevent the enormous volumes of material from sliding any further. The heavy precipitation triggered another landslide which had been known to exist for 200 years but had been stable for the past 100 years. Over one million m³ of loose material slid down to an area close to a village. The landslide is around 1 km long, 60 to 100 m wide and covers an area of around 15 ha. Significant sums have been spent on risk avoidance in the meantime. Apart from the sliding of the forest down towards the valley, no damage has arisen so far. If precipitation is expected in this area, the Slovenian meteorological institute transmits regularly updated weather forecasts as further sliding can be expected in both cases.

Conclusions for future work in the area of prevention

As part of a national hazard prevention programme, the Slovenian authorities would like to carry out geological studies and further investigations in potentially endangered areas so as to identify all possible landslide areas. A separate environmental plan for the future and emergency plans to be implemented during natural events would be developed on the basis of the results of these studies.

It is aimed to further improve efficiency in the area of the prevention of accidents caused by such natural hazards through greater co-operation between the hazard identification, education and operational sectors.

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5 The action required to improved prevention

In the context of protection against natural hazards, it is possible to make significant improvements in the area of prevention through the implementation of a balanced combination of different measures. What is required, however, is not only the involvement of the authorities, but also the acceptance of individual responsibility on the part of private property owners.

The action required for all Alpine states has been identified in the following problem areas:

Hazard assessment

- Hazard analysis must be improved. Hazard maps – and, hence, knowledge of the areas at risk – are an essential prerequisite for exhausting all of the possibilities offered by optimally tailored preventive measures, and for the appropriate and timely reaction to natural hazard events.
- Unlike natural processes that occur and reoccur on a regular basis, for example avalanches, the hazard analysis of slope instabilities can only be based to a certain extent on previous events or witness accounts. Thus, the evaluation of current geological factors is more important in this case. These factors include, for example, the structure and soil properties of the loose stone substratum. Equally important are the position of the rock surface and hydrogeological factors, such as the slope water situation. All of these factors must be recorded in a three-dimensional context.
- Potential for improvement still exists in the area of the accuracy of forecasts and the possibilities for the extension of warning times. In the case of slope instabilities, on-site measurements can provide important information on the dynamics of processes – depending on the storm conditions. This enables the production of high quality forecasts. This kind of early warning service is above all important for areas with known slide activity. Speed measurements create new possibilities for reaching a better understanding of mass movement processes which are not easy to predict, for verifying the uncertainty of hazard forecasts and for making better use of the available range of suitable protection measures.
- The assessment of floods and mass movement processes leaves much to be desired. Thus, it is important that the quality standard – with regard to the working bases and spatial use processes – be raised as quickly as possible to that achieved, for example, in the context of avalanche hazards in Bavaria, Austria and Switzerland.

Flood evacuation – river wash transport

The pressure on water courses should be reduced through the increased use of water and debris retention basins:

- The scarcity and availability of open spaces which allow the unhindered overflow of flood water depends on settlement density. Where such open spaces still exist, they must be conserved or, where possible, re-established and used in a way that makes it possible to avoid the need for expensive flood protection systems.

- Targeted flood spillage or evacuation systems must be provided for dams to prevent uncontrolled breakthroughs. Possible solutions here include dams that can be flooded, the one-sided raising of the dam crest and secondary dykes/dams which prevent the flooding of areas with high potential for damage.
- The prevention of the entry of debris into receiving water courses using collector systems is extremely expensive. The emptying of the debris collectors is also expensive if carried out in a way that complies with environmental, nature conservation and landscape protection requirements. For this reason, their use should be planned in the framework of concepts for the consolidation of sites and debris management. In each case, it should be verified whether at least a partial and acceptable level of permeability can be maintained with the help of open structures.
- Hundreds of thousands cubic metres of debris and driftwood can be blocked by installing numerous gravel traps on mountain torrents. The driftwood grills, which held back 300 m^3 of wood in the Lainbach torrent in Bavaria, proved effective.
- In the case of Bavaria, the Whitsun floods showed that if the threat of flooding is to be realistically assessed, estimates of debris transport and driftwood volumes must be added to the calculation of the HQ100 line for larger water bodies with Alpine watershed areas and for mountain torrents. This is an essential prerequisite for the avoidance of conflicts between the use of land for building and flood protection requirements. For example, 62% of the settlement area affected by the Whitsun flood is covered by a development plan. A right to build exists in around 33% of the flooded area. This problem also exists in the other Alpine countries.
- The control of debris transport is a key factor in the avoidance of flood damage in the mountain region. Thus, major events cannot be controlled if the relevant space is not available for the valley rivers. Problems involving backwater in the tributaries of the Rhone in the Swiss canton of Valais have shown that sufficient safety cannot be provided by increasing dam height alone. Instead, the water level must be kept low and this is only possible by widening the drainage channel.

Taking natural hazards into account in land use planning

- The avalanche winter of 1999 demonstrated that it is worth taking avalanche hazards into account in the context of land use. The hazard maps made a key contribution to the fact that despite the intensive use of the Alpine region, the number of lives lost was significantly lower than was the case in the avalanche winter of 1950/51.
- The hazard maps and the information they contain about the potential threat posed by floods, landslides, rockfall, rockslides etc. must be taken into account in all spatially relevant planning measures. This starts with the draft planning and includes the plot-base definition of hazard zones and the instructions issued as part of planning authorization processes. Officials and landowners are required to take full note of these requirements – not least in their own interest.
- Land-use planning should be appropriate and based on existing risks.

- The space required to guarantee and increase the retention capacity of water bodies must be conserved and created.

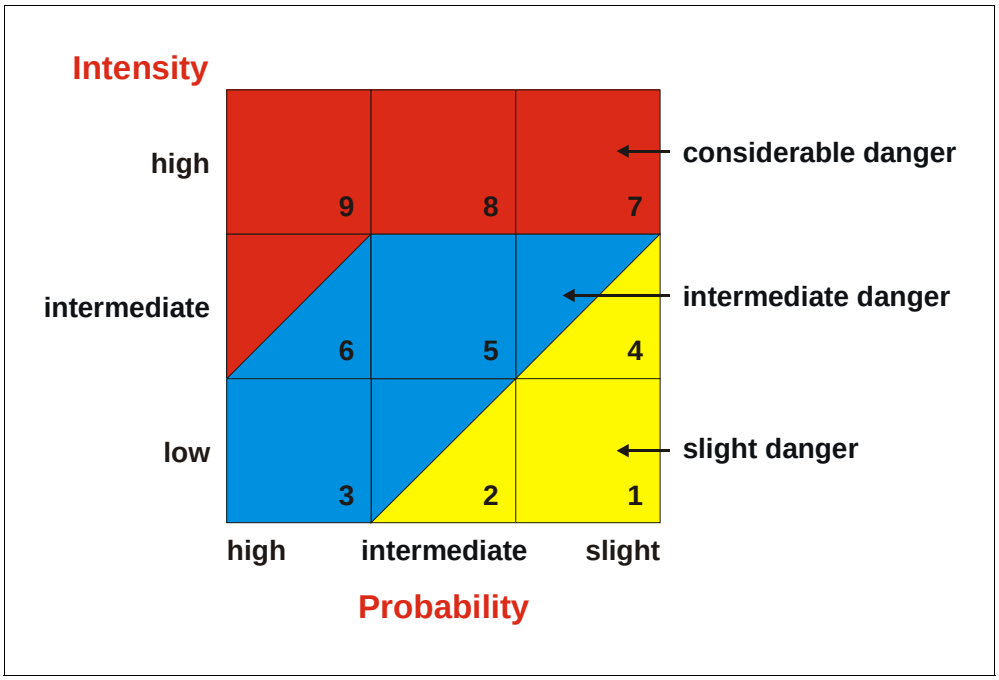

Figure 10:
Diagram of intensity and occurrence probabilty which is used as a basis for risk assessment and the compilation of hazard maps in Switzerland.

Maintenance of existing protection structures

- Given that active protection against natural hazards – for example structural flood protection – is expensive, prone to damage and limited in its duration, the erection of barrier structures represent an investment for future generations.
- Risk-appropriate land use and the maintenance of existing flood protection systems are, therefore, a higher priority than the construction of new protection structures.
- The top priority with respect to the repair, adaptation and development of protection structures, is the renaturation of water bodies.

Protection of objects, emergency planning and water management

- Measures such as the moving of the main electricity control panel to the upper floors of buildings, the securing of oil tanks, water-proofing of structures and infrastructure systems and the insulation of doors and windows also offer an effective means of limiting damage.
- Emergency planning and the use of crisis committees must be improved. Experience and preparation are of crucial importance for crisis committees. Thus, hazard zone plans must be updated for specific events through the addition of intensity maps and risk maps, depending on the situation. The vulnerability of buildings and infrastructure in flood areas must be checked – at the latest when possible risks posed by the protection structures themselves are identified. In or-

der to minimize residual risks, it must be ensured that the defence forces and their resources are always available and ready to be deployed.

- The optimum management of reservoirs requires the development and implementation of better system models for influx, drainage and storage capacities. An additional potential exists here for a use of reservoirs that is favourable in terms of both energy use and flood protection. All optimization efforts must aim to provide the best possible protection for settlement areas upstream and downstream of the water retention systems without endangering the safety of the barrage, dam or reservoir in question.
- Vulnerable areas that are identified as such due to the rapid succession of extreme weather must be improved rapidly. Nature will not wait until society has implemented its planned safety precautions.

Climate change

- Climate change and the increasingly intensive use of the Alpine region necessitate the constant verification of the situation with respect to natural hazards. As with all human actions, the possible and necessary precautionary measures must be constantly revised and taken into account in the context of land use and emergency planning.
- The accumulation of disastrous storm events in recent years (1987, 1993, 1999, 2000, 2002), which affected large areas of the Alpine region, are an indication that so-called 100 year events can now occur with far greater frequency.
- Given the current above-average warming period, there is much evidence to support the view that further extraordinary flood events can be expected in the next years and decades. As a result, storm-induced constellations with an overlap of heavy precipitation and snow melt, giving rise to an increasing number landslide and debris flow events, can also be expected in the future.

Crisis management – communication

- Communication within crisis committees and the timely availability of suitable information for the affected population are crucial to the success of the management of natural hazard events.
- In our age of communication, interaction with the media is also very important. Media contacts must be clearly defined and integrated into the flow of information.
- Rapidly unfolding and hazardous natural process necessitate the rapid transmission of data if it is to provide a valuable aid in decision-making. Thanks to modern telecommunications and internet technology, in an ideal case, reliable analyses of current hydrological situations are readily available. In order to maximize the benefits of modern communications technology, the fast and effective provision of data requires special efforts in the problem area. Weather and drainage forecasts have improved significantly in recent years. Crisis committees should also have access the most recent forecasts.

- In view of the high level of development achieved in the area of early warning systems for debris flows and floods in Japan, the exchange between the Alpine countries and Japanese «early warning» experts should be intensified.

Research

- Knowledge of mass movements such as debris flows, slides, rock fall and the preconditions for the spontaneous release of superficial slides is inadequate. There is extensive need for research in this area.
- Statistical analyses of precipitation and drainage data that are based on historical experience can only describe the category of very rare events unsatisfactorily. For this reason, they need to be complemented by detailed models. These provide a basis for the safety studies which demonstrate the kind of events that could occur in the future.
- Knowledge of the possible scope of damage and the vulnerabilty of society represents an important basis for risk assessment. Vulnerability research that is not merely limited to earthquake issues needs to be intensified.
- In order to ensure the correct handling of risks, knowledge and methods of risk evaluation need to be furthered as a basis for risk analysis.
- Research on climate change, its causes and effects on the mountain regions and the consequences for the planning of protection measures is indispensible. Such research provides a crucial basis for the future containment of damage arising from natural events.

Risk dialogue

The development of modern society which has to live with a wide range of risks necessitates a risk dialogue focussing on the perception, awareness and acceptance of (residual) risks. The following questions must also be addressed in this context: How much is safety worth to us? What are we prepared to pay for it? What can we do and what do we want to do in the terms of individual responsibility? A distinction must be made here between preventive measures for the reduction of voluntary and involuntary risks.

The risk dialogue should lead to the reduction of risks using cost-effective and «sustainable» methods, on the one hand. On the other hand, the possible measures for the minimization of risk should be implemented on the basis of clear priorities. Correspondingly, the risk of an increase in the number extreme natural events, such as storms etc., should be included in the dialogue as a possible consequence of climate change.

6 The most important consequences for the Alpine region

Due to the increasingly intensive use of areas at risk from natural hazards and the associated rise in values in these areas, the potential for damage in the Alpine region is growing continuously. At the same time, the general public expects the state to continue to provide ever-improving protection against natural hazards. However, the growing safety requirements cannot be fulfilled without the consistent adaptation of land use to the existing risks.

Natural hazards like avalanches, rockfall, landslides and floods have been part and parcel of the Alpine region for centuries. The following two questions are central to the future of the region:

- How should the use of the Alpine environment be organized in the future so that it meets the requirements of sustainable development?
- Where do the boundaries lie with respect to the use of the mountain region and the Alps – from an ecological, economic and social perspective, in particular?

The answers to these questions are of crucial importance for the future of part of the 14 million people who live in the eight states, 53 regions and 5800 local authorities in the area covered by the Alpine Convention.

In the context of the organization of livelihoods, the question also ultimately arises with respect to the level of safety necessary to safeguard livelihoods and the willingness to provide the resources required to provide this safety.

The tension between risk-appropriate land use, careless exploitation and absolute protection requirements necessitates the permanent weighing-up and balancing of the different interests. This can only be achieved through a democratic debate between all of the participating parties at local, regional, national or international level, depending on the issue at stake.

6.1 The increasing potential for natural hazards and damage

In using the Alpine region, mankind has had to confront the forces of nature since the beginning of time. The extreme weather conditions in combination with the steepness of the terrain and its propensity to erosion are mainly responsible for the more or less distinctive dynamics of the natural processes. The hazard potential has altered drastically over the past century. Around 1900, in many places, the threat of natural hazards was still due to the extreme over-exploitation of the mountain forest as settlements and transport axes were insufficiently protected against avalanches, rock fall, landslides, floods and debris flows. Today, the potential for damage is constantly growing, above all as a result of the increasingly intensive use of areas at risk – and the associated increase in values.

While in the past avalanches and debris flows in mountain areas only threatened seasonally used agricultural buildings, pasture land and agricultural crops, today

these areas contain permanently occupied houses, important transport and transit axes and tourist infrastructure.

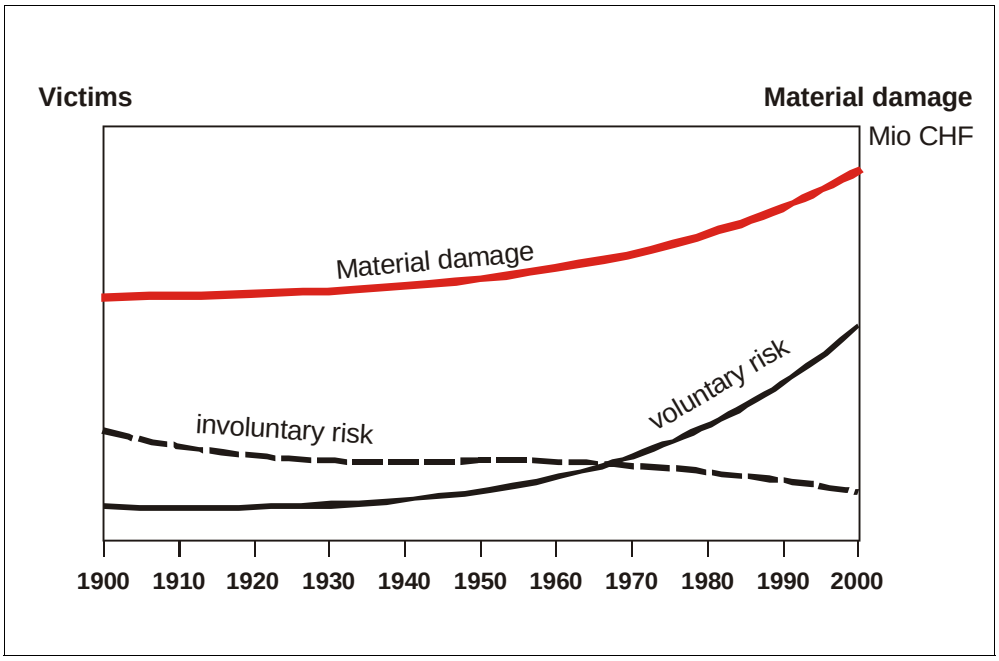

Figure 11:
The decreasing trend in the loss of life due to natural events as compared with the increasing trend in the loss of life through voluntary risks undertaken in natural settings (assumptions).

The following scenarios must be assumed for the Alpine region, which is already densely populated (cf. also Figure 11):

- Due to growing settlement density and vulnerability, the material damage arising from natural disasters will increase.
- The willingness of individuals to take greater risks in the pursuit of leisure activities (adrenaline kick) – including risks posed by natural hazards – will increase.
- In our society, there is a tendency to hold the community and the state responsible for ensuring that the desired level of protection against natural hazards is provided. Individual responsibility is increasingly denied.
- The demands of society for greater safety in the area of protection against natural hazards will put the public purse and insurance companies under increasing pressure to finance the requested safety services.
- Settlement pressure will continue to increase in already densely populated areas.
- The value of development areas that have already been built on – and those that have just been zoned as such and are not yet built on – will continue to grow and at the same time intensify the risk posed by natural hazards.
- The increasing mobility requirements, which are fuelled by both economic and leisure factors, will give rise to greater risks along transport axes in the Alpine region.
- The extraordinary storm events will become more extreme and even more frequent.

- The pressure to adopt more intensive uses in the vicinity of protection structures will continue to increase as the public is less prepared to spend money on preventive protection against natural hazards if these investments do not pay off in the form of the availability of extra development land.

It is difficult to quantify the threat posed by climate change which will lead to a growth in the potential for damage and thus also increase the risks posed by natural hazards.

The current understanding of climate change prompts the conclusion that proven climate warming involves extreme wind speeds and increased heavy precipitation. Furthermore, it can be expected that flooding in winter and in transitional periods will become more intense.

6.2 Society's increasing safety requirements

The legislation governing protection against natural hazards has been extended and expanded on a regular basis over the past century. In addition, the insurance system was established and natural disaster funds created in some countries. As a result, the state, the insurance industry and voluntary organizations became the guarantors of protection against natural hazards and the management of natural disasters. Today, the fire brigade, military and emergency services are also trained and equipped to be able to limit the damage caused by natural events through rescue and clean-up operations. In general, they also ensure the rapid rehabilitation of damaged areas – under the crucial condition, of course, that well established emergency planning is in place.

Society's safety requirements grow with the improvement of the public services provided for protection against natural hazards. While individuals may consciously take considerable risks in certain specific situations, the demand for state-guaranteed and virtually comprehensive safety dominates in the collective sphere.

Due to modern leisure requirements and the fact that places of work and residence are often considerable distance apart – in the mountain region also – the volumes of both rail and road traffic have increased significantly. As a result, the likelihood of accidents occurring along the transport routes in the Alps due to natural events is increasing. This in turn gives rise to the demand for additional safety measures such as protection structures, early warning systems and the improvement of communication options. Thus, for example, rock fall nets and other protection systems are being requested and installed on roads where the risk of rock fall was not previously a matter of particular concern.

This increase in safety requirements can be demonstrated using the example of protection measures implemented along the Gotthard railway line in Switzerland. Increased use, more passengers and more valuable freight as well as the trend

towards «just-in-time» deliveries have given rise to a level of risk that is no longer acceptable and must be reduced through suitable measures. Figure 12 shows the technical developments in the reduction of risks posed by natural hazards over the past century. It also demonstrates modern society's increasing safety and mobility requirements.

Figure 12: Development of safety requirements between 1900 and 1980 based on the example of the Gotthard railway line.

6.3 Protection at any price is an illusion

The current proliferation of extreme meteorological events and the damage they cause is a clear reflection of the fact that even modern industrial societies – like those of the Alpine countries – with their access to state-of-the-art safety technology cannot guarantee absolute protection against natural hazards and are becoming more and more vulnerable to them.

Thus, for example, in a typical Swiss Alpine canton like Graubünden, 450 known natural hazard locations have been identified along the 1600-km-long road network. For financial, technical and ecological reasons it would be simply impossible to provide protection against all of these risks or to safeguard the transport routes using suitable protection measures. However, the general public's awareness of the

limits of technology is declining. Today, people in the Alpine region want roads that can be used safely day and night all year round, irrespective of the difficult climatic and topographical conditions. The availability of such infrastructure is taken for granted with respect to Alpine transit traffic, in particular.

Due to the increasing trend for the expression and validation of individual freedom and self-fulfilment, individual responsibility now takes a back seat. The erroneous view that nature must submit to human requirements often prevails. This can be seen in the boom in dangerous sports such as off-piste canonyoning and snowboarding which involve a willingness among participants to voluntarily expose themselves to natural risks – for example the release of an avalanche (cf. Figure 11). Thus, the increase in fatalities, for which the victims themselves bear responsibility, is not coincidental.

In view of the knowledge that an absolutely reliable level of safety does not exist, it is important to identify the risks arising from natural processes and the implications of their development for man and his infrastructure. For it is only when we know what can happen that we will have an opportunity to define what we wish to do about it in terms of precautions and how much we are prepared to invest in the eventual safety measures.

6.4 Integrated risk management

In order to guarantee the risk-appropriate and sustainable use of the Alpine region, the necessary decision-making basis must be developed for spatially-based integrated risk management. Together with overviews of the potential damage, hazard maps constitute an indispensable basis for decision-making in the context of risk-appropriate land use.

In order to fulfill sustainability criteria, land use must take equal account of economic, safety technology, ecological and sociological factors.

These documents, be they hazard, intensity, damage potential maps or risk maps provide valuable decision aids in the context of prevention. This also includes the use of the fire brigade, military, emergency services and other aid organizations for the management of disasters and the subsequent rehabilitation. Thus, for regions that still do not have such documents, their creation is a key priority.

Crisis management, which requires simple, safe and fast communication and decision-making channels, is also an important part of integrated risk management.

In the interest of risk-appropriate land use, users require documentary and regulatory bases created with practical application in mind for the definition of protection objectives, risk analysis and risk assessment. Furthermore, the state should introduce suitable measures to ensure that risks in threatened areas do not increase any

further as a result of rises in the value of previously zoned and built-up development zones and in agricultural zones.

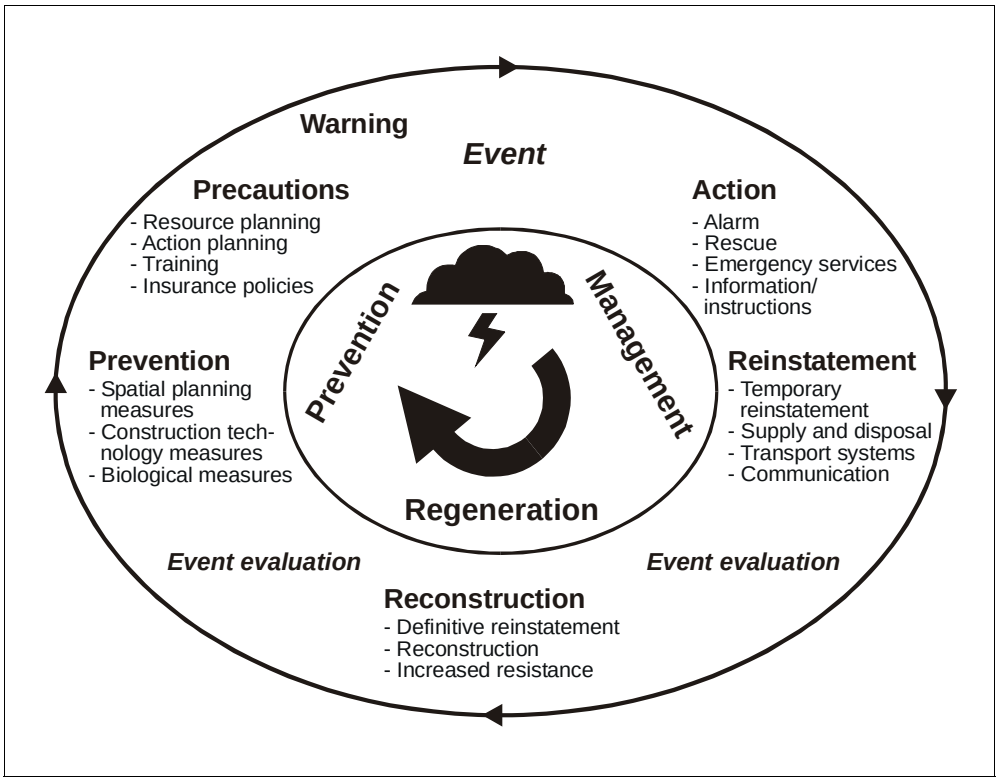

Figure 13:
Integrated natural-hazard risk-management means the equal implementation of all possible measures for the protection of human life and significant material assets. Risk communication and risk dialogue are essential prerequisites of this process.

6.5 Prevention for protection against natural hazards

In the interest of sustainability and comparable levels of safety, protection concepts should incorporate larger spatial units like valleys or entire catchment areas. Integrated regional management that takes all requirements into account can only be implemented in larger spatial units. If these preconditions are fulfilled, all of the available preventive measures can be tailored to each other and implemented in an equal and balanced way.

Systematically structured documentation of disastrous natural events and their management is necessary to enable the lessons from the past to be made to benefit future prevention work. For this reason, attempts to develop natural hazard registers should be promoted as is the case with the DOMODIS project. The planned follow-up project, DISALP, which is being implemented in the framework of INTERREG IIIB, intends to establish the natural hazards register on a broad international basis so as to enable its widespread practical implementation.

Risk-appropriate and sustainable land use necessitates knowledge of the potential hazards and potential damage. The protection objectives which the state acknowledges as worthy of promotion must also be defined. Close co-operation and risk dialogue between state bodies, the owners of land and other assets, aid organizations and the insurance industry are also indispensable. This is the only way that the co-ordinated and thus optimum use of the resources and instruments available for disaster management and subsequent rehabilitation can be guaranteed.

The future organization of the living environment in the mountain region is of crucial importance for the Alpine countries. In view of the increasingly difficult production conditions for the agriculture and forestry sectors in mountainous terrain, which, for reasons of cost, mean that they can no longer compete with the same activities in the lowlands, the maintenance of watershed areas, which also provide preventive protection to man and his infrastructure, is no longer guaranteed. Current requirements in terms of landscape management and protection against natural hazards – with suitable forms of land use – and the lack of public funding necessitate greater efficiency and effectiveness in the use of public resources. A change in direction, which involves both consideration of the land-use aspect from an economic perspective and the natural hazard protection aspect from an ecological perspective, requires substantial and organizational adaptations. If the financing of the producers of socio-economic safety and traditional landscape services is not guaranteed, the existence of primary sector producers is also under threat.

6.6 Risk-appropriate zone planning

In many cases, the options available for land use in the Alpine countries with their characteristic water courses, mountains and forests are very limited. Depending on settlement pressure, the concentration of material assets under threat – in settlement areas in particular – has increased significantly in recent decades. Recent extreme events have repeatedly presented us with evidence of the limits of hazard prevention. In view of the increased values in the areas at risk, the basic question with respect to the acceptance and acceptability of the risks posed by natural hazards is highly relevant today.

The following core questions must be clarified in a detailed risk dialogue between the responsible authorities and, ultimately, with the populations to be protected: What can happen? What may happen? How much are we prepared to pay for safety?

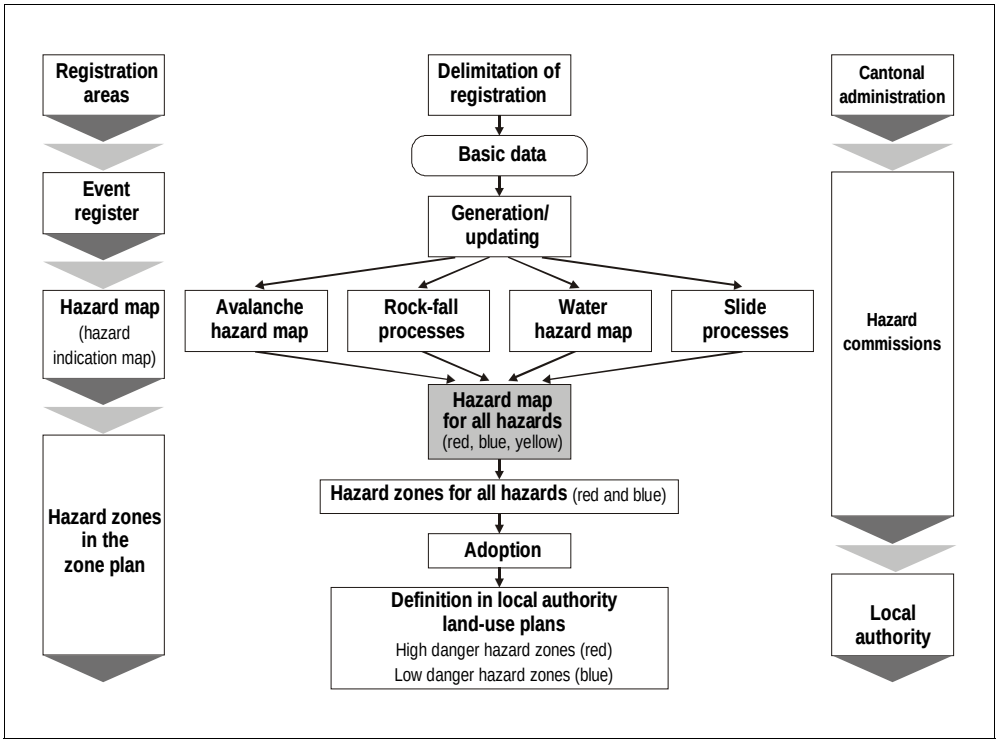

Figure 14:
Process diagram for the consideration of natural hazards in the context of land use.

Over the past 50 years, encouraging experience has been gained in dealing with the avalanche hazard and its consideration in the context of land use. Thus, although it concerns a spatially limited problem as compared, for example, flooding, this experience can be used as a yardstick for dealing with other natural hazards.

The avalanche winter of 1999 showed that consistent preventive and integrated protection against natural hazards pays off. An approximate comparison of the number of deaths and cost of damage in the extreme avalanche years of 1951 and 1999 supports this observation. The blocking of roads and rail links and the evacuation of people in the yellow and blue hazard zones made an important contribution to the «success» of the adopted management approach, although it must be said that luck also played its part.

Based on the knowledge that land use cannot continue to expand unchecked in areas at risk from avalanches, the results of the avalanche hazard maps have been integrated into spatial planning since the 1970s. However, it was only with the publication of the «Guidelines for the consideration of the avalanche hazard in the context of land-use-related activities» (*Richtlinien zur Berücksichtigung der Lawinengefahr bei raumwirksamen Tätigkeiten*) in the 1980s and the deployment of special hazard commissions in Switzerland, for example, that the threat of avalanche was consistently taken into account in the context of land use. As a result, the preconditions were created for the improvement of early warning systems and for organizational measures – such as evacuation and the closing of transport routes.

The municipality of Brienz in the Bernese Oberland (Switzerland) is an example of how settlement development expanded in areas at risk from landslides and overbank sedimentation between 1870 and 1993 (cf. Figure 4).

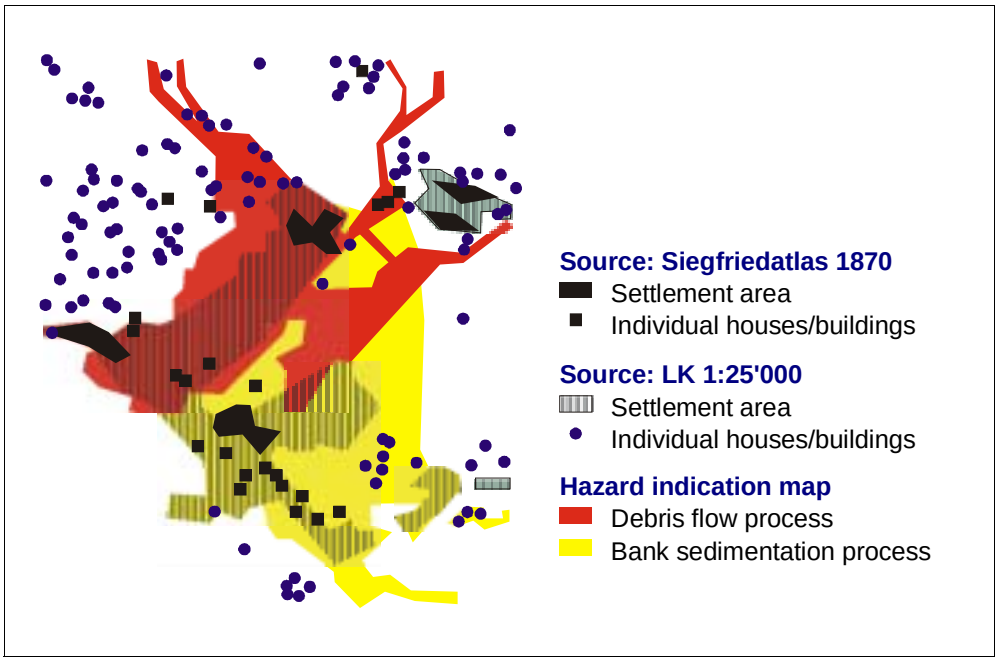

Figure 15:
A comparison of the hazard situations prevailing in the municipality of Brienz (Bernese Oberland) in 1870 and 1993 shows that hazardous processes like landslides and bank sedimentation were not given sufficient attention in previous zone planning.

In view of the extensive number of such examples based on the experience of earlier avalanche and flood disasters, it is important that other natural hazards be taken into account in spatial planning along with avalanche, for example slope instabilities, debris flows, rock slides, rock fall and flooding.

This should also be based on solid foundations that obligate the authorities and land owners.

Correspondingly, the relevant instructions for the consideration of flood hazards and mass movements should be added to the avalanche guidelines. The application of these guidelines represents a challenge in areas in which the municipalities have already zoned plots for development that are located in areas at risk and which require additional areas for development. Cases whereby zoned development land must be rezoned because of a natural hazard pose particular difficulties for authorities and land owners. This is particularly applicable if the price of development land exceeds the standard agricultural price by multiples – by several thousand Euro per m², in extreme cases.

7 The possibilities and limits of technical measures for protection against natural hazards

Hazard protection structures that are intended to remain functional on a long-term basis must be maintained regularly. The costs associated with this maintenance are likely to increase significantly in the years to come.

The current status in the development of barrier and anchorage technology makes it possible to implement protection measures that would have been unthinkable in the past. However, there is still room for development in the areas of flood and rockfall protection. The first official system for the testing of rockfall nets came into operation in Switzerland in 2002 in accordance with the corresponding guideline.

However, it would do nothing for the advancement of sustainability if every major or disastrous event were to result in the further development of hazard protection structures. Technical protection structures offer no guarantee of 100% safety as evidenced by the collapse of a tunnel following a rockslide at Lake Brienz in Switzerland in 2002.

With investments in protection structures, it must be taken into account from the outset that they involve maintenance costs that should not be underestimated if their protective function is to be guaranteed on a permanent basis. Thus, it is important to define the protection objectives at which a particular measure or set of measures should be targeted.

The value of all existing structures for protection against natural hazards in the entire Alpine region probably exceeds EUR 100 billion and this represents a major commitment for the owners of these facilities. The basic prerequisite for the long-term preservation of the protection function is the ensuring of maintenance, repair and redevelopment measures. The cost of investment in sustainable protection against natural hazards, which also includes protection forest maintenance, should not be underestimated. It is foreseeable that the costs involved will increase considerably in the years to come if these structures and systems are not to be bequeathed to future generations as abandoned orphan sites and a growing source of potential danger.

8 Learning to deal with risks

In the case of natural hazards, the possibilities for risk reduction are also increasingly hampered by technical, ecological and economic limits. The distribution of the tasks adopted hitherto must be reconsidered. For when it comes to the use of sites in threatened locations, in many cases the individual responsibility of the landowner has not been given the necessary emphasis. The future organization of the division of tasks between private individuals, the state, insurance companies and voluntary organizations must be adapted to the changing economic, ecological and social conditions.

«Disasters are known only to humans, provided they survive them. Nature is unaware of disasters». Max Frisch

Thanks to technical progress and the concentration of material assets, such as important infrastructure, in hazard zones, modern industrial societies are increasingly vulnerable to natural disasters. Extreme events threaten human life, destroy buildings and other facilities, bring entire systems – such as transport – to a standstill, and as a result have serious economic consequences.

The safety requirements of a modern society are determined by the variety of the risks it faces, for example, biological, climatic and social risks.

Thus, protection against natural hazards is merely part of a public sustainability-oriented risk-management strategy.

Together with the limits of technical feasibility, ecological and, increasingly, economic restrictions diminish the possibilities for risk reduction – including reduction of the risks arising from natural hazards. The state and private individuals can no longer afford the cost of reducing the residual risks involved in dealing with natural hazards or the adaptations in the social, health and transport sectors on the scale that would be seen as desirable from an individual perspective. Insurance companies will find themselves confronted with the same problem if the damage caused by natural disasters continues to increase in the way it has in recent years.

In the case of abrupt process such as those arising from avalanche and rock fall hazards, lives are instantly endangered and the risk involved is intolerable. For this reason, avoidance and prohibition strategies are to the forefront in the area of avalanche and rock fall protection.

In the case of processes that unfold more slowly, for example floods, the threat to life is generally minimal, however the potential material damage is extensive. Sites on the shores of inland water bodies have always been attractive settlement locations thanks to the use of hydropower and the various other advantages offered by inland water bodies. In this case, the disadvantages posed by occasional floods were viewed as acceptable and prepared for accordingly. Thus, despite regular floods, extensive settlements have continued to developed in lake locations and along rivers. The advantages attained during flood-free periods significantly outweighed the losses suffered in the event of damage.

In the past the damage was contained with the help of suitable measures – such as the limited use of ground floors and basements, the implementation of temporary protection measures and precautionary construction of footbridges. Today, there is no such awareness of exceptional situations and individuals are no longer as willing to become personally involved in the event of a crisis. Individual responsibility is being replaced by the expectation that the state will undertake the necessary measures which are expected to provide complete protection.

Based on the development of the distribution of tasks between the state, private enterprise and land owners, from today's perspective, natural hazards must be seen as events that are characteristic features of certain locations and which must be taken into account in all land uses adopted in the area. Thus, the negative consequences are accepted when the land is acquired and any resulting costs must be born by the land owner. Due to the transformation in values and further development of the requirements of our modern society, which must live with a wide range of risks, a fundamental risk dialogue between the various groups and stakeholders is essential.

9 Nature sets limits

Balanced protection against natural hazards cannot be based entirely on technical measures and must take ecological criteria along with economic and social criteria into account. Agriculture and forestry have a key role to play here. They not only create employment, but also make a crucial contribution to the appearance and management of the landscape and to the safety of entire valleys and watershed areas. Their effects cover wide areas while technical measures are more restricted and punctual in their effect.

The report on the avalanche winter of 1999 which was presented to the Standing Committee of the Alpine Convention indicates that the burden on the fragile ecosystems in many tourist locations in the Alpine region is becoming intolerable. For this reason, greater attention must be paid to the demand for the sustainable development of the mountain regions.

The final assessment of the damage caused during the avalanche year of 1999 clearly demonstrated this. Thus, for example, in the entire Alpine region, 60 people lost their lives through no fault of their own and the cost of the material damage caused – including consequential follow-up costs arising from economic losses – exceeded € 1 billion. The traffic chaos on the transit axes, the supply bottlenecks and psychological problems suffered by marooned holiday makers are indicators of the fact that the limits of acceptability have been reached in some places.

The importance of agriculture and forestry

The future management of the Alpine region represents a major challenge for local populations. What is ultimately involved here is making the region capable of sustaining life and worth living in. It is one of the state's tasks to ensure that natural hazards arising from the location do not become an existential problem for the population in the mountain region. The priority here is the protection of the community and the reduction of the involuntary risk posed by natural hazards. The conservation of quality of life in the Alpine region also requires a sufficient supply of local jobs as a basis for the existence of the native population. Agriculture and forestry continue to represent important sources of income in this context. Furthermore, they contribute to the management of the landscape and the safety of entire valleys and watershed areas and this, in turn, benefits tourism, the protection of settlements and infrastructure and the subjacent areas.

Concepts for sustainable protection against natural hazards

Sustainable protection against natural hazards cannot be based on technical measures alone, but must take social and ecological criteria into account along with economic factors (cf. Figure 5). As key sustainability factors, social solidarity, a precautionary approach to the environment and economic efficiency are decisive in this context.

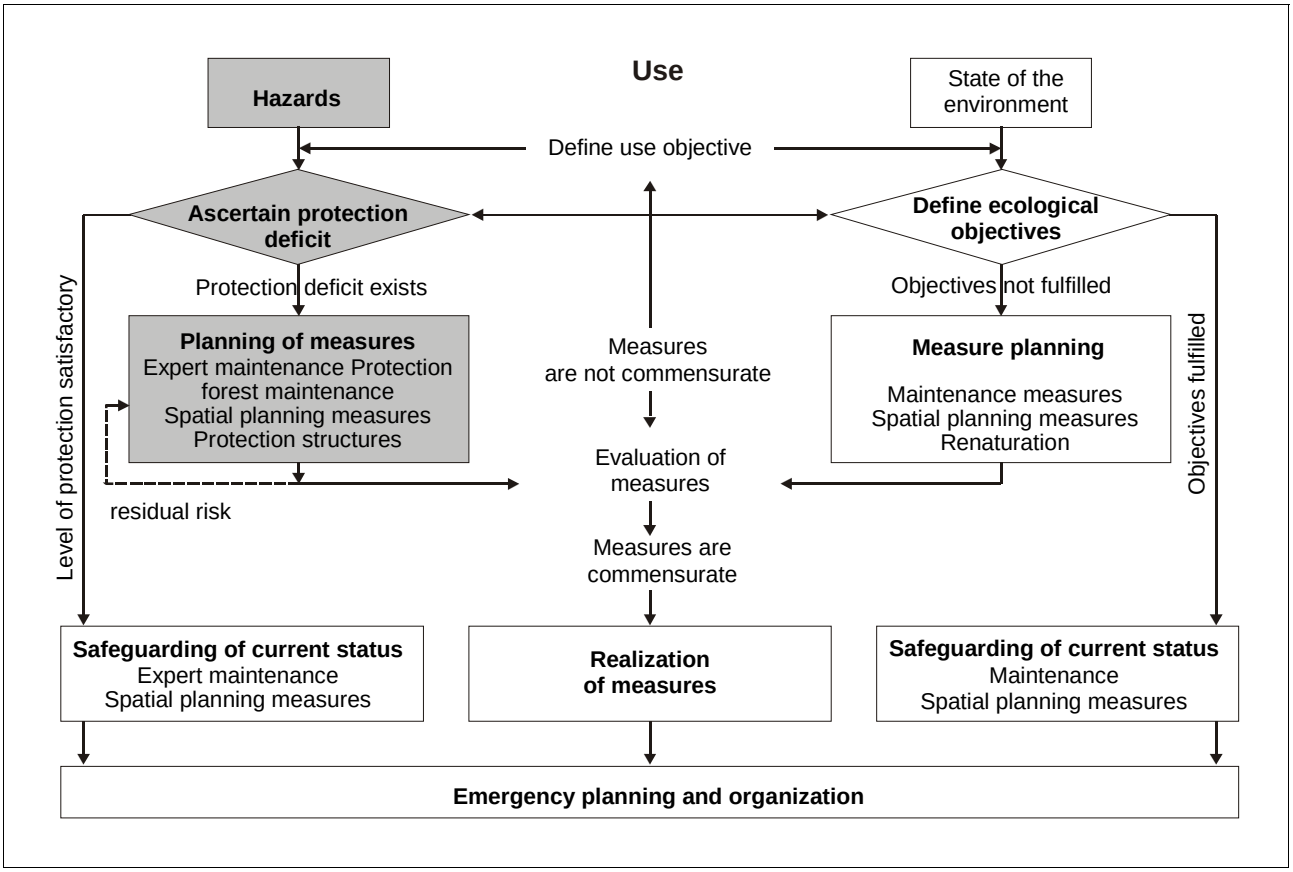

Figure 16: Protection concepts must provide integrated protection against natural hazards.

For reasons of sustainability and in the interest of safety it is essential that measures listed below for protection against natural hazards be implemented – in the listed order of priority:

- The use of areas at risk from natural hazards should be avoided.
- The effect of classified protection forests should be conserved and improved through maintenance and the establishment of new protection forests.
- Rural areas should be maintained through agriculture and forestry, in particular watershed areas that are prone to erosion.
- All land uses should be risk-appropriate.
- An increase in the risks arising from intensive land use and the associated increase in values in threatened settlement areas and along transport routes should be avoided.
- Organizational measures, such as early warning, evacuation, road closures etc., should be implemented.
- Flowing water bodies should be revitalized and additional retention areas created.
- Existing hazard protection structures should be maintained properly.
- New protection structures should be built.

Figure 17:
Along with other functions, protection forests make an important contribution to the protection of settlements and transport routes in remote Alpine valleys, for example Spiss in Austria and Samnaun in Switzerland.

10 Solidarity as a prerequisite for the protection of human life and infrastructure against natural

The mountain region is more vulnerable to natural disasters than the lowlands. This inequality gives rise to a continuing need for solidarity between the victims of natural events and those in the areas less vulnerable to risk who are not affected by them.

Despite the implementation of sensible precautionary measures, extreme events in the mountains can threaten lives and livelihoods – for it is simply impossible to provide 100% protection against natural hazards. This increased vulnerability to the effects of natural hazards necessitates solidarity between victims and those not affected, between areas that are less vulnerable to the risk of natural hazards and areas exposed to major risks, like the mountain regions. In addition to the land and property owners, storm and tempest insurers also have a key role to play here. The aim of this kind of solidarity, however, is incompatible with a system whereby the gains arising from the use of land in potentially threatened areas solely benefit the land owner while the state, insurance companies and aid organizations are expected to make provision for eventual damage. Social solidarity can only be guaranteed in the long term if it is not one-sided or subject to abuse.

In order to guarantee trust in the area of natural hazard prevention, when disasters occur, it is important to increase transparency with respect to the scope of the damage, the cost of remedying it and how this is financed. Close co-operation between the various donors – from the state to the insurance companies and charities – is essential.

11 International co-operation

The Alpine countries could benefit even more from the exchange of experience in the area of natural hazard protection and prevention, irrespective of the specific risk and the level of safety in question. The testing and joint development of sustainable protection concepts play a key role in this context.

In view of current social and climatic developments, all Alpine states must confront the problems posed by the risks arising from natural hazards if unpleasant surprises are to be avoided. In the case of more densely settled areas, more stringent safety requirements must be satisfied and the options for preventive spatial planning measures are extremely restricted. As opposed to this, there is greater scope for the adaptation of land use to natural hazards in less densely populated areas.

Irrespective of the specific risks and the levels of protection involved, the Alpine countries can benefit and learn from each other through the exchange of experience in the area of natural hazards. This is particularly applicable with regard to the central question of the sustainable design of preventive measures for the protection of human life and material assets, which concerns not only research, but also the various authorities and practitioners working in the field.

Not least for this reason, in its report on the avalanche winter of 1998/1999, the Alpine Convention working group requested that the standing committee to convene a meeting of experts for the discussion of the following questions:

- Have the limits of growth and tolerance been reached in the Alpine region?
- Which justified safety requirements for protection against natural hazards must be financed by the state?
- How can spatial planning and land use be designed in a way that takes natural hazards into account in the future?
- How can we promote holistic risk dialogue?

The Alpine Convention protocols on the mountain forests, spatial planning, mountain farming and transport provide an excellent basis for promoting co-operation and the exchange of experience on the protection against natural hazards beyond national borders – including at the level of administration and practice.

12 Recommendations to the Alpine Conference

The working group's recommendations to the Alpine Conference include the promotion of an integrated risk management which makes optimum use of the possible measures for the reduction of risk in the different areas of activity and tailors these activities to each other.

Based on the analysis carried out, the Alpine Conference «Avalanche, Floods, Debris Flows and Landslides» Working Group recommends the promotion of the following measures as a matter of priority:

- Promotion and support of the early recognition of the life-threatening hazards posed by climate change, and of avalanche, flood, debris flow and landslide hazards.
- Promotion and support of an integrated risk management that makes optimum use of the existing range of measures and tailors them to each other. This includes – in the area of prevention – land-use planning, protection-forest maintenance, renaturation of flowing water bodies, the construction and maintenance of protection structures as well as disaster management (intervention) and rehabilitation.
- Targeted and consistent promotion of a risk dialogue with all participants for the improvement of prevention in risk management and of risk awareness and acceptance among the general public.
- Guaranteeing, conservation and improvement of protection forest effects through suitable measures. It is particularly important that the rejuvenation of the protection forest be ensured.
- Conservation and creation of retention areas to reduce flood peaks, and the renaturation of water bodies.
- Promotion of the development of a modern computer-based hazard and protective structure register system as a basis for periodic analyses of the development of the measures implemented for the protection of human life and material assets. The documentation of events is the top priority in this context.
- Promotion of the knowledge required to guarantee risk-appropriate land use.
- Promotion of the transfer of expertise for the optimum use of all options offered by preventive measures such as spatial planning, protection forest maintenance, organizational measures, protection structures, precautionary measures for crisis management and rehabilitation, taking safety-technology, economic, ecological and social criteria into account. Early warning is the top priority in this context.
- Improvement of communication options for the promotion of cross-border exchange of experience at administrative level.
- Increased support of the bodies in the Alpine Convention countries responsible for the implementation of the «Avalanche Report 1999» ratified by the 6th Alpine Conference.
- Promotion of interdisciplinary education and training for dealing with natural hazards and the maintenance of watershed areas through the creation of corresponding post-graduate courses.
- Increase in the efforts to reduce the risks arising from anthropogenic climate change through the targeted and consistent promotion of sustainable develop-

ment which reduces the burden on the environment and ensures the careful treatment of non-renewable raw materials of limited availability.

- Sustainable provision of the resources necessary for optimum, integrated and holistic natural hazard management.

Annex

1 Resolution of the 6th Alpine Conference of 30/31 October 2000 in Lucerne, Switzerland

Item 8
Report on the Avalanche Winter of 1998/1999

The standing committee of the Alpine Convention set up an Avalanche Working Group with the task of compiling a report on the avalanches of the winter of 1999 (causes, effects possible consequences).

The avalanche disaster in February 1999 claimed 70 lives in the Alpine countries and caused material damage totalling almost CHF 1 billion. In addition to these costs, additional losses of almost CHF 500 million were sustained due to the interruption in the operation of companies and loss of revenue.

The enormous scale of the damage is not the result of neglect in the area of prevention, but of an extreme situation spread over an extensive area which, depending on the region, should only occur once every 50 to 100 years.

Previous prevention efforts proved their worth. The protection forests, early warning services and technical protection structures, such as avalanche barriers, provided the expected protection. However, the extreme situation brought weaknesses to light that must be corrected in the context of the future reduction of the risk of damage.

The working group recommends that cross-border co-operation be intensified. The aim of the joint efforts must be the further development of prevention work for the prevention of human life and material assets against avalanches, to be more consistent in taking natural hazards into account in the context of land use and to adapt preventive measures to current possibilities and requirements. Ecological, economic, social and safety-technology boundaries should be taken into account here.

Enclosure: «Report on the Avalanche Winter of 1998/1999»

Resolution

In mid-October, mud avalanches, debris flows and floods claimed lives in Italy and Switzerland and destroyed the livelihoods of many families. The Alpine Conference would like to express its solidarity with the affected populations.

1. The Alpine Conference hereby acknowledges and agrees with the *Bericht zum Lawinenwinter 1998/1999* (Report on the Avalanche Winter of 1998/1999). It considers the report as providing important information on the raising of the awareness of the population and visitors to the Alpine region. The Alpine Conference particularly welcomes the comprehensive analysis of integrated avalanche protection in the convention states and the recommendations to the governments of these states derived from this analysis.

2. The Alpine Conference calls on the parties to the convention to examine and implement all measures that could contribute to the strengthening of avalanche warning services and to the optimization of the early warning systems and to a uniform assessment of avalanche situations in the entire Alpine region.

3. The parties to the convention shall do everything in their power to design their sectoral policies in such a way that the protection of the populations and important material assets against avalanches, flooding, slides etc. is guaranteed, namely through the ratification and implementation of the «Mountain Forests» and «Soil Conservation» Protocols. This protection and prevention concept must also be taken into account in the convention parties' climate policy.

4. The Alpine Conference commissions the Standing Committee to create a platform for the fulfilment of the following tasks:
   - Convening of expert meetings and implementation of audits
   - Evaluation of the protection forests
   - Promotion of the exchange of experience and ideas

   By adopting a holistic approach, the platform shall ensure that protection against natural hazards is made more effective through:
   - the dissemination of information and coordination of communication;
   - provision of access to expertise;
   - the harmonization and standardization of reporting.

5. The mandate of the Avalanches Working Group is extended until the end of 2001 and extended to include the areas of «floods, debris flows and landslides».