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INTEGRAL NATURAL HAZARD RISK MANAGEMENT:

RECOMMENDATIONS

Platform on Natural Hazards of the Alpine Convention (PLANALP)

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Foreword

The task of the Platform on Natural Hazards (PLANALP), set up by the Permanent Committee of the Alpine Convention, is to monitor closely climate change and its effects on hazardous processes such as avalanches, floods and landslides. It is intended to provide the necessary decision-making information for the continued development of the adaptation strategies, as a basis for adjustments to hazard prevention in the Alpine region.

At the end of 2007, the delegates of the Alpine countries participating in PLANALP, taking note of the mandate received in Alpbach,[1] decided to focus on four of the most important problems of integral natural hazard risk management, which they designated as "Hotspots". Germany took on lead management for the "Climate change and natural hazards" Hotspot, France for "risk dialogue", Austria for "residual risk" and Italy for "land use". Switzerland took charge of synthesis and coordination work.

The continued development of the Hotspot Papers was discussed at five PLANALP meetings. The discussions were both engaging and challenging. Different legal foundations result in different prevention cultures. In drawing up the principles of reporting, the variety of technical disciplines, the different functions performed by PLANALP members, and the multitude of languages demanded mutual understanding and respect on the part of all those involved, enabling us, time and again, to find a common denominator.
The will to learn from and with each other facilitated much which had seemed unthinkable when the discussions first began.

This document presents a synthesis of the analysis carried out by PLANALP. The members of PLANALP are of the opinion that the work hereinafter proposed is valid in any given context; however, climate change projections justify more than ever before an integral approach to natural risk hazard management.

This document thus proposes some recommendations that each concerned actor will be able to extract useful information to apply to its own context, in order to improve, if necessary, the natural hazards management methods already existing.

[1] The Ministers of the Contracting Parties of the Alpine Convention decided to establish PLANALP during the XVIII Alpine Conference in Garmisch-Partenkirchen (2004, Decision n°10). In the IX Alpine Conference (2006, Alpbach), the mandate was prolonged and further specified.

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1 Hotspots in integral natural hazard risk management

The members of PLANALP have defined four priority action areas for prevention work against natural hazards. Described as "Hotspots", these areas of action represent the key elements of future work in the Alpine region.

1.1 Introduction

Safety is a basic human need and one of the key requirements for the welfare of society. The same applies to protection from natural hazards. The worrying increase in weather-related incidents in the recent past has made us painfully aware that we can never fully control the forces of nature.
Scientists predict a possible further increase in extreme weather and the associated natural hazard-related events over the coming decades as a result of climate change. Consequently, instead of spending large sums attempting to combat such events, we would be well advised, wherever possible, to avoid them in the future. This may also mean refraining from types of land use that place people and property at potential risk, if they cannot be protected at reasonable cost.

Based on different studies it has to be assumed, that the consequences of glacier melt and thawing permafrost, the frequency and magnitude of floods and debris flows, rock falls and slides, avalanches and the destabilisation of entire hillsides will increase the risk of damages caused by natural hazards. An increased occurrence of low tide periods or droughts is conceivable in some areas. A change in processes is also possible, such as debris flowing down torrents where only floods have occurred so far. The effects of climate change on the mentioned processes will impact differently on different regions.

The PLANALP platform within the Alpine Convention focuses on the principal, predominantly meteorologically-driven, natural hazards affecting the Alpine space, namely floods, debris flows, land slides, rock falls and avalanches.

The following "hotspots" were evaluated as areas in which priority action is needed:

- Climate change and natural hazards – **Hotspot 1**
- Risk dialogue – **Hotspot 2**
- Residual risk – **Hotspot 3**
- Land use – **Hotspot 4**

PLANALP also drew up potential problem-solving strategies in order to accelerate the development of solutions to these key problems. These strategies provided a basis for a set of conclusions and recommendations.

1.2 The basis of integral risk management

Integral risk management incorporates all measures that contribute to the reduction of damage caused by natural hazards. These include, for example, emergency management during disasters, the maintenance of protective structures, repair work, the maintenance of protective forests and structural measures. It is a fact that technical measures have a long tradition as counter-measures. In fact, early warning systems, hazard maps, organisational measures and other programmes were introduced as long ago as the 1960s.

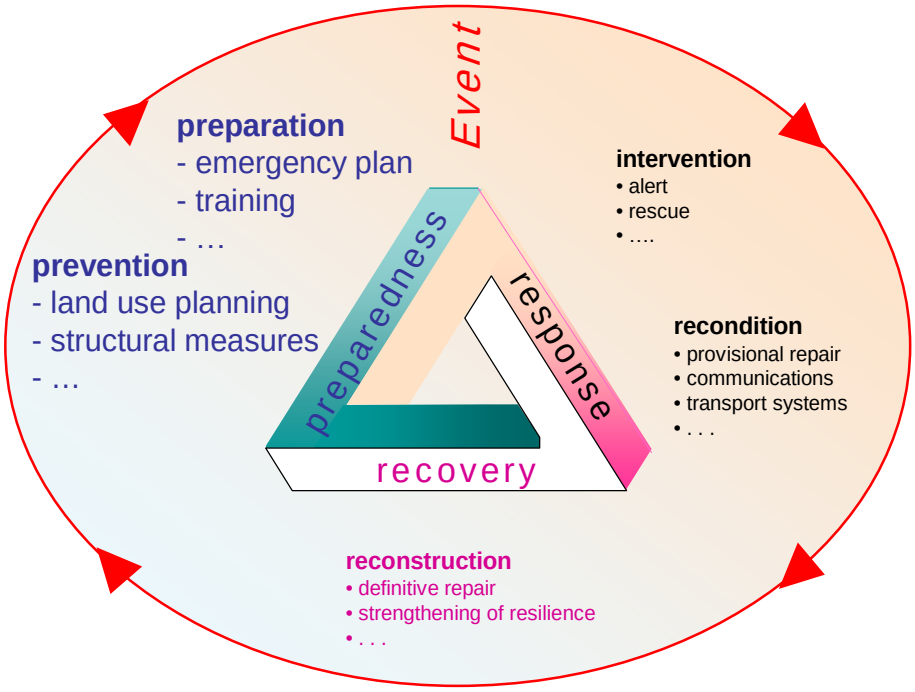

Figure 1: All activities are necessary to maintain security with regard to risks posed by natural hazards to humans and their infrastructures. The solutions on which to act are those that offer the potential for an integrated approach.

The aim of PLANALP is to support the management of risks caused by natural hazards in an integral way, to maintain such risks at a level that is accepted by society and that avoids increasing vulnerability.

2 Hotspots

Preventive protection against natural hazards is of existential importance to life in the Alpine region. On the one hand, the density of urbanisation, the number of important structural facilities, not to mention the frequency with which traffic routes are used, have increased sharply over recent decades. On the other, the safety requirements of business and society have also risen significantly. Climate change and the handling of possible hazard and damage scenarios pose a particular challenge to prevention work.
The priority objective of a strategy to adapt to climate change must be at least to preserve the current level of residual risk and to take new and additional action on safety in terms of organisation, planning and construction, as necessary.

2.1 Hotspot 1 – Climate change and natural hazards

According to the widely accepted ICCP report, climate change will take place, and the higher temperatures which it would generate must be viewed in tandem with a rise in Greenhouse gases emissions.
Producing a nuanced assessment of the potential consequences of global warming for meteorological phenomena at the national, regional or even local level is immensely demanding. This applies in particular to meteorological phenomena in the Alpine region, which will be hit more than most by climate change. In turn, a stronger and more frequent occurrence of extreme weather events is likely to exacerbate the impacts of natural hazards. Given this fact, it is especially important to define heavily future-oriented and effective adaptation strategies to protect people from natural hazards such as avalanches, land and rock slides, and flooding.

Introduction
Recent years have repeatedly witnessed natural disasters throughout the Alpine region. Examples include the exceptionally bad winter of 1999 and the catastrophic floods of 1999, 2002, 2005 – as well as 2007 in some areas. These events caused many deaths and losses that ran into billions of Euros.
As studies in recent years indicate, climate change is already in progress. An increase in global temperature of 1.8 to 4°C by the end of the century is predicted. The scenario: decline of precipitation in the Alpine region during summertime, whereas winter rain will increase seems to get some evidence. Some degree of

Figure 2: It may be assumed that climate change will bring an increase in extreme rainfall, which may lead to more widespread flooding.

uncertainty is still attached to every climate model, especially where regional analysis is concerned. It is assumed that the general trend is correct, however. Furthermore it is assumed that changes to the north, south, east and west of the Alps will differ, and possibly at the scale of valleys too.

Even if we do not yet have scientific proof of the effect of climate change on natural hazards, we must nonetheless assume that a more strong and frequent occurence of extreme events is likely to happen in the future.

The Alpine region is, has always been, and will stay, a sensitive and to some extent unstable system. Even small changes can have significant effects. Therefore, the extent to which climate change will influence natural hazards cannot be calculated precisely; only best guesses of risk and trend estimates are possible.

The core problem arising from this situation is that the present degree of protection decreases and, with it, safety. This condition is brought about by the overload of existing safety constructions, or new and dangerous situations in which areas that have previously been considered safe are now under threat.

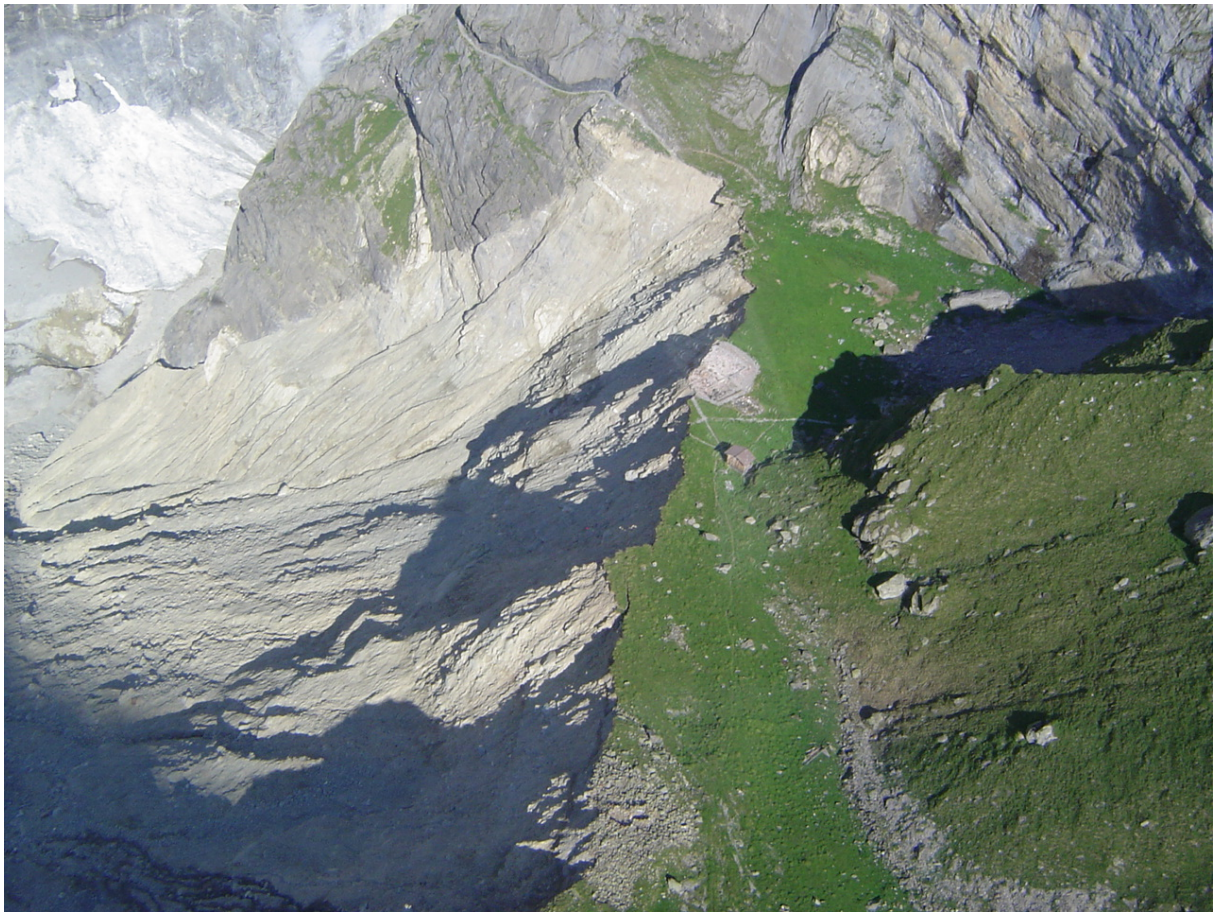

Figure 3: As the glaciers melt away, adjacent slopes may become unstable, leading to rock and land slides, subsidence and rock falls. The picture shows the Stieregg hut on the lower Grindelwald glacier. In the spring of 2005, the slope slipped so far down that the hut was partially destroyed (photo: Andreas Götz, FOEN, Switzerland).

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

Possible strategies and measures
Essentially, there are only two possible strategies:

- Measures to influence the extent of damage (reducing potential damage)
- Measures to reduce danger (reducing hazard potential)

The following catalogue of possible measures to reduce the risk caused by natural hazards is not given in order of priority**.** The extent to which climate change scenarios should be taken into account in planning such measures must be decided on the basis of regional knowledge and the corresponding bodies of data.

Reducing damage potential
- Develop and adjust consistent hazard maps as an important basis for adapted land use. These hazard maps must then be included in land use planning. Preserving threatened areas from any building development is still the best and most sustainable protection from natural hazards.
- If effective as well as efficient, improve early warning systems and perfect disaster operations, which can be put into action quickly and may help to improve safety generally.
- Maintain and check existing constructions to preserve their protective function and increase their degree of protection where appropriate to adjust to new situations. An overload capacity should be taken into consideration for new protective structures. Overloading should be considered and the residual risk estimated. If necessary, predefined discharges should be planned to check this loading scenario (including the impact of climate change). Predetermine several lines of defence to set priorities for emergency planning.
- Implement robust and adaptable protective systems which do not suddenly collapse under excess loads.
- Larger areas to conduct or retain water, sediment and driftwood are required; corridors must be kept free in case of extreme events.
- Provide the necessary human and financial resources. In this regard continuity is of special importance, even at "quiet" times.
- Integrate the public in a risk dialogue, particularly in terms of how to treat residual risks.

Reducing hazard potential
- Set up and continue natural hazard monitoring, e.g. measuring changes in the temperature of the permafrost. This must also include event documentation.
- Set up knowledge-sharing networks on regional, national and international levels that also highlight examples of best practice.
- Encourage individual responsibility on the part of those concerned, so that they take individual protective action or insure themselves against loss.

- Consistently practise compatible land use and, in particular, preserve and improve protective forests.
- Examine ways to optimise the control of artificial reservoirs and natural lakes in line with local conditions to improve flood protection or low-water regulation.
- Uncertainties related to natural hazards are considerable. All opportunities to manage and minimise residual risks must be taken (e.g. property protection measures, emergency planning and insurance).
- Forecasting is vital, but only when time for action can be gained. Improvements are necessary to deal with the inherent uncertainties in regional forecasting and to improve its reliability.

Risk management and preventive action

Common preventive action to reduce risk can be grouped into *non structural* and *structural* measures. The effectiveness of all measures depends heavily on precise knowledge of the territory and its dynamics, the ability to raise local awareness, and the quality and appropriateness of structural as well as non structural measures – not only as a factor of financial resources.

Objectives in dealing with natural hazards

The primary objective must be to maintain the Alps as a living and working space for people. The principles of an integral natural hazard risk management do not change even if we consider the worst possible climate scenarios. However, more attention must be paid to the aspect of management that involves thinking the unthinkable. We need solutions that at least maintain the current level of protection while at the same time, where necessary, reducing residual risk with new protective organisational, planning and construction measures. Particular areas of focus here are a risk-based decision-making strategy, as well as the implementation of sustainable solutions.

Figure 4: The strategy of allowing rivers and streams broader, undeveloped flood plains will make and important and lasting contribution to reducing the risk of flooding. The picture shows measures against floods in Schladming, Austria (photo: Styrian Government, Austria).

2.2 Hotspot 2 – Risk dialogue

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

Introduction

Serious incidents have been the main factor in increasing awareness and prompting the adoption of measures concerning major industrial or natural hazards.

Figure 5: To ensure that prevention measures have a sustained effect, authorities, politicians and society must be informed about the most important risks and how they are developing (photo: FOEN, Switzerland).

Industrial disasters in all Alpine countries, such as the explosion on 4 January 1966 in France, the explosion at a chemical plant in 1974 in the United Kingdom and the 1976 accident in the dioxin plant in Seveso, Italy, threw into sharp relief the inadequacy of the safety measures that were in place. They resulted in a variety of new legal foundations, such as the adoption in France of the act of 19 July 1976, concerning installations classified on environmental protection grounds (ICPE).

More recently, surveys in France revealed that half of the population living in areas prone to flooding were unaware of the situation.

Finally, the extremely important role played by the state and local authorities in risk management (prevention, protection and safeguard measures) in the past has contributed to a certain loss of a sense of personal responsibility on the part of the people themselves, who are either unaware of or simply neglect the individual steps that they themselves can take to enhance their safety and protect their property. The fact insurance companies in Alpine countries have increasingly taken responsibility - albeit to differing degrees - for the loss and damage caused by natural disasters has resulted in property owners increasing handing over their personal responsibility for loss and damage to the state and the insurance industry. This prompted France, for example, to restore the individual's central role in risk prevention with the 2004 Civil Security Act.

To ensure that prevention measures have a sustained effect, society and public authorities must be informed about the most important risks and how they are developing.

Prevention work should enable people to find out about the dangers to which they are exposed, the foreseeable damage, the preventive measures they can take to reduce their vulnerability and the protection and rescue measures implemented by the public authorities.
Risk awareness, familiarity with safety instructions and good preventive practices are essential factors in creating a climate of confidence, while minimising the number of victims and the consequences of any damage. It is the base of efficient and effective prevention work as well as to be aware of it's self responsability.

This is essential in helping people to overcome a feeling of insecurity and in creating a responsible attitude toward risks. It is also useful in building and maintaining an ongoing record of collective risks and, above all, a collective risk culture.

Risk communication as a basis for preventive work and risk dialogue
Risk communication and risk dialogue are important components in prioritised, risk-appropriate prevention work.
In France, the principle of a duty to provide information is laid down in the 1987 act, which states that "all individuals are entitled to information about major natural and technological risks to which they are liable to be exposed in certain areas of the country, and about safeguard measures".

Risk communication with the public can be built around two complementary approaches, *preventive information* and *preventive education*.

- *Preventive information* is the information that people are due as part of the effective management of major natural and technological risks.
- *Preventive education* is information on the prevention of major risks. This requires that safety training be incorporated into the teaching syllabus. It must cover the major risks and include the appropriate response for dealing with them. This training in risks and how to prevent them, particularly in the school environment, is a key element of the broader risk prevention system. By targeting a young audience, it also promotes a "risk culture".

Figure 6: Information boards, posters and flyers inform the population of current risks and how they should act.

Requirements for maintaining a risk dialogue
Information about risk must include:

- The nature of the risk and its implications: location, description, consequences (scenarios)
- The steps taken to solve the problems with prevention work
- Safety instructions and the appropriate response.

Since levels of knowledge and recommended safety instructions can change over time, the information must be kept up to date.

To achieve a high quality of information, the following questions must be answered:

- What is the purpose of the information: general information, familiarisation with risk, location, appropriate response, to motivate people to do something, etc?
- Who makes up the target group for the information: individuals, general population, holidaymakers, decision-makers, elected officials, etc?
- Which institution will be responsible?
- Who will do the work?
- Who will disseminate the information, and what is the appropriate method?

2.3 Hotspot 3 – Residual risk

Assessing natural hazards and the probability of their occurrence is an extremely demanding task. It always involves a degree of uncertainty with regard to forecast accuracy. The same applies to the assessment of potential damage to people and infrastructures, and the associated harm to the national economy. It is thus clear that incidents cannot be predicted exactly, neither can absolute protection from natural hazards be guaranteed. Even in hazard prevention work, we repeatedly face the challenge of how to deal with residual risk. The residual risk that remains even after protective measures have been put in place must simply be accepted. The assessment of residual risk is becoming increasingly important given limited options for incorporating natural hazard risks created by climate change into an adaptation strategy.

Introduction

"The actual magnitude of the "rest" of a risk becomes apparent only when it becomes a reality." (Wise saying)

The term "residual risk" was introduced to common parlance and public dialogue concerning natural catastrophes although its actual meaning is still elusive upon closer scrutiny. The term is often used as a synonym for the uncertainty which remains as regards the assessment of a hazard in spite of the safety precautions taken. In some cases it is interpreted to indicate that there is no such thing as "absolute safety".[2]

Figure 7: When dealing with natural hazards, 100% safety can only be achieved by avoiding the hazard area. Otherwise there is always a residual risk that must be countered by suitable means. (photo: Walter Arnold, Canton Uri, Switzerland).

[2] The term "residual risk" is explained in Annex 1.

Interpretation and sense of term "residual risk"

The term „residual risk" can not be defined in an unambiguous sense. Quite on the contrary the interpretation of this expression requires an understanding of the technical background and relevant environment in which it is used as well as the consideration of its conceptual components.

"Residual risk" related to natural hazards is composed of …

a. unknown (unpredictable) risks
b. unrecognised risks
c. deliberately accepted risks
d. risks, which are deliberately taken
e. negligible risks
d. risks caused by inappropriate safety measures.

The term "residual risk" **in a socioeconomic** sense may be narrowed down conceptually by

- describing a "tolerable" risk as measured against current social values.
- laying down politically/technologically the accepted residual risk by formulating protection targets.
- reducing the risk in the extent to which a person/society is willing to pay for having his/her/their safety interests met. The term "residual risk" **in a technical sense** is the risk which, in the respective special case, is hardly predictable by calculations or statistical methods and which is
- due to the failure of protective structures.
- due to a human error.
- due to uncertainty in predictions

In summary, these interpretations demonstrate that the term "residual risk" is by no means unequivocal and may evoke different connotations depending on the point of view. Thus, it is advisable to consider the background as well when using this term.

Functional approaches to "risk"

- Mathematical approach
  Probability calculation and games theory are important tools in mathematics for assessing risks as incalculable uncertainties without turning them into certainties. The way mathematics deals with risk is a naturalistic one: in probability theory the distribution of "natural" frequency is explored.
- Economic approach
  Mathematical probabilities found their first important application in economics. Probability theory was used to estimate risks and uncertainties. The term risk in its widest sense is of economic origin, pursuing the aim of hedging material and financial risks arising from entrepreneurial activities in the market.
- Technological approach
  In technology and in the wake of technological developments, the term "risk" has assumed a totally new dimension. The approaches to risk in technology aim to identify the risk sources, to qualify the risks which have been derived from them, and to develop measures to mitigate them. The economic dimension is reflected here in the cost-benefit balance whose strategic goal is, on the one hand, to reduce the risk of high costs and, on the other hand, to enhance efficiency.
- Ethical approach
  The ethical-normative approaches in risk ethics pursue the goal of determining the scope

within which experts' judgments are valid. Risk ethics is the normative dimension of the risk problem and poses itself the fundamental question "how safe is safe?" searching for possible arguments.

- Cognitive approach
  In risk theory there are a number of cognitive approaches. The aim of these approaches is to identify the subjective elements of risk perception and risk estimation. It is a fact that risk situations are becoming increasingly complex. Taking the right decision at the right time requires a high degree of rationality on the part of the stakeholders. It is not only crucial to reduce complexity but the way in which complexity is dealt with is equally important.
- Cultural – sociological approach
  In sociology, the chief aim of risk approaches is to offer a cultural explanation for risk perception and to define the specific features of risk behaviour. Humans, in order to survive at all, have to take risks of various kinds in their individual as well as their social sphere all the time. Thus, "residual risk" is also a social and cultural value. What is decisive is the acceptance of risk by society.
- Ecological approach
  The aim of ecological risk approaches is to bring about a rapprochement between risk research and environmental research. In their methodology, they use predominantly technological-scientific facts as employed in environmental policy. The question of how to assess the risks for a climate change and environmental pollution that have been caused chiefly by ecologically harmful technologies is the main issue here.

The Political dimension of the term "residual risk"

"There is no risk-free society" (proverb)

Both the frequency in the occurrence of natural hazards and their intensity are following a rising trend by global standards. Due to climate change, the incidence and severity of climate-induced disasters are likely to increase; human action has an adverse effect on these natural phenomena (IPPC, 2007) and increases, at the same time, the exposure to natural disasters.

In the industrialised countries, this trend is driven primarily by two developments:

- As economies grow, more and more assets are accumulated, and
- the areas for settlements and infrastructure spread into endangered zones.

In the less developed countries, these processes are overlain by strong population growth.

Thus, even if it is assumed that the level of endangerment by natural phenomena remains unchanged, the damage potential to the economy will increase.

The development of damage positional in Austria may serve as an example: In the 90s, the capital stock of Austria's national economy grew by 2.6% in real terms. By 2006, almost 6% of Austria's permanent settlement areas had become sealed up. With a daily land consumption of about five hectares, the sealing up of areas continues unabatedly, although the Austrian Sustainability Strategy has set itself the target of limiting it to one hectare per day. (The situation in other Alpine countries such as France, Switzerland, Germany, Italy and Slovenia is comparable.)

The question arises in what way private and public stakeholders should adjust their plans and behaviour to reduce the damage potential and consequently the residual risk. Dealing efficiently with natural hazards includes, inter alia, keeping the extent of the damage as small as possible and, in spite of a certain level of endangerment, carrying out as many economically profitable activities as possible. Efficient risk management contributes to keeping overall damage as small as possible at all phases.

The fact that entering into risk also offers opportunities for profit is a considerable obstacle to prevention work geared to sustainable development.

The legal dimension of "residual risk"

From a legal point of view, there is the concept of "permitted risk" or "socio-adequate risk", which excludes an objective breach of the duty of care.

What is decisive for a risk to be "permitted" is that the action which is associated with it lies within the domain of ordinary use and that it is carried out in conformity with the applicable rules. Thus, not every kind of behaviour which entails a risk and causes damage is, objectively speaking, necessarily unlawful. It is so only if it exceeds the risk tolerated by the respective legal system.

If "residual risk" (regarding natural hazards) is looked at from the technological point of view (e.g. frequency and intensity of endangerment in zones which are protected by defence structures), the focus shifts to the question of liability.

Damage caused by natural hazards and through no fault of humans ("force majeure"[3]) falls within the sphere of risk of the aggrieved party in principle only. Cases where the risk is shifted under the operation of law are pertinent only if natural conditions have been changed by human action. Compensation for damages must be awarded as a matter of principle if the damage has been caused by unlawful and culpable action.

It is generally acknowledged that whoever has created a source of danger or has opened up a building/property etc. for traffic has the duty to implement safety precautions and ensure proper upkeep, including the responsibility actively to prevent damage which may be caused by others. The theory regarding the duty to implement safety precautions and guarantee the proper upkeep of buildings etc. serves to ensure, in many cases, that the failure to take large-scale measures to avert damage is unlawful and thus liable for compensation for damages.

Risk management: Can residual risk be controlled?

Figure 8: Surveys of defence measures must always consider what happens in the case of overload. Flood control reservoirs and outflow corridors must be created in case structural measures prove insufficient for the scale of the incident (photo: Swiss Air Force, Switzerland).

Natural hazard risk management is geared to prevention aims in order to find an optimum combination of protective measures. To be sustainable, these measures must fulfil economic, technical safety and ecological criteria. A given defence objective can be achieved only via an interplay of monitoring, prevention, precautions and action as an incident occurs.

The planning, prioritisation and implementation of protective measures is thus based on methods for reducing dangerous situations in natural areas. Natural hazard management encompasses the identification of protection deficits, the assessment of the cost effectiveness of various protection

[3] Force majeure: An extraordinary event which does not occur or is not anticipated to occur at certain regular intervals and which can neither be avoided, not even by the exercise of all reasonable care, nor rendered harmless in its consequences; impacts from outside.

concepts, the selection and prioritisation of measures, the decision to carry out the measures and, finally, an implementation program. By making optimal use of the means available, the measures are suited to reducing the endangerment to a reasonable level, but not to eliminate it completely ("residual risk").

In practice the ability to control risks is very much related to the acceptance of the persons concerned or human behaviour in an uncertain (insecure) situation. Thus "management of risks" is also a psychological and cultural problem.
In order to be successful, risk management must be adapted to the social and cultural expectations of the people concerned and to their specific awareness/acceptance of natural hazards and risks .
If involved parties are to become affected parties, it is vital that a risk dialogue is held that targets participation on the basis of the findings of risk and cost-effectiveness analyses. Risks and risk reduction measures can then be analysed jointly in a participative dialogue among the involved parties, those with official responsibility, technical experts and those who can offer local knowledge and experience.

2.4 Hotspot 4 – Land use

Spatial planning is a key element in protecting against natural hazards. However, past experience has shown that it is extremely difficult – occasionally even impossible – to try to maintain existing, natural hazard-related risks at their current level using spatial planning tools. An even greater challenge is to mitigate the risks that already exist in the Alpine region, and to reduce the associated level of risk.

Introduction

All the disasters in the Alpine space, as well as around the globe, and their consequences, are examples which show that land use (sometimes land abuse) is a key element in the growth of risk, at a certain level of hazard.
Basically, land uses depend on both geomorphologic – climatic and social – and economic characteristics of the land. The latter include its natural resources and local environmental, cultural and traditional heritage.
Land uses change over time according to shifts in the ability and will of the population to exploit or, better, "use", its land following – and sometimes inducing – changes in the aforementioned parameters.
The progress of economic activity and wealth has so far resulted in a tendency to expand into land traditionally used for farming or grazing. To slow down this trend, recent policies have focused on recovering areas which have already been developed, such as disused industrial sites and poor-quality constructions. The concentration of human activity and services (including infrastructures) in valley areas and increased population mobility are contributing to the abandonment of marginal mountain areas. These areas may nonetheless be favoured locally as tourist resorts, which in turn often means environmentally costly infrastructures.
Any environment – even outside the direct reach of man and protected through national and regional parks (high mountain slopes, glaciers, forests, etc.) – interacts with human territory and activities. In fact, the way land is maintained, and any change of use, has a significant

impact not only on the space at the heart of such changes, but often much of the surrounding environment as well.
If we look at the changes across all regional territories (also including hill and flat areas), we see a marked increase in man-made areas and a decrease in farmed land. These changes obviously have a major impact on land management and on the distribution and level of risk.
Urban growth generally results in an increase in risk, by:

1. Occupying hazardous areas, hence increasing the value of exposed property
2. Helping to amplify the effects of hazard-generating phenomena, for example by reducing natural flood retention areas or by soil sealing.

Since a large body of evidence testifies to the relevance of the hydrogeological risk related to land use and land use changes in the Alpine space, it would seem appropriate to address this category of hazard, especially in the light of ongoing climatic change.

Strategies for appropriate land use management in respect of natural hazards

To reduce the harmful domino effects of land-use modifications, the most effective strategy would be based on a risk management plan which appropriately considers, and periodically monitors, all of the hazards and functions within a watershed or mountainous ares. The reconstruction stage also provides a fundamental opportunity to tune up structural and non-structural preventive measures and redefine land use where appropriate.

Figure 9: The most effective way to protect people and infrastructure against natural hazards is consistently to factor those hazards into land use planning.

<u>Mitigating the destructive effects of hydrogeological hazards: preventive measures</u>

In general, the component of land management aimed at protecting humans and human activities from hydrogeological hazards makes use of a fundamental preventive tool which:

- Recognises the territories potentially affected by such events and assesses their effects
- Identifies risk-prone areas, classified according to the level and type of risk
- Defines and implements an action plan to lessen, possibly neutralise, the most harmful effects of such events. The related measures may be a) non structural, i.e. impeding the increase in risk by forbidding new construction in hazard-prone areas; b) structural, i.e. engineering intervention to reduce or eliminate risk. These structures may range from levees, retaining walls, etc. to the removal of structures that are particularly vulnerable or causing additional hazards (e.g. obstructing water flow).

The effectiveness of this strategy depends heavily on its ability to influence, and possibly redefine, land use in the threatened areas.

Recognition of hydrogeological hazard-prone areas

Both deterministic and probabilistic methods are applied to evaluate the level of hazard in a given area. They are based on the knowledge provided by past events, forecasts of future meteorological input (basically, the amount of rain over a given time period, from hours to days), and some basic parameters about the territory, such as its morphology, lithology, permeability, and land cover. The latter parameters are to be treated as variables because of continuous changes in many catchment systems, from ski slopes to urban settlements, commercial compounds, factories, parking areas, bridges, roads, and even changes in forest management (maintenance, periodic felling, introduction of new tree species). They represent actual changes in land cover and morphology (buildings, landfills, roads, rectified river beds). They generally reduce permeability and the space available for flow paths, which are rigidly imposed. It should also be remembered that floods often originate upstream in the mountains, so that only an integrated approach that considers land changes over the whole system of sub-basins can predict future trends effectively.

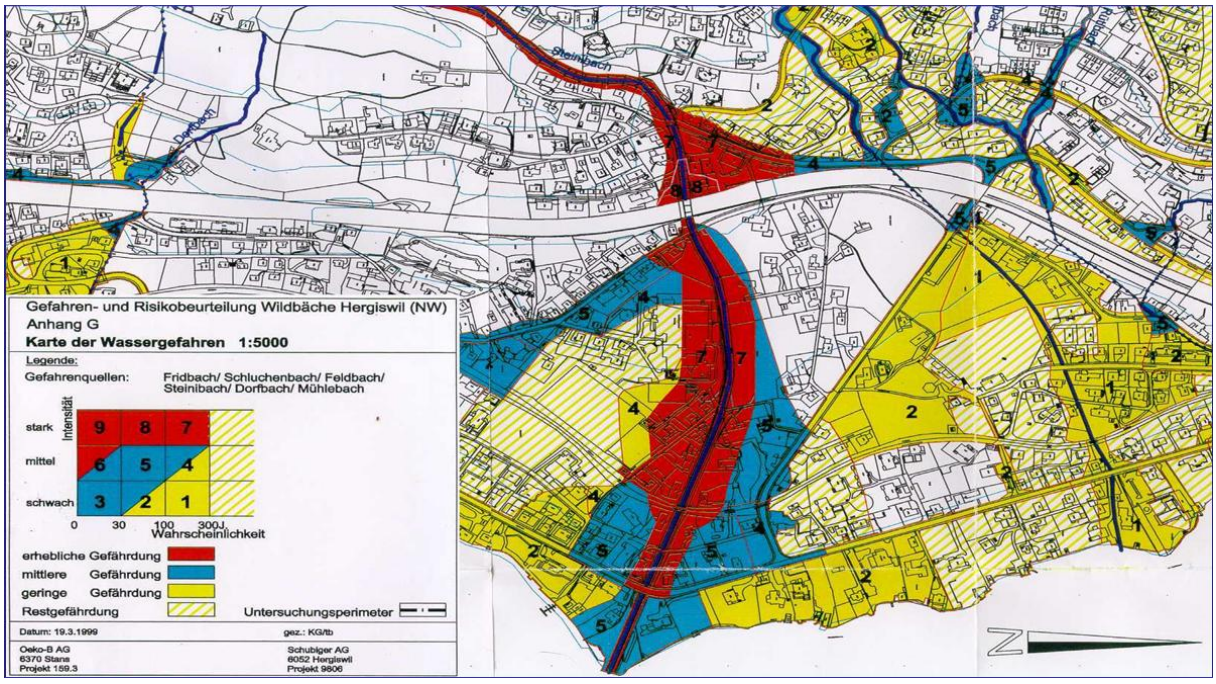

Figure 10: Hazard assessments, in the form of hazard and hazard intensity maps, constitute an essential basis for land use planning and integral natural hazard risk management. (Hergiswil, Switzerland).

Structural work and levees in particular are also an important change in land use which significantly alter fluvial dynamics locally and especially downstream. Identifying hydrogeological hazard-prone areas is therefore an extremely complex and never-ending task, requiring great attention to land use changes, both locally and up and down stream. Moreover, the probabilistic approach, which defines the recurrence interval of given rain/flow events based on the statistics provided by historical record, is flawed because there are clear climatic trends (changes), in addition to land use changes. As such, rather than occurring once a century, severe flooding might recur every ten years or so, or vice-versa. The easiest way to factor in such uncertainty is to base the model on longer intervals (more extreme

events), which results either in large areas being excluded from land use changes, or in the building of ever-larger preventive structures.
Landslides are localised phenomena, but they may have dramatic effects downstream should they dam valleys to produce ephemeral basins, or fall occur within a basin, as in the Vajont disaster in 1963. Thus, land use is relevant not only above a landslide-prone area but also downstream. In such cases, drawing the boundaries of hazard areas becomes an even more difficult task.

Multi-function and coordination

Land use is a typical example of multi-functionality. The enormous and widespread changes in the use of the Alpine territory since the end of the 19th century mean that land is now used for a number of activities, many of which were previously unknown in the local area. These activities often have contrasting aims and requirements.
The conflict of contradictory interests in land use and the exploitation of resources common to different economic sectors (tourism and recreational activities, infrastructure networks including transport, energy, agriculture, forestry, and industry) is an obstacle to the integrated management of natural hazards. Instead, a concerted effort to create synergies between all of the sectors involved is essential to promote truly multi-functional intervention. These are aimed at, for example, stabilising slopes in risk zones, reducing peak flow, regulating water resources, recovering abandoned territories, protecting/improving the landscape, creating nature reserves, establishing tourist/sport resorts, and building infrastructures (e.g. roads, railways, etc.).
To this end, considering that the financial resources allotted to hydrogeological risk mitigation are usually deficient, strategies aimed at obtaining an adequate flow of funds, either public and private, are necessary. As an example, in Italy the Basin Authority of the River Arno has defined a set of primary interventions for hydro safety that will interact and create synergies with other sectors that should contribute to their funding. Such works will include, for example, new and justified road connections along dikes bordering the flood retention plain, an international sports resort (rowing basin) within one of the flood retention areas, a reservoir, and an energy plant. Near the outlet, the extension and adaptation of a floodway, in addition to helping to mitigate the flood hazard in a large residential and industrial area, will also allow the transport of goods by boat, generating significant savings in terms of energy, emissions, road maintenance and safety.

Risk-based land use management: a major challenge for the Alpine region

The legislative and coordinative elements of land use planning lay the foundations for a use of space that is appropriate to the attendant level of risk. Only if risk-based land use management is driven forward jointly at national, regional and local levels, in collaboration with politicians, business and society, in a way that will develop its own momentum for the future, will it be possible to turn the potential damage generated by human interaction with natural hazards in to risk-based land use.

3 Conclusions for the future

Despite continued uncertainty with regard to the potential impact of climate change on natural hazard risk management in the Alpine region, possible climate scenarios must still be defined at regional and local levels. In cases in which the negative influence on human safety caused by climate change can be quantified, the results must implicitly be factored into plans for defence measures. If this is not the case, such risks must be regarded as residual risks, to be countered with appropriate monitoring and emergency planning.

The areas of action – or Hotspots – within the Alpine region that are determined under Point 2 lead us to the following conclusions concerning future preventive work in respect of natural hazards in the Alpine region.

3.1 Hotspot 1 – Adapting to climate change

1. Land use planning
Risk maps that plot natural disasters in the Alpine region must be factored in to spatial planning, in order to prevent further risk to the population in the future.

2. Knowledge-sharing, risk dialogue
Networks to share knowledge and experience at regional, national and international levels make a major contribution to knowledge transfer in the handling of natural hazards.
An appropriately focused risk dialogue that responds to society's needs can significantly reduce residual risk and damage.
Alongside all state and local authority endeavours, it is vital to effective risk management that acceptance and awareness of unavoidable risks from natural hazards are raised in order to stimulate a new approach to risk prevention that emphasises personal responsibility.

3. Monitoring, event documentation
Natural hazards in the Alpine region are caused by the interaction of complex processes that are often difficult to capture. Monitoring systems must therefore be set up – and maintained long-term – to improve our understanding of these processes. The consequences of climate change can already be seen today most strikingly in receding glaciers and thawing permafrost. Studies must nonetheless be extended to cover other areas such as flooding, mudslides, landslides and avalanches.
Event documentation and analysis is a very important element in this. We cannot draw conclusions about what may happen in the future if we do not understand what is happening now, and why.
Even more than in the past, governments must lend the necessary weight to cross-border knowledge-sharing about monitoring methods, as well as the attendant findings.

4. Early warning, disaster management
Every effort must be made to improve early warning systems. Although this may be difficult because structures in the Alps are often small, every opportunity must be taken to improve early warning.
In combination with early warning systems, the emergency plans of the competent disaster defence authorities must be updated and optimised continuously in close collaboration with

experts on natural hazards. The efficient use of defence forces can save lives and minimise damage.

5. Technical measures

Technical man-made defences will remain an essential part of risk management in the future. New structures, in particular, must be tested to establish the consequences of an overload. In some circumstances, predetermined breaking points may considerably reduce damage should the structure fail. Furthermore, structures should be as robust and adaptable as possible, without suddenly failing in the event of overload.

The maintenance of existing structures is a very important aspect of these technical defences. Man-made defences have been built in the Alpine region for some 150 years. They must continue to function and, were necessary, must be adapted to the present situation. This task will require major long-term funding in all Alpine countries.

6. Risk maps

Knowledge about events that have occurred in the past, as well as an analysis of at-risk areas from both the landscape and engineering perspectives, is indispensable in the prevention of natural hazards. Apart from hazards that are not specific to a particular area, such as hail, storm winds and earthquakes, most natural hazards such as flooding, mudslides, rock falls, landslides and avalanches are associated with specific localities.

Risk maps of natural disasters in the Alps provide a basis for consistent, risk-adjusted land usage and form an essential part of preventive action. The production and updating of hazard and risk maps form the basis of such action.

Mapping:

- The *management basin plan* is a cognitive and technical-operative tool to prevent hydro-geological risk. Its protective action is based on several basic components.
- H*azard maps* identify and classify hazard-prone areas.
- *Land use maps* give the information needed to identify and estimate exposed elements in the hazardous areas.
- The *risk map* is drawn overlapping the land use and hazard maps. It shows and classifies exposed property as a function of its risk level.
- Accurate and updated land use information provides detailed and reliable scenarios for elements to be protected, permitting adequate rules of land use to be drawn up.

7. Provision of resources

Political decision-makers must make the necessary human and financial resources available in the medium to long term in order to implement the measures that are needed. Taking the action that is required will cost more than EUR 1 billion per year throughout the Alpine region. We must take advantage of the quieter times between disasters, in particular. The next disaster will come – the only thing we do not know is when.

All in all, the task is to take the prevention strategies that are already being pursued to protect against natural hazards – those that were drawn up without factoring in climate change – and to implement them even more consistently on the basis of natural hazard risk management. Particular attention should be paid for the first time to climate change and the associated hazard potential.

3.2 Hotspot 2 - Risk dialogue

Risk dialogue is the key to risk awareness and fundamental to perceptions of personal responsibility.
The aim of a risk dialogue is jointly to find risk-appropriate solution for preventive protection against natural hazards. Responsibility lies with those who are affected, those with official responsibility, experts and society, politics, governments and researchers.

1. Informing and educating the population about major risks forms the basis of any steps taken to combat natural hazards

This may be undertaken for the following reasons:

- To improve local people's knowledge of the risks to which they are exposed and their consequences;
- To place the individual citizen at the heart of efforts to combat natural hazards; or
- In response to European directives on information.

Risk awareness, familiarity with safety instructions and good preventive practices are essential factors in creating a climate of confidence, while minimising the number of victims and the consequences of any damage.

This kind of information is called "preventive". It should enable people to find out about the dangers to which they are exposed, the foreseeable damage, the preventive measures they can take to reduce their vulnerability and the protection and rescue measures implemented by the public authorities. This is essential in helping people to overcome a feeling of insecurity and in creating a responsible attitude toward risks.

Preventive information is also useful in building and maintaining an ongoing record of collective risks and, above all, a collective risk culture.

2. Information on risks is aimed at the entire population

In principle, all individuals are entitled to information about major natural and technological risks to which they are liable to be exposed in certain areas of the country, and about safeguard measures[4].

Depending on the aim of the risk dialogue, there are two possible approaches to raising the population's awareness of risks and possible preventive measures. These are as follows:

- *Preventive information* is the information that people are due as part of effective management of major natural and technological risks.
- *Preventive education* is education aimed at the prevention of major hazards. This requires that safety training be incorporated into the teaching syllabus. It must cover the major risks and include the appropriate response for dealing with them. This training in risks and how to prevent them, particularly in the school environment, is a key element of the broader risk prevention system. By targeting a young audience, it also helps promote a "risk culture".

[4] Wording based on French legislation

These two approaches can be used separately or in combination as part of a targeted risk communication plan. Informing the public needs to be based on two complementary approaches: preventive information and preventive education.

3. The information must be complete, comprehensible and organised

Information about risk must be exhaustive and must include:

- The nature of the risks: description, consequences, location, etc.
- The steps taken to combat the risks
- Safety instructions and the appropriate response.

Since levels of knowledge and recommended safety instructions can change over time, the information must be kept up to date.

The following questions must also be answered:

- What is the purpose of the information: general information, familiarisation with risk, location, appropriate response, etc?
- Who makes up the target group for the information: individuals, general population, holidaymakers, decision-makers, elected officials, etc?
- Who is responsible for drafting and disseminating the information: the state (central or local government), the community (e.g. village), individuals, etc?
- How will the information be disseminated: posters/signs, leaflets, the media, languages, internet, etc?
- To increase efficiency, it is important to try to harmonise the different objectives, targets and dissemination methods.

French experience enables us to differentiate between the following:

- An inventory and description of the phenomena and risk management plans within a territory;
- Methods for informing the local population: posters/notices giving information and instructions about hazards, regular communication campaigns, improved cooperation when drawing up prevention plans, access to information online, etc.
- Maintaining risk memory: setting up flood markers, obtaining information from owners and tenants of a property regarding current risks and previous incidents
- Preparation and dissemination of weather bulletins (floods, storms and gales, avalanches), before and during an alert
- Training pupils in school.

Responsibility for this information falls primarily to the public authority – central or local – which holds the information and whose job it is to protect the population. When competencies are split between different bodies, the precise role of each must be clarified. The mayor is one central figure, but the state and the individual citizen also have their roles to play in the information system. Preventive education should feature on the school syllabus.

French experience enables us to differentiate between the following:

a) An inventory and description of the phenomena and risk management plans within a territory

For a regional or local territory, this involves identifying and mapping known or potential, technological or natural phenomena (flooding, landslides forest fires, avalanches, etc.),

their effects and the various risk management plans or regulatory measures implemented to prevent risk and ensure the safety of persons and property. The documents are public (freely available for consultation) and distributed to the stakeholders concerned.

b) Methods for informing the population
This involves making provision for and implementing various means of informing people in the exposed sectors. A number of options might be used: posters/signs, meetings, documentation, radio or TV messages, internet, and so on. Certain methods may become mandatory and systematic in certain situations. These would then be used to address the people, with no action required on their part. Other methods are available to the public who, in this case, are then required to take the initiative of seeking out the information. The various methods can be designed to complement each other.

c) Risk records
It is essential to keep track of known events that have occurred in the past.

3.3 Hotspot 3 – How to deal with residual risk

Residual risk encompasses a large number of hazard variables for which neither impact nor probability can be forecasted. Incidents that humans judge will not occur but must still be thought through so that they can be included in a risk-appropriate way into emergency planning. The disasters of recent decades have shown that almost nothing is impossible.

Recommendations on how to deal with residual risk primarily in flood protection
Recent natural disasters have demonstrated that there are natural phenomena which are beyond belief and that the forces of nature are able to destroy man-made buildings in spite of all efforts undertaken to protect them. Real casualties are the actual proof of “residual risks”. This means that there is no absolute protection; to a certain extent “residual risk” will always remain.
Protection goals in natural hazard management have to be adapted to this principle. These include, above all, the protection of human lives and of the means of subsistence, the mitigation of material damage, the safeguarding of rebuilding and the enabling of starting again from scratch as well as the sustainability of protection measures. In order to achieve these goals and to mitigate the damage as far as possible in case of future natural disasters, a great variety of precautions have to be taken.
The following strategic goals are highlighted (related to “residual risks”):

1) The limits of protection as well as the responsibilities of all parties involved must be clearly spelled out: Natural hazard protection is an issue which concerns everyone.

2) Promoting the knowledge about and the awareness of dangers: Risk communication is one of the most important and effective protection measures.

3) Providing hazard and risk maps in order to manage spatial development in regions exposed to natural disasters.

4) Safeguarding adjusted land use by spatial planning: The use of land must be adjusted to the prevailing hazards and risks at the site and not vice versa.

5) Encouraging incentive systems for self-responsibility and own precautions.

6) Recognising negative developments relevant for concerning natural hazards.

7) Coordinating all planning activities undertaken by the public authorities: Many conflicts of interest can be avoided by coordinating all the relevant planning activities.

8) Protective measures where necessary: Defence structures will fulfil their function of protecting existing settlements only if they are properly maintained and examined for their effectiveness and refitted on a regular basis.

9) Providing for emergency planning and disaster prevention measures.

10) Creating adequate framework conditions for financial provision, insurances and settlement of claims: Victims of disasters shall able make a new start after a disaster through savings, insurance and private or public assistance.

The principle for dealing with the problem of residual risk in an integrated natural hazard risk management process is basically independent of the type of processes involved. When making comparisons, however, it must be remembered that the quality of knowledge about individual hazard processes differs widely. For example, there is less uncertainty attached to the residual risks associated with avalanche hazards than is the case with mudslides.

Figure 11: Surveys of defence measures must always consider what happens in the case of overload. In this example, in a flood situation the water flow through the urban area is controlled to minimise damage. Studies have shown that the measures in place here averted considerable damage during the 2005 floods (photo: Swiss Air Force, Switzerland).

3.4 Hotspot 4 – Future land use management

The experience that has been gathered in the Alpine region over recent decades shows that land use planning must be lent even greater weight and implemented more strictly in the real world. Since assessing the risk associated with land use may be difficult for the competent bodies at local authority level, it is important that such assessments are promoted and supported by politicians, in tandem with the local authorities themselves.

1. Land use management

To allow sustainable territorial development, land administrations need planning tools that define rules at the local, regional and interregional levels for sustainable urban and industrial development, the exploitation and protection of natural resources and cultural heritage, and the safety of people and property from natural and man-made hazards.

Management plans, which are the common tool of land management, must always take into account different needs and must strive to establish the most appropriate land uses for a given territory. In reality, economic and social forces often push urban development on the one hand, while on the other, increasing attention is being paid to the protection of the environment and especially of the wilderness. These areas are now seen as part of the wealth of common heritage, and are often able to offer growth and wealth to local communities in many Alpine regions, without the disadvantages of industry or invasive tourist resorts – provided they are appropriately preserved or recovered where degradation has occurred in the past. In any event, a complex dynamic balance must always be sought between economic development and safeguarding ecosystems.

Thus, in general, planning strategies must analyse in detail the natural trend in the territory and select those uses which best permit its "exploitation", considering that, sometimes, the best use is non-use! The latter conclusion might be based not only on the will to protect particularly valuable environments, but also on a hazard perspective and the related potential risks and costs of their reduction, both environmental and economic.

2. Land use priorities

Land management should defend and, at the same time, improve the value of environmental resources. It should also avoid significant impacts on local economic growth.

The safeguarding of people and man-made structures, without overlooking environmental and cultural sites threatened by natural and man-made hazards, must be given the highest priority, with urban and infrastructural planning forced to adapt to such needs. In the future, the coordination of priorities in land use management must be discussed more and more on an interregional level.

3. Compensation and involvement

Very often, land management plans face opposition from local communities, essentially because of:

- Unsatisfactory compensation for the disadvantages to the community that is subject to specific works or restrictions
- The lack of – or even non-existent – involvement of local communities in the development process for the plans. This creates confusion and even open mistrust about new works or restrictions (even when they have a sound scientific and technical value). This often leads to strong opposition.

4. Measures

Hazard maps must be drawn up quickly so that hazardous areas can be avoided or, if they are already used, so that their use can be adjusted to the prevailing risk. It is essential that a potential damage map be drawn up assess the attendant risks.

4 Recommendations

In conclusion, it must be stated that the population, buildings and important infrastructure facilities can be protected effectively only if the authorities, owners, insurance companies and the population enter into a risk dialogue that targets existing natural risks and derives a plan of action. In drawing up this action plan, a comprehensive solution should be chosen that allows ongoing protection from natural hazards. Within the scope of the Alpine Convention, governments are required to give the following measures top priority:

Target

Safety is a fundamental condition for the development of the Alpine Space and its sustainable development. We should guarantee the same safety for everyone living in the Alpine Space.

Mitigation

- Reduce the burden on the environment by acting in a sustainable way. Treat non-renewable and limited resources with care.
- Ensure the long-term provision of the resources needed for integrated, holistic natural hazard management.

Adaptation

- Promote and support integrated risk management that fully exploits the potential of possible protective measures in a coordinated way. These protective measures include prevention (land use planning, care of protective forests, early warning systems, renaturalisation of waterways, protective structures) and disaster management (intervention), repair and rebuilding.
- Considering the possible increasing frequency and intensity of events, it is vital that existing and planned protective measures be reviewed in terms of the conceivable overloading of protective structures. Particular attention must be paid to the maintenance of protective facilities.
- Targeted, consistent risk dialogue with all of the parties involved in order to strengthen prevention efforts and promote risk-consciousness and the acceptance among the public of risk-appropriate action. Monitoring systems must be set up to keep risk situations under observation. These systems offer an important means of communicating risk.
- Promote knowledge to ensure risk-appropriate land use via targeted training.
- Promote and support the early recognition of potential hazards that are caused or influenced by climate change, such as avalanches, flooding, mudslide and landslide hazards.
- Finally, an information document should be created to draw the attention of those organisations and local authorities that are ultimately responsible for protection against natural hazards to the need for a risk dialogue about climate change and natural hazards.

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Platform on Natural Hazards of the Alpine Convention PLANALP

The contracting parties to the Alpine Convention delegated high-level experts to PLANALP in order to ensure effective networking and coordination of activities in the Alpine region and exert influence on national strategies. Andreas Goetz, a vice director of Switzerland's Federal Office for the Environment FOEN and the president of the Swiss National Platform for Natural Hazards PLANAT, has held the chair of PLANALP since 2005. PLANALP works closely with the relevant professional international and national institutions in this field. The platform consists of between 16 and 20 members with no more than two representatives (national and/or regional) per contracting party. Observers to the Convention may put forward two representatives selected by the observers themselves. PLANALP meets at least once a year in the country that holds the chair. An administrative secretariat assists the platform for the time being. It is affiliated to the secretariat of PLANAT Switzerland.
Further information: http://www.planat.ch >Alpine Convention

Alpine Convention

The Alpine States signed on 7th November 1991 the Convention on the Protection of the Alps, recognising the Alps as a unique, common area which needs a common development and preservation Policy.
The Alpine Convention reflects a global awareness of the importance of the mountains, defines our responsibility for the Alpine world and draws our attention to the potentials and challenges for the development of the natural, cultural and social patrimony. Its goal is to develop the common heritage of the Alps and preserve it for future generations through transnational cooperation between the Alpine countries, the regions and the local authorities and with the involvement of the scientific community, the private sector and the civil society. With this approach, the Alpine Convention is an example for other mountain regions and similar cooperation initiatives, such as the Carpathian Convention.
Further information: http://www.alpconv.org

Platform on Natural Hazards of the Alpine Convention PLANALP

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Annex 1

Considering this obvious confusion of idea a closer analysis of the term “residual risk” is justified. The definitions and arguments should serve for the conceptual clarification in the technical and political discussion.

Definition of terms

Residual risk is the risk which remains after all protective measures have been implemented and is closely related to the question which risk is accepted by the individual or by society.

- *Protective measures* generally aim at reducing the endangerment to a reasonably acceptable level, but rarely can it reduce it to zero.
- The decision of which risk is *acceptable* depends on objectifiable, economic, social and ecological factors.
- Thus, residual risk is a function of the individual or collective acceptance of a risk and, consequently, difficult (or impossible) to describe in mathematical or actuarial terms.

To reveal the underlying meaning of the term “residual risk”, the most important ***definitions of related terms*** are summarised below:
Hazard is a condition, situation or process from which damage may arise for humans, the environment and/or material goods.
Endangerment is a hazard which relates concretely to a certain situation or a certain subject/object.
Risk
(in a wider sense) is the possibility that a condition, situation or process may cause some damage.

(in a narrower sense) is the magnitude (intensity) of a potential damage and the probability of its occurrence.

- The definition of risk refers to dangerous situations which may entail adverse consequences but do not inevitably have to do so.
- A distinction is made between the risk to which an individual person is exposed (individual risk) and the risk to which a community as a whole is exposed (collective risk).

Technical risk is the exposure to loss arising from activities such as design and engineering, manufacturing, technological processes and test procedures.
Protection is the entirety of measures or natural conditions which mitigate an existing hazard (risk).
Safety is defined as a status for which the remaining risk (residual risk) is rated as being acceptable.

- Protection is the reduction of the risk by measures which either decrease the occurrence of the damage in frequency or in extent or both.
- Thus, safety and protection are not absolute but relative quantities.
- Protective measures must enhance safety.

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Risk assessment is the process od analyzing and evaluating the probability of adverse effects caused by natural hazards.
Risk acceptance is an informed decision to accept the consequences and the likelihood of a particular hazard.
Risk aversion is the desire to avoid uncertainty. (The term is related to the behaviour of people under uncertain conditions.)

To elucidate the divergence between (technical) „risk assessment“ and “risk acceptance” the following examples are given below:

Damage event 1: every year a small accident with 3 fatalities for a period of 100 years.

Damage event 2: a major accident with 300 fatalities once in 100 years.

The risk would be exactly the same in both cases, but the acceptance of major accidents is generally lower (risk aversion).