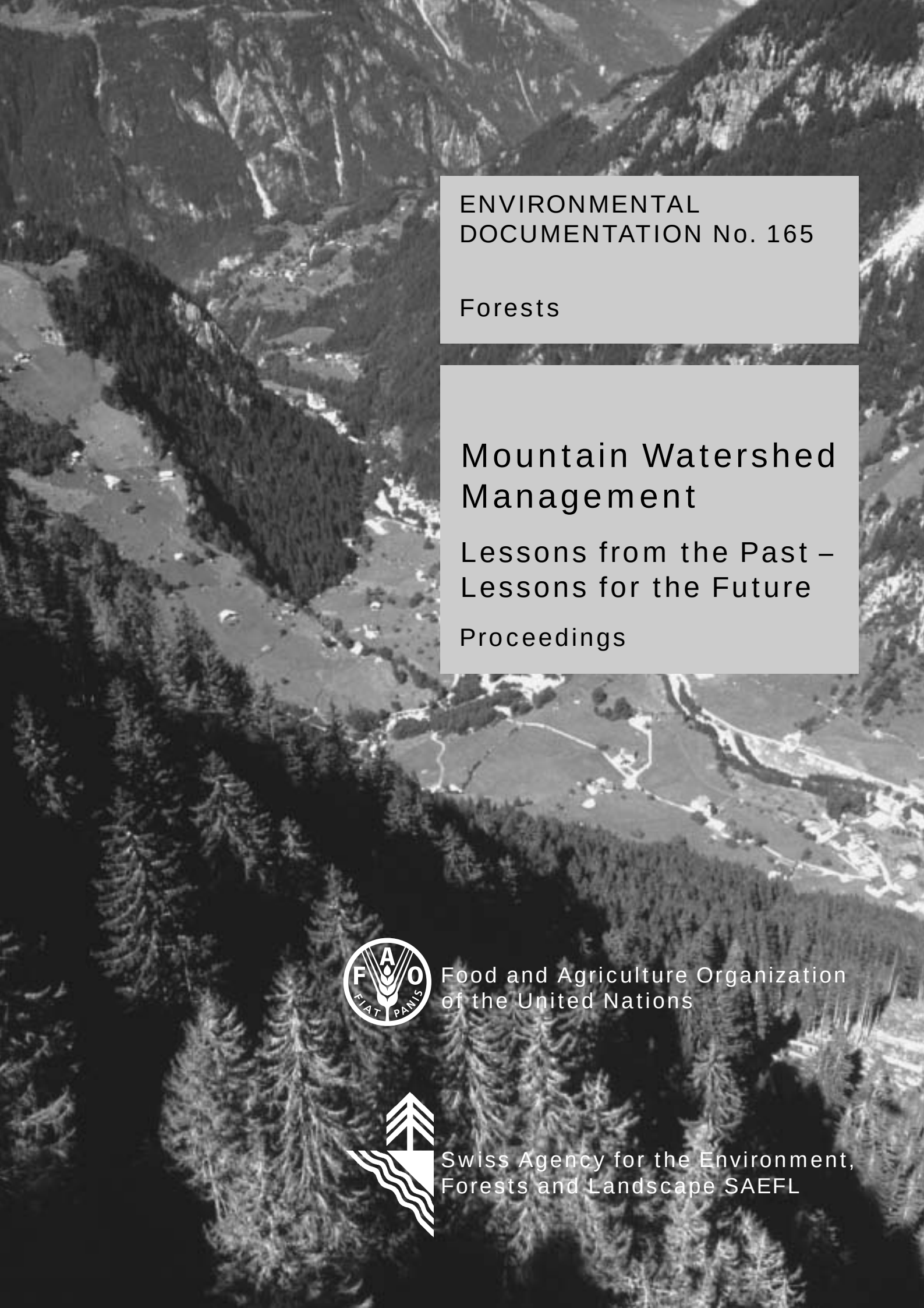


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Forests

Mountain Watershed Management

Lessons from the Past – Lessons for the Future

Proceedings

Food and Agriculture Organization of the United Nations

Swiss Agency for the Environment, Forests and Landscape SAEFL

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on Mountain Watershed Management

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Foreword

The **Working Party on the Management of Mountain Watersheds**, a working group of the European Forestry Commission (EFC), has been in existence now for 50 years. At its biannual sessions throughout this period, the Working Party has discussed themes of contemporary relevance in the areas of protection against natural hazards in the Alpine region as well as environmental problems in mountain watershed areas in general. The Working Party has also fostered ongoing opportunities for contact between professionals working in these areas and this, in turn, has facilitated the promotion of the exchange of information and experience beyond subject, institutional and national boundaries. It was therefore a great honour for Switzerland to host the 23rd Session of the Working Party in Davos in September 2002 and at the same time celebrate the 50th anniversary of the Working Party.

The Davos Conference can be deemed an unqualified success. Attracting participants from 14 countries, the Conference marked a clear change in direction towards the involvement of a greater number of countries, if compared with the previous conferences in 2000 and 1998.

The Working Party's 23rd Session also demonstrated that particular attention needs to be paid — beyond the borders of Europe — to rural development in the Alpine region and in mountain regions, both in the context of the sustainable development of the mountain regions themselves and the general development of <<subjacent regions and countries>>. Whether related to reservoirs or erosion and torrent catchment areas or seen in terms of guaranteeing the quality of our drinking water, the state and development of watershed areas has a crucial role to play in the development of mountain regions.

Thanks to Switzerland's efforts, the Working Party's insights were also included in the Ministerial Declaration issued at the Kyoto World Water Forum. According to this Declaration, the sustainable supply of high-quality water should be guaranteed through the protection and sustainable use of the ecosystems that absorb, filter and store water such as forests, wetlands and soil.

As the Davos Conference clearly demonstrated, much can be learned from past events and man's previous experience with natural processes, and this knowledge can be put to even greater use in the future.

What is certain is that an increasingly modern service society such as our own must approach the risks created by man with a greater awareness of the environment.

We must ask ourselves the following questions, continually and in all areas of life: Which risks are we willing to bear and to what extent? What would it cost us to reduce these risks? And will these actions contribute to the sustainable development of the mountain regions? This last question also applies to the management of watershed areas in those regions where the forest is an important and influential factor.

The Working Party on the Management of Mountain Watersheds will also tackle this theme in its future work. An opportunity to do so has already been created with the announcement of the Working Party's next session in Krakow, Poland in 2004. The work arising from the Krakow session will also contribute to the resolution adopted in Davos.

Swiss Agency for the Environment, Forests and Landscape (SAEFL)	Forestry Department Food and Agriculture Organization of the United Nations
Ph. Roch *Director*	*M. H. El-Lakany* *Assistant Director-General*

A Invited papers

1 Welcome addresses

Josef Krecek
Chairman
of the Working Party
Department of Hydrology
Czech Technical University
in Prague

Ladies and gentlemen, dear colleagues,

It is my great pleasure to welcome you in Davos. I feel honoured to open the 23rd Session of the EFC/FAO Working Party on the Management of Mountain Watersheds. This year, the Working Party reached a remarkable anniversary: the international co-operation on the field of mountain hydrology, risk assessment, control and prevention of natural hazard in mountain watersheds exists already over the period of the 50 years.

I am very pleased that Switzerland is the host country of this jubilee session. Switzerland is widely known as a home of the mountains. However, in Switzerland at the end of the 19th century, the paired catchment experiment at Rappengraben and Sperbelgraben introduced a new approach of research on impacts of forests on hydrological phenomena in the mountains. For the period of more than one hundred years, Swiss hydrologists and foresters have been involved in the leadership of internationally sound programmes on mountain hydrology, risk assessment, control and prevention of torrential floods, avalanches or landslides in the mountain terrain. At least one name I would like to mention now: Dr. Hans Keller, chair of the IUFRO Working Group on Forest Hydrology, who significantly contributed to the interdisciplinary oriented research on the field of alpine hydrology in the second half of the 20th century.

During the last 50 years, the mandate of the Working Party have been modified with changing highlighted tasks of the society in the dominant mountain regions within Europe. The priorities have been developed from the control of avalanches and torrential floods by the reconstruction of mountain watersheds after the World War II (1952–1960), respecting the socio-economic aspects in different regions (1960–1970), stressing the environmental impacts of technical interventions (1970–1980), transferring the knowledge to developing countries (1980–1990), the reconstruction of deteriorated mountain watersheds of East European countries in the post – Soviet era (1990–2000), finally, to the integrated management of mountain watersheds addressing all the aspects of mountain environment, including the sustainable development of the society, and upstream – downstream solidarity.

Nowadays, in mountain watersheds across Europe, relatively new environmental problems (global climate change, toxic atmospheric deposition etc.) are significantly changing the periodicity of extreme hydrological events. Facing this new situation, an important advantage of the Working Party is just the long-term tradition and experience.

My particular thanks go to all the colleagues who participated in activities of the Working Party within the last 50 years, to the FAO Forestry Department providing the Working Party with an organizing secretariat, and to Switzerland, the host country of the twenty-third session.

Dear colleagues, let me to wish you a successful session and enjoyable stay in Davos. To the future of the Working Party, I would like to wish you enough human resources to negotiate effectively the forthcoming urgent targets on the management of mountain watersheds.

H. El-Lakany
Assistant Director-General
Forestry, Food and
Agriculture Organization
of the United Nations

Ladies and gentlemen,

It is a great pleasure to be here with you today and an honour to be representing Mr. Hosny El-Lakany, the Assistant Director-General responsible for Forestry at FAO, during this special 50th anniversary session.

To all those who have worked so hard to organize this event, I offer my sincere congratulations.

A 50th anniversary is a time for celebration and reflection. As one of the longest-standing, hardest-working technical bodies in history, you've done a great deal to improve knowledge of mountain watersheds, not just in Europe, but world wide. Because of your efforts, policymakers, politicians, scientists and many others have a better understanding of the importance of managing mountain watersheds to prevent avalanches, floods and other natural disasters, benefiting mountain communities as well as those who live in lowlands.

You have accomplished so much in this half century. Yet there is still much work to be done. Particularly, in light of recent disasters, such as the floods and avalanches we've witnessed this past year in many parts of Europe.

The need has never been greater.

Neither too has there been such a significant opportunity for the Working Party to make great strides towards achieving its goals.

The reason is the confluence of two major events: the International Year of Mountains 2002 and the International Year of Freshwater 2003.

As you know, FAO is the lead agency for the United Nations International Year of Mountains. We are honoured to do this work and see it as an essential extension of our responsibilities as task manager for Chapter 13 of Agenda 21, the global blueprint for sustainable mountain development that evolved from the Earth Summit in Rio in 1992. This work furthers our global responsibilities for forestry and watershed management, and our commitment to alleviate hunger and poverty throughout the world.

Indeed, at FAO we believe our work in mountains is crucial to global security. Like the earth's oceans and rainforests, mountains are fundamental to life itself. More than half of humanity – three billion people – depend on mountains for safe, fresh water to grow food, to produce electricity, to sustain industries and most importantly, to drink.

Mountains too are host to more biodiversity than any other single ecoregion on the planet, including lowland rainforests. Not simply steeper or higher versions of ecosystems found in lowland areas, these unique landscapes harbor much of the

world's remaining biological heritage, including many species of plants and animals found nowhere else.

Yet as diverse as mountain ecosystems are, in reality, mountains are exceedingly fragile. Each day, climate change, pollution, as well as exploitative mining and unsound agriculture practices, take a toll on mountain environments.

Through the International Year of Mountains, millions of people worldwide have come to understand that most of the Earth's freshwater comes from mountains – and that mountain forests are crucial to ensuring and controlling that water supply. Next year, the International Year of Freshwater will hammer home the relationship between mountains, forests and water.

This means, of course, that your work has never been more relevant or so important to so many. Because of your efforts, many governments now understand the relationship between mountain forests and climate change, mountain forests and biodiversity, mountain forests and water, mountain forests and tourism. They also see the links between uplands and lowlands.

Now, it's up to you to decide how you can best share your technical expertise and understanding with others – and to influence the world's reaction to climate change, biodiversity loss, water scarcity and many other issues of global importance.

Just a few weeks ago in Johannesburg, at the World Summit on Sustainable Development, a number of countries, UN Agencies and international organizations launched the International Partnership for Sustainable Development in Mountain Regions.

The partnership is structured to ensure multi-stakeholder participation and long-term approaches. It is also conceived as an evolving alliance with the flexibility to address the complexity, diversity and magnitude of mountain issues. For example, partners may come together to consider ways to better protect biodiversity, to develop laws and policies in support of community-based property rights, or to implement strategies that support sustainable farming practices.

Plans for the Partnership will be further defined at the Bishkek Global Mountain Summit, 28 October to 1 November in Bishkek, Kyrgyzstan.

When we meet again in two years time, I believe that I will be able to tell you that the Partnership is strong and changing the course of mountain development so that all people – highland and lowland – benefit from the resources and services mountain watersheds provide.

Ladies and gentlemen,

During that time, I believe the Working Party can play a significant role by:

- encouraging increasing representation from government policy decision-makers
- sharing all that you've learned in 50 years with others beyond your borders who would benefit greatly from your experience
- supporting education efforts that lead to better understand and support from lowlanders
- and finally, to be vigilant in your efforts to continue your work as researchers, particularly as we witness the increasing effects of global climate change

The momentum is here for us to build on. The stage is set. I look forward to working with you in the next few days to establish our agenda within this new and exciting context.

Thank you.

W. Schärer
Director
Swiss Forest Agency
SAEFL
Bern

Honorable chairman, ladies and gentlemen, esteemed colleagues,

It is an honor and pleasure to welcome you all to the 23rd Working Party of Watershed Management. Given that this is UNESCO Year of the Mountains and in view of the fact that this working group has been in existence for 50 years, I am particularly pleased that you chose Switzerland as a venue for your conference. As a small Alpine country in central Europe, we truly value the opportunity to exchange information and experience with representatives from other countries that face the same or similar problems as we do. We can and must all learn from each other so as to make a positive joint contribution to the future management of mountain regions.

The serious flooding in Europe this year brought home to us once again that natural disasters repeatedly occur on an unimaginable scale leading to death and destruction. And this happens in spite of all the efforts made to prevent such catastrophes. I would like to wish the delegates from the countries affected by this summer's floods courage and success in the clean-up effort and in the creation of flood protection plans which are an integral component of watershed management. With its theme of «Lessons for the Past – Lessons for the Future», this conference would like to make its own contribution towards ensuring that we improve the ways we deal with our responsibilities in this context.

The conservation of mountain regions that are viable and capable of sustaining life

The topics dealt with by your working party and indeed its significance have undergone quite a transformation in recent decades. While in 1952, the main concern was the exchange of information and experience in the aftermath of the winter of heavy avalanches of 1950/1951, today, the main focus lies on the comprehensive protection of human life against natural disasters and the protection of water in the watershed areas of the lakes and rivers in mountain regions in as natural a way as possible. On the other side of the coin, the use of mountain regions must be restricted so as to protect nature against human intervention. This conflict poses an enormous challenge to all those involved in the future management of mountain regions. It is only when we set ourselves this challenge that it will be possible to preserve the Alpine mountain regions as viable locations that are capable of sustaining life.

It is our firm belief that in those cases, in which snow, ice, water, driftwood and riverwash pose a threat to the safety of subjacent settlements and infrastructure, only intact river and stream watersheds can limit the danger of landslides, debris flows and flooding.

While food and timber production used to be the driving forces that ensured the existence of intact, viable watersheds that are capable of sustaining life, today, it is the stringent requirements for protection against natural hazards and the attractiveness of the mountain landscape that require the targeted use of these traditional

landscapes and thus also the protection of man and his material assets against the forces of nature. This does not mean, however, that there is no place for natural refuges such as national parks, large-scale nature reserves or biosphere reserves.

Climate change – a challenge for the future management of mountain regions

The way we deal with the influence of climate change on the weather and its consequences for watersheds represents a particular challenge. Reputable experts are today convinced that the frequency and scope of major natural disasters will increase drastically throughout the world in the future. The intensification of storms and rainfall and the rise in sea level are a consequence of global warming.

As experts in the field, you will take this problem seriously. The scope and variety of the tasks you face is certainly not about to diminish.

Protection against natural hazards

Both the global statistics and those for Switzerland show that storm damage repeatedly occurs in locations where avalanches, debris flows, rockfalls, rockslides, landslides and flooding have been part of the landscape and its natural development for centuries.

In using the Alpine regions, human civilization has been confronting the forces of nature since time immemorial. The extreme weather conditions combined with the steepness of the terrain and its susceptibility to erosion are responsible for the more or less distinctive dynamics of the natural processes. There has been a dramatic change in the potential for risk over the past hundred years. Around 1900, the threat in many places still centered on the extensive over-exploitation of mountain forests which resulted in the inadequate protection of settlements and transport axes against avalanches, rockfalls, landslides, flooding and debris flows. The situation in the mountain forest is completely different today. Stringent provisions in the forest legislation have led to the elimination of this over-exploitation. In fact, timber reserves have increased so much that Swiss mountain forests have become overmature and are in part under-used. Despite this, however, the potential for damage in Switzerland continues to increase, particularly as a result of the increasingly intensive use of threatened areas and the associated increase in their value, and also as a result of increasing mobility.

Thanks to the construction of kilometre-long roads and railway tunnels, galleries, bridges, cable railways, avalanche barriers, rockfall nets and dams, new settlement areas, recreation zones and transport links were made accessible in the Alpine region which were previously virtually inaccessible and believed to be extremely dangerous. Thus, around one million people in Switzerland today live in areas which are repeatedly exposed to the threat of natural hazards and subject to the damage they cause.

While in the past avalanches and debris flows in the mountains only represented a threat to the Alpine farm buildings, pastures and cultivated land that were used on a seasonal basis only, today we have residential buildings, important transport and transit axes and tourist infrastructure there that is used throughout the year. Furthermore, the settlements have been developed in attractive locations on the banks of rivers and lakes.

Safety at any price is an illusion

The current increasing number of extreme meteorological events and their destructive consequences clearly demonstrates that even a rich industrialized country like Switzerland with its highly developed safety technology cannot guarantee absolute protection against natural hazards.

For example, here in the typical Alpine canton of Graubünden, 450 natural hazard spots have been identified along the 1,600-kilometre-long road network. For financial, technical and ecological reasons it would be simply impossible to attenuate all of these risks with the help of construction measures or to protect the actual transport links.

In addition to this, we face the fact that the general public's awareness of the limits of technical feasibility is declining. The population in the mountain cantons also wants roads that can be safely used around the clock, irrespective of climatic and topographical conditions. Today, the availability of such services is seen as an automatic right.

There is an increased focus on individual freedom and self-interest while individual responsibility takes a back seat. The prevailing attitude is that nature must subject itself to the requirements of man.

Indeed, the increasing willingness to voluntarily confront the risks posed by natural hazards is witnessed in the creation of endless new adventure sports such as canyoning, off-piste snowboarding etc. A corresponding increase in fatalities can also be observed.

Priorities in the protection of human life and material assets

The aim of the public authorities is to ensure the implementation of a consistent standard of safety throughout Switzerland using cost-effective measures. This means that sources of danger and areas at risk should be identified in good time and the emergence of potential natural hazards shall be minimized through timely preventive measures such as protection forest maintenance and integrated watershed management.

Along with this, where possible, areas that are potentially at risk should be avoided and where this is not possible, the land use should be monitored from the perspec-

tive of risk protection so as to counteract the steady increase in the risk is limited through suitable use. Early-warning systems and protective structures should only be used in situations, in which there is no alternative course of action. It must always be kept in mind, however, that the use of these technologies also involves maintenance measures.

The mountain forests, and particularly the protection forests in the watersheds of the rivers and lakes, are crucial to the ability of mountain areas to survive and conserve their quality of life.

There is also a need for action in the Swiss protection forests because, firstly, their regeneration is insufficient and, secondly, the timber reserves are already so high as to prompt an increasing destabilization of protection forest stocks. This could lead to a dangerous proliferation of driftwood and the corresponding threat of jamming, particularly in mountain streams.

Through the maintenance of protection forests, the forestry services in Switzerland make an important contribution to the conservation of the traditional landscape in the Alpine region with its mosaic of meadows, pastures, fields and forests. Today, the prevailing trend involves increasing interdisciplinary co-operation with other actors from the agriculture, spatial planning, transport, hydraulic engineering and tourism sectors which have an equal stake in the sustainable development of the mountain regions. With their extensive training, excellent powers of observation, comprehensive organizational structure and strong local presence, detailed local knowledge and close relationships with communities and land owners, the forestry services make an indispensable contribution to integrated natural hazard risk management and the management of watersheds.

The approaching end of the UN Year of the Mountains brings an extremely busy and intensive year to a close. Each association and professional group, many state and semi-state organizations and indeed everyone who feels associated with the mountain region have dedicated this year's congress to the Year of the Mountains and many additional events are taking place throughout Europe. The knowledge and experience that has been accumulated at these events could probably be used to create a sizeable paper mountain. If we only succeed in implementing a fraction of all these good ideas, demands, proposed solutions and remedies etc. within a useful period, this effort will have been worthwhile. In this spirit, I wish you all – both as a group and as individuals – success in finding a seed of gold that will accompany you at the end of this week on your return to your everyday environment and will enrich this environment and alleviate the tasks you face.

A. Goettle
Prof. Dr.-Ing.
Bavarian Water
Management Agency
President of IUFRO S08

Dear Mrs. Von Ballmoos, dear Mr. Krecek, dear Mr. Schärer,
dear Mr. Hosny EL-Lakany, Ladies and Gentlemen,

I feel very much honoured and take great pleasure in welcoming you to the 23rd Session of the European Forestry Commission Working Party on the Management of Mountain Watersheds.

I am delighted to see that within the course of this 23rd Session a 50 years old tradition of international co-operation in the field of Mountain Watershed Water management is continued.

My particular thanks I would like to say to Switzerland, the host country of the twenty-third session of our working party. Your great support is very essential for a successful session.

The subject of this Session is more important and urgent than ever, remembering the most recent horrible natural disasters, floods and debris flows which happened in China, France, Austria or Germany this year, and the increasing pressure related to an even more intensive use of the mountainous areas in almost every alpine region on this earth.

In this connection, Modern Watershed Management as a contribution the future sustainable development of mountain areas, plays a key role.

With this 23rd Session the FAO has again created a forum for an extensive exchange of knowledge and expertise to the advantage of all those who bear responsibilities in this field. In this respect, the FAO's Forestry Department demonstrates once more its role as task manager of Chapter 13 of Agenda 21 «Managing fragile ecosystems» such as sustainable mountain development.

In this role the FAO works closely together with other international organisations and governments to help implement Chapter 13, to strengthen partnerships in this process, as well as to develop communication and to share information.

In this connection I gratefully acknowledge the co-operation of FAO with IUFRO, the International Union of Forest Research Organizations. This massive engagement of the FAO here as well as in many other fields does indeed deserve our special thanks an appreciation.

The EFC Working Party on the Management of Mountain Watersheds since its first session 1952 in France has essentially supported the exchange of ideas in important fields like torrent hydrology, forest and water relationships in mountain areas, avalanche-, flood- and mudflow-control, risk prediction and hazard mapping, and particularly in mountain forestry.

It has been a forum for watershed management discussions and exchange of information not only for Europe.

This is in complete accordance with IUFRO goals.

As an Organization with a longstanding tradition in forestry, IUFRO decided at the begin of a new millenium to open the door more widely for those outside the scope of traditional forestry research.

IUFRO has a clear vision of strengthening science-based sustainable management of the world's forest resources for economic, environmental and social benefits.

IUFRO wants to be seen as a leading advocate of forest science, with a mission to promote the co-ordination of and the international co-operation in scientific studies embracing a broad spectrum of research related to forests and trees.

These aims shall be achieved by further improving our well-known global network of forest science co-operation and promoting international dialogue and the dissemination of scientific knowledge.

With this new philosophy and strategy behind all our activities, IUFRO is proud to be the only worldwide international organization devoted to forest research and related sciences and to promoting the use of science in the formulation of forest-related policies.

IUFRO in one of the oldest international organizations having been establishes in 1892. It comprises today 682 member institutions in 113 countries and includes approximately 15'000 Scientists grouped in 8 Divisions, 71 Research Groups, 198 Working Parties and 8 Task Forces; these bring together scientists in all relevant disciplines to foster mono- and multi-disciplinary approaches to forest-related problems of global, national and local significance.

After the replacement of Subject Groups and Project Groups with Research Groups in 1995 and the creation of Task Forces and special Projects IUFRO modernized the organization and created new strength.

Within Division 8 – Forest Environment – IUFRO has Research Groups on Natural Disasters with working parties on

- Torrent and erosion Control
- Landslides and debris flows
- Watershed management and Land-use-planning
- Hazard assessment and disaster documentation
- Disaster management.

These units and additional 8 Task Forces form IUFRO's scientific base, which can be enlarged in co-operation with FAO within this meeting of EFC-Working Party on the Management of Mountain Watersheds.

I wish you much success and good result.

Thank you for attention.

2 The Management of Mountain Watersheds – A Political Perspective

S. Engler
Cantonal Councler
of «Graubünden»
Chur

1 The mountain canton of Graubünden – facts about water

1.1 From precipitation to discharge

The canton of Graubünden is regarded as the region in Europe most resembling a moat.

Along with the landscape, with its myriad lakes, rivers and streams, water is also the canton's most important economic resources and today forms the basis for tourism in the region. Two important European rivers, the Rhine and the Inn, rise in the Graubünden. The Rhine flows into the North Sea, the Inn into the Black Sea and the rivers in the southern valleys flow into the Mediterranean Sea. The canton's surface water bodies are not only a characteristic feature of its landscape, they are also fundamental to its life and the economy.

Graubünden is not just the land of 150 valleys, it is also the land of 615 lakes, and 937 mountain peaks. At 1,443 mm per year rainfall corresponds to the Swiss average but it can vary significantly. The average proportion of the rainfall that ends up as drainage water is 76%. On average around 8,100 million m^3 (cubic metres) of water flows out of Graubünden each year through the rivers. Thus, water is an important export product. If you correlate this to the 186,700 inhabitants in Graubünden, about 120,000 liters of water per person flow out of the canton each day.

While rainfall varies very significantly, the volumes of water discharged also very significantly. The river Rhine at Felsberg has a mean annual value of:

- 120 m^3/s (cubic meters per second)
- a winter discharge of 35 m^3/s
- a one yearly high water point of 230 m^3/s
- and a maximum flood discharge of 580 m^3/s

The ability of rivers and streams in the intensively used valleys to function ecologically and recover is mainly impaired by interventions such as the construction of artificial barriers, the creation of sewage and drainage systems, gravel extraction and use of the water in the generation of hydro-electric power. They are exploited in many ways, and in some cases also over-exploited, polluted and spatially restricted. The current Swiss legislation governing hydraulic engineering, the protection of water bodies, fishing, the protection of nature and cultural heritage and spatial planning provides the legal basis for the implementation of measures to secure sufficient space for rivers and streams and to improve the state of surface water bodies. The canton's first major revitalization projects for the improvement of habitat and species variety have already been completed.

1.2 Water bodies and management (draft plan)

The preservation of intact surface water bodies that offer sufficient space to serve the many functions of man, animals and plants and can be used on a sustainable basis in the long term is the overriding objective of the management of water bodies. To this end, the water bodies are given comprehensive consideration with reference to their five main functions and their interaction with the surrounding countryside and its uses. In accordance with an integrated water body management system, when it comes to the setting of objectives and concrete project design, the requirements relating to flood protection, ecology, fishing, recreation and the economy are examined and co-ordinated. This occurs on both a regional basis and in the context of individual cases.

In the case of rivers and streams, sufficient space must be secured to ensure that flood waters are drawn off and the correct sediment balance is maintained, and to conserve and promote ecological qualities. To this end, the floors of rivers and streams and the area near to banks on both sides of rivers and streams are kept free of structures and installations (minimum space requirement). The minimum space requirement is extended where the natural dynamics of the rivers and streams need to be maintained, encouraged or re-established and/or where recreation or resource use is very important.

The areas near river banks used by agriculture and forestry and, in consultation with the users, the strips of land that bordering these areas are extensively managed to promote diversity and reduce nutrient pollution. The possibility of designating ecological compensation areas and implementation of alternative measures in connection with forest clearcutting have been exploited to the full.

1.3 Comprehensive examination and co-ordination

The instruction concerning comprehensive examination is necessary, but difficult to co-ordinate due to the various authorities involved and sometimes this can only be achieved at a certain cost. The cantonal Office for the Environment (Amt für Umwelt) is responsible for legislation governing the protection of water bodies. The hydraulic engineering department of the Office for Civil Engineering (Tiefbauamt) is responsible for hydraulic engineering measures. The Office for Forests' (Amt für Wald) hazard commissions draw up hazard maps and implement them along with the local authorities in the mandatory zones defined in the land-use planning. The Office for Nature and Landscape (Amt für Natur und Landschaft) is responsible for legislation relating to the protection of nature and cultural heritage (e.g. riverbank vegetation, alluvial sites). The Office for Hunting and Fishing (Amt für Jagd und Fischerei) is responsible for legislation on fishing. Surface water bodies can also incorporate forest areas (Office for Forests) and their shores and banks can border areas used for agricultural purposes that have an influence on water (Office for Agriculture, Structural Improvements and Surveying – Amt für Landwirtschaft, Strukturverbesserungen und Vermessung). The planning principles laid down in

article three of the Law on Spatial Planning refer to the need to keep the shores of lakes and riverbanks free from buildings and other obstructions and to facilitate public access to surface water bodies. This shows that co-ordination for the purpose of timely and consensual co-operation is very important.

1.4 Graubünden's water is worth its weight in gold!

Apart from the – in part – world-renowned mineral springs and associated culture of water drinking and bathing, water in Graubünden also has inestimable value as a form of energy. Electricity production from the Swiss hydro-electric power stations is very important for the Swiss national economy. Over a fifth of Swiss electricity production comes from the hydro-electric power stations in Graubünden which translates to around seven and a half billion kilowatt hours (kWh) per year. About 60% of the canton's hydro-electric power potential is used. The quality of this energy from Graubünden is particularly valuable. Approximately 45 dams with a capacity of 870 million m^3 allow the water to be stored until a particularly high volume of electricity is required (winter, particular times of day). This enables the production of high-grade peak energy

Graubünden's power stations employ around 800 people throughout the year and a further 100 on a part-time basis. The gross wage bill for power station personnel totals around CHF 50 million. The fact that these jobs are mostly located in so-called «development regions» increases their significance.

The power stations account for one third of the taxes paid by legal entities in Graubünden. In fact, the annual sum of the taxes, charges and interest paid by the power stations is around CHF 100 million. These payments make a very important contribution to the canton‘s budget and the budgets of many local authorities. In total some four billion francs have been invested in the existing power stations in Graubünden. This sum is based on the costs incurred when the power stations were built. If they were to be converted to to-day‘s prices, due to price increases, the expenditure would be far greater. When the power stations were built, roads and other infrastructure that do not only serve the power stations were built or improved in many of the valleys. The dams also help to control the discharge of flood waters.

2 Protecting residents and tourists against natural hazards

2.1 The changes taking place in Graubünden's strategy for protection against natural hazards

The canton of Graubünden has also been affected by significant flooding. Ever since the canton (1870) and the Swiss Confederation (1877) established conditions governing payments for the construction of barriers through appropriate legislation, extensive barriers have been built throughout the canton and, as a result, the necessary preconditions for the development of settlements and transport routes (roads

and rail) were established. By the early 20th century, the courses of most rivers in populated valleys had been corrected. In addition to the creation of flood defences, the resulting reclamation of agricultural land was also a driving factor. The constant growth in settled areas and the associated uses prompted interventions in the water bodies which, in some cases, led to the drastic impairment of the ecological functions of the rivers, streams and surrounding areas.

Due to the increase in environmental awareness, it has now been accepted that such barrier structures need to be seen as part of a wider context. In addition to the purely protective function, ecological, economic and planning considerations must also be taken into account.

The insight that nature must no longer be first and foremost controlled using structural defenses, but must also be given certain freedoms, is also highly significant for Graubünden. Sustainable flood protection projects also provide rivers with flood areas and weigh up the ecological advantages – e.g. greater diversity of animal and plant species that are dependent on periodic flooding – against the economic disadvantages.

2.2 Hazard zones, hazard commissions and compulsory building insurance

Hazard zones (previously mainly created for avalanches) have been included in local planning in Graubünden for over 20 years. The Office for Forests' hazard commissions have been given the task of developing and implementing these zones throughout the canton. With the help of test engineers from the cantonal insurance company, requirements are laid down for all building projects in the medium-risk hazard zone (blue) which reduce the risk so as to protect the property. Construction zones are not designated in areas identified as being at considerable risk (red hazard zone), in other words there is a ban on building in these zones. The hazard zones have proven very effective in many locations. The flooding in 1987, storm Vivian in 1990 and the various landslides and rockfalls in recent years prompted recognition of the need for an integrated natural hazard management system in Graubünden.

The setting up of a Technical Office for Natural Hazards within the Office for Forests has ensured that hazard maps are drawn up to cover flooding, landslides, rockfalls and avalanches and that they will be implemented in land-use planning in the systematic and consistent way that has previously served Graubünden well. All designated hazard zones in Graubünden will be examined over the next ten years. Using both data on past events and state-of-the-art calculation methods, hazard maps will be drawn up by experts which will clearly show for each plot or parcel of land the frequency and intensity of the hazard effects that can be expected in settlement areas.

2.3 Risk-based priority setting

As part of the canton's integrated natural hazard management system, both spatial and content-based priorities need to be set for its territory of 7106 km^2 (the largest canton in Switzerland). For this reason, so-called registration areas have been designated, in which people and important material assets (potential for damage) are located. Initial analyses using a GIS indicate that 10% of the area of the canton is being registered. These registration areas form the starting point for a risk-oriented process, i.e. hazard maps, event registers, and other instruments used in risk management are being concentrated on these areas. Risk areas, i.e. areas where there is potential for damage and hazards strike, can ultimately be limited to less than 5% of the canton territory (excluding mean of transport). As part of the revision of local plans or as an immediate measure, the hazard zones in areas assumed to be at risk or in which damage has already occurred are being examined and adapted as a matter of priority. It should, therefore, be possible in the long term to keep residual risk within calculable limits.

Structural defense measures are only examined if spatial planning instruments prove inadequate or existing protection deficits are localized. In the context of the wide-ranging analyses and optimization exercises, the most popular question from a political perspective is «What safety at what price?». From the expert perspective, such considerations require the availability of the necessary risk management instruments, thus facilitating controlling in both the short and long term and – today more important than ever – ensuring that it can be transparently justified and communicated.

The establishment of economically viable flood protection systems involves the setting of risk-based priorities; comprehensive protection measures are taken where key facilities (such as hospitals, schools etc.), residential housing, industrial zones and important transport routes are at risk. On the other hand, occasional flooding in meadows and woodland areas is acceptable.

Thanks to the Office for Forest's canton-wide organizational structure, expertise and ongoing reorganization, favourable prerequisites have been created for the establishment of regional competency networks in the area of natural hazard management. The standard recording of natural phenomena using the Swiss Forest Agency's electronic register is an example of this. 110 registration points (forest rangers) reporting to five regional centers have been set up in Graubünden for this purpose. The foresters acquire knowledge in the field which can be of use to the community in exceptional situations. The hazard commissions are also based on this organizational structure. This facilitates collaboration with other institutions at cantonal level, e.g. the Hydraulic Engineering Department at the Office for Civil Engineering and insurance companies, and interfaces can be agreed. However, the co-ordination of the many actors involved is set to remain a major challenge.

2.4 Example: diversion of the river Flaz, Samedan.

The Samedan flood protection system is an exemplary case involving the implementation of the developments discussed above. Regular flooding of the Samedan valley floor resulted in the restriction of settlement development to the northern edge of the valley.

Following the devastating floods of 1924, 1951 and 1954, as part of the major project initiated in 1957 and entitled «*Barrier structures on the Inn, Flaz and tributaries, Pontresina – La Punt*», the protection dams that had been built around the settlement area from the late nineteenth century were raised and the courses of the rivers Flaz, Inn were diverted into an enclosed channel.

During the next major flooding incident in July 1987, Samedan only narrowly escaped devastating flooding. The flood peak did not reach record levels, however it was only 20–30 cms short of overflowing the dam. Thus, the hazard situation was comprehensively examined using state-of-the art calculation processes. You can see the result on an aerial photograph of Samedan: the hazard zones are shown in red (considerable risk) and blue (medium risk).

Based on these results, the government had to order the introduction of construction requirements for some parts of the settlement area and a ban on construction in others. The local authority was also ordered to take appropriate protective measures by 2005 and it has already discharged this task in an exemplary way. It decided not to opt for a purely technical minimum solution, but instead selected a forward-looking and sustainable flood defense system. Following a thorough feasibility study, the local authority had to decide between two alternatives: a scheme costing CHF 11 million involving the development of the existing dams with a system for discharging floodwater on to the airport plain, or a second solution which was better in terms of long-term protection, appearance and ecological benefits, but at a cost of CHF 29 million significantly more expensive.

Thanks to the far-sighted decision to divert the river Flaz, a more future-oriented solution was adopted. A 4-km stretch of the river Flaz that drains the water of the Bernina region is now being naturally diverted. This involves the removal of 1.7 km of the old river embankments and allowing 3 km of the remaining channel of the river Inn to develop more naturally. The new course of the Flaz will be developed in as natural a way as possible, with variable channel widths, bank slopes and gravel areas and the planting of vegetation appropriate to the location. In this way, ecological niches will be created for the conservation and encouragement of biodiversity. The former channel of the Flaz will be transformed into a small natural stream which will also provide a habitat for reptiles. The river diversion, which is being carried out as part of the ongoing Samedan flood protection scheme, is the first project of this nature to be implemented on this scale in Switzerland since 1920. Safety, quality of life and nature are the three main thrusts of this daring «project of the century».

Thanks to the enormous commitment of an open-minded authority and the Hydraulic Engineering Department at the Office for Civil Engineering, a project can now be embarked on that will attract a lot of attention throughout Switzerland. The state and the canton have expressed their appreciation and support of these efforts by allocating extraordinarily generous funding. Thanks to the multiple benefits of this project (safety, quality of life and nature), this additional expenditure represents a sound investment for the future.

3 Impact on subjacent settlements and infrastructure, co-ordinated co-operation and solidarity

3.1 Co-operation on the Alpine stretch of the Rhine

An international and interdisciplinary development concept is being initiated for the first time in the history of the Alpine stretch of the Rhine. As part of this plan, crucial topics – such as flood protection, groundwater and drinking water, ecology, energy etc. – are being carefully worked through and their needs co-ordinated. The plan consists of a joint model or clearly defined objectives and an agreed program of measures. The International Government Commission for the Alpine Stretch of the Rhine (Internationale Regierungskommission Alpenrhein) includes representatives of the Principality of Liechtenstein, the Austrian province of Vorarlberg and the Swiss cantons of St Gallen and Graubünden. The project principals are the International Government Commission for the Alpine Stretch of the Rhine and the International Regulatory Body for the Rhine.

3.2 The tasks of a large mountain canton and reasons for co-operating

Article 43 of the Federal Swiss Constitution states, that «the cantons determine the tasks they fulfil within their areas of responsibility». The state basically leaves or instructs all cantons to carry out the same tasks. The way these tasks are discharged and the problems facing individual cantons in their own areas of responsibility can vary significantly. Size, in some cases difficulties of access and diversity (e.g. different climate zones) do not merely present important potential, they also set significant tasks for the canton and require that valleys and regions be given consideration.

In Graubünden, we often have to rely on the solidarity of our fellow countrymen in the other parts of Switzerland when it comes to certain types of tasks (e.g. road construction). Neighbourly co-operation between cantons or between countries can be particularly helpful, as the most recent flooding events in Germany, Austria and the Czech Republic have clearly shown.

Practical experience that should be made available to wide circles of users was gained from the widening of the Alpine stretch of the Rhine at Felsberg and the newly constructed fish ladder at the retaining dam at the Reichenau hydro-electric

power station in Domat/Ems. Cross-border co-operation in the Alpine stretch of the Rhine is, therefore, an important matter for Graubünden.

3.3 Preventive solidarity – the example of the canton building insurance companies

The insurance of buildings against damage caused by the elements is mandatory in Graubünden and – as is the case in 19 of the 26 cantons – it is guaranteed by the cantonal building insurance company. At the cantonal building insurance companies, loss prevention, the minimizing of loss by the fire brigades and insurance are subject to jointly managed. The positive consequences of this concentration of activities include complete solidarity among the insured, guaranteed insurance cover for all buildings at officially determined values and an optimum use of funds based on risk management. What is surprising is the low premium charged for this combined «securing and insuring» service: it is less than half the premium charged by the private insurers operating in the cantons in which there are no public building insurance companies.

Through the combined forces of reinsurance (IRV), intercantonal solidarity (IRG) and its own reserves, the Graubünden cantonal building insurance company would be in a position to cover damage to a level of CHF 1.2 billion. If flood damage occurs, for example, on the Rhine in the canton of St Gallen and the damage exceeds the sum that can be covered by the St Gallen cantonal building insurance company, the Graubünden cantonal building insurance company would contribute towards covering the loss through the above-mentioned **I**nterkantonale **R**isiko **G**emeinschaft – IRG (Intercantonal Risk Association) and conversely, the St Gallen company would also make a contribution to Graubünden under the same circumstances.

4 Managing the watershed area (planning and systematic forest management)

4.1 Forest area has increased

The stocking of a watershed area has a decisive influence on drainage. Area statistics provide inter alia information about the development of stocked areas. Forest area has increased by more than 30% over the past century. Between 1985 and 1995 alone, the rate of increase in Graubünden was around 4% (data from National Forestry Inventory I and II). This increase in forest area has basically had a positive effect on water discharge or the movement of flood water. The reasons for the increase stem from the consistent implementation of forestry legislation by the forestry service and, in the more recent past, from changes in the agricultural use of land. This clearly illustrates how measures in one policy area can influence other areas and how they are linked through the various chains of effect. These interactions underline the importance of clarity with respect to the fulfillment of objectives – in this case the preservation of watershed areas. Co-operation between forestry,

agriculture, spatial planning, nature conservation and landscape protection has already been mentioned. This is all the more important when the dynamics of the framework conditions (e.g. climate) are on the increase.

4.2 The state of the forest is a key factor

In terms of policy, even more scientific and practical knowledge needs to be acquired on the effects of the forest in relation to protection against natural hazards. The evaluation of the Sachseln storm of 15 August 1997 carried out by the Swiss Research Institute for Forest, Snow and Landscape (Eidg. Forschungsanstalt für Wald, Schnee und Landschaft – WSL) is a good example in this context. The knowledge acquired through research must be processed or transmitted for practical and policy purposes in an easily accessible form. The leaflet on the Sachseln evaluations compiled by the Swiss Agency for the Environment, Forests and Landscape and the Swiss Research Institute for Forest, Snow and Landscape is an excellent example of such effective communication. The leaflet impressively demonstrates the positive protective effect of a healthy forest in the event of a landslide, however it does not neglect to mention the limitations of this effect. (See leaflet with the transparencies).

Based on scientific and practical knowledge, the integrated management of watershed areas needs to be planned with foresight and approached with a focus on the objectives. In Graubünden, the practical forest management instruments that are implemented at the appropriate stages include forest development planning (Waldentwicklungsplanung), the concentration on forests with special protective functions (besondere Schutzfunktion) and the guideline entitled «Minimum Maintenance Measures for Forests with a Protective Function» (Minimale Pflegemassnahmen für Wälder mit Schutzfunktion). The Graubünden water body information system, which is used by the Office for the Environment to record and periodically update information about the state of the canton's water bodies, is another such instrument. Finally, the Graubünden GIS forms the nerve center for information to be made available to responsible or interested persons and institutions.

4.3 Final thoughts – the dynamics are accelerating

As the example of the increase in forest area shows, certain changes that took place over the past century have been understandable or to some extent manageable. The increasing pace of change in the areas of nature (hazards) and land use pose a particular challenge to policy makers. The risk posed by natural hazards is now characterised by higher peaks which are, moreover, accompanied by greater uncertainties. The forecasts (e.g. as provided by the Intergovernmental Panel on Climate Change IPCC) which predict an increase in the dynamics of rainfall intensity are a source of concern for a mountain canton like Graubünden. Different mountain cantons have already experienced the consequences of very heavy rainfall with sudden unexpected landslides. What is needed are decentralized organizational structures (regional competency networks) and well-trained personnel on-site

(firemen, civil defense people, forestry people) who can facilitate targeted action. Ultimately, however, everyone is needed, from the politicians to the authorities and autonomous individuals. The following principle could prove increasingly applicable when dealing with future natural hazards:

«Denn erstens kommt es anders und zweitens als man denkt» which translates badly as «For, firstly comes different and secondly while you think»!

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3 Mountain Watershed Management: Scaling-up and Scaling-out

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1 Introduction

Mountains are the water towers of the world (Liniger et al. 1999) and pressure on the water resources is increasing due to the growing demands from agriculture and urbanization in the lowlands (Gleick 2002, Smil 2001), increasing recreational pressures within the mountains, demand for hydro-power, and increasing climatic variability (Schindler 2001). Because our knowledge in mountain watersheds is poor, and the research and monitoring capacity is limited, it is evident that a major effort is needed to improve our knowledge base of all land use activities in order to understand how they affect hydrology and water quality. Most land use activities change the soils and land surface configuration and modify the fluxes of water, nutrients, sediments and contaminants within watersheds. These impacts bring about changes in hydrology and water quality that affects people within the watershed and many kilometers downstream.

Mountain research has mostly focused on the key processes associated with forest activities, road infrastructure development, and hydropower development. However, most of the studies are confined to local watersheds and extrapolation to other watersheds is extremely difficult given the large climatic variability and complexity of mountain watersheds.

Some of the key scientific challenges in mountain watersheds that are addressed in this paper are:

- Integrated assessment of all land uses and their individual and cumulative impacts on water
- Scaling-up processes from small mountain catchments to river basins (upland-lowland interactions)
- Scaling-out by comparing watersheds and learning from each other
- Adaptation of land use mountain watersheds due to greater climatic variability

The advances in micro-processors and information technologies have given us new opportunities that can help in the monitoring of processes in remote areas, and allow us to improve our communication and networking capabilities at a global scale. It is the aim of this paper to address these challenges and to suggest that the development of partnerships and networks can greatly assist in gaining a better understanding of the complex issues associated with climate change in mountain watersheds.

2 Integrated assessment of land uses and their individual and cumulative effects on water

Geographic information systems (GIS) techniques have been extensively used to map and monitor land use changes in many watersheds (Price and Heywood, 1994). However, linking land uses to hydrology and water quality remains a challenge because of the diffuse nature of many of the activities and the lag time between inputs and changes to the land and the watershed response. The spatial and the

temporal processes are complex and the non-linear behavior of many of these processes makes extrapolation difficult. It has become evident that sequential land cover mapping alone is insufficient to predict impacts on water resources. What is needed is an integrated approach that involves social scientists who can obtain management and input information, and bio-physical scientists who collect the soil, climatic, hydrologic, and vegetative components of land use activities. Once combined we can then determine the dynamics of management inputs, biomass production and possible impacts on water resources.

Based on a case in a Canadian watershed Berka et al. (2001) have shown that land use changes alone provide an inadequate picture on land use impacts on water. Based on a GIS analysis in the Sumas River watershed in British Columbia, they showed that agriculture (62%) and Forestry (28%) are the dominant land uses and over the 40 year period the area under both land use activities has changed little (Table 1). Over the past 15 years the agricultural land area has increased by less than 10%, while agricultural intensification has been dramatic (Table 2) with very large increases in animal stocking densities (particularly chicken and pigs, and expenditures on fertilizers). The information on land use intensity cannot be inferred through remote sensing techniques and requires field survey information that is carried out in a participatory manner. The watershed was divided into 9 contributing areas and at the bottom of each area a water quality monitoring station was established where nitrogen and phosphorus concentrations were monitored over a two year period. In each contributing area the farm management information which included areas under different crops, number of animals, fertilizer rates used, and crop yields were obtained from a comprehensive farm surveys conducted every 5 years. With this information it was possible to determine nitrogen and phosphorus balance sheet for all farms in each contributing area (Berka et al. 2001).

Table 1: Changes in land cover analysis using digital aerial photography between 1954 and 1994.

Land use classes in Sumas watershed	Changes 1954–1979	Changes 1979–1994
Forest cover	- 3.3%	- 1.5%
Agricultural land	-0.5%	+ 1.1%
Number of farms	+ 10.7%	+14.1%

Table 2: Changes in agricultural intensification 1986–2001 using participatory surveys.

Changes in number of animals and fertilizers	Changes 1986–1991	Changes 1991–1996	Changes 1996–2001	Changes 1986–2001
Cattle numbers	+ 1.2%	- 1.4%	+ 8.1%	+ 7.9%
Pigs numbers	+ 49.2%	+ 6.3%	+ 45.4	+ 130.7%
Chickens numbers	+ 48.6%	+ 78.4%	+ 104.2%	+ 442.4%
Expenditures on fertilizers and lime in $	+ 14.6%	+ 26.0%	+ 4.2%	+ 50.3%
Land under agriculture (ha)	+ 3.9%	-1.4%	+ 6.9%	+ 9.6%

The results of the budget analysis showed that excess nitrogen was being applies to more than 80% of the agricultural land in the watershed. For five of the 9 contributing areas the nitrogen surplus applications exceeded 100 kg/N/ha/year, while excess phosphorous reached more than 30 kg/P/ha/year. Depending on the soil and site conditions some of this surplus will find its way into the stream and groundwater causing stream eutrophication. The streamwater quality data was then used as an independent data set to determine if the streams below contributing areas are adversely affected. Correlation between surplus N applications and wet season streamwater quality (Nov-Feb) then showed that surplus N was positively related to Ammonia-N and negatively related to dissolved oxygen content in the stream (Berka et al. 2001). What this example shows is that by using an integrated approach that links land use with survey information, GIS, and modeling, it is possible to calculate surplus nutrient applications and then predict what the resulting water quality impacts will be. By combining the results from the 9 contributing areas it was then possible to arrive at an assessment of the cumulative effects in the entire watershed.

3 Scaling-up processes from small mountain catchments to river basins (upland-lowland interactions)

The scaling problem is another topic that is challenging researchers involved in watershed management (Swallow et al. 2001, Schreier and Brown, 2001). It has long been argued that processes that dominate 0 and 1st order streams are different from those that dominate higher order streams. Surface run-off processes dominate headwater systems while channel and bank processes dominate the lower part of watersheds. Scaling-up from headwaters to watersheds and river basins is therefor difficult because the processes are not linear (Brenda and Dunne, 1997). Within a very limited range headwater processes can be linear but as we move downstream networks take over and these can be synchronized or desynchronized (Gomi et al. 2002). This seriously limits the use of regressions to scale-up from headwaters to watersheds. A good example of this is shown in Figure 1, which summarizes sediment transport for a number of different size headwater systems in the Nepalese Himalayas. As can be seen in Figure 1, relationships are very different when we increase the watershed size and there appear to be a threshold level between 10 and 1000 km^2 watersheds where the processes shift. The land use component can be

linked to this to some extent. In the Jhikhu Khola watershed study in Nepal (Schreier et al. 1995, 2000, Brown et al.1999, 2000) it was shown that nitrogen, phosphorus budgets for individual farms were very different between upland rain-fed systems and intensively used irrigated lowland systems. The watershed was stratified into two elevation, two aspect, two dominant soil types and four land uses classes using the GIS overlay technique. Based on the soil nutrient analysis of 10 farms in each combination of elevation-aspect-soil type-land use category. The results showed that the nutrient conditions were the poorest in upland south facing forest and grassland sites followed by rainfed agriculture and only the lowland irrigated soils had adequate soil nutrient status. This is in part due to the nutrient losses through leaching and soil erosion and the recapturing of sediments and nutrient in irrigation water downstream.

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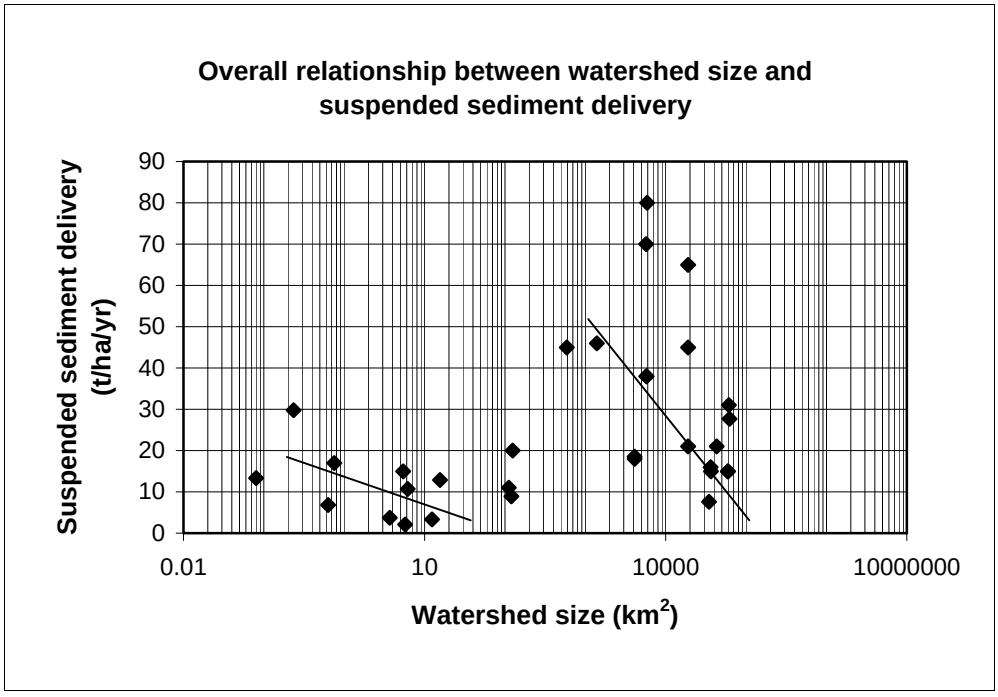


Figure 1: Relationships between suspended sediment delivery and watershed size.

However, when conducting nutrient budget analysis (von Westarp 2002) it became evident that upland rainfed systems received insufficient nutrient inputs, while the lowland systems had excessive N and P budgets as a result of high fertilizer inputs accompanied by the introduction of cash crops (potatoes and tomatoes) for marketing. These changes have occurred in rapid succession and over the past 5 years stream eutrophication is threatening drinking water supplies and fish production downstream. Again a PRA survey of 200 farmers was needed to obtain the necessary input and management information to show the spatial differences and to verify the soil nutrient status in each fields. Due to the poor fertility conditions the main problem in the headwater system is soil erosion, while nutrient leaching is the dominant process that affects the water resources downstream.

A similar type of analysis was conducted in the forest component of the watershed. Over the past 7 years the responsibility for managing the forest have been transferred from the national forestry department to community forest user groups. In order to finalize this transfer the community forest user group has to submit a management plan that has to be approved by the forest ministry. At present some 50 different community groups are now managing the forest in the Jhikhu Khola watershed and each group has a different management plan that best suits their needs. In order to arrive at an evaluation of the impact of forestry on the water resources one is then required to determine the quality of the forest (nutrient status, ground cover, biomass, productivity, rate of erosion) and the use and conservation practices carried out by the forest users. The soil nutrient survey showed that all forests and rangeland had a very poor nutrient status and minimal ground cover due to the to the excessive collection of forest litter and fodder, due to widespread shortages of animal feed. Soil erosion from degraded forest is therefore a major concern. From a PRA survey with the forest user groups it was possible to establish the forest use and conservation practices for each forest user group. The results of the physical forest survey (nutrient status and ground cover) and the management information were incoprorated into the GIS database and it is now possible to develop a risk index for soil erosion in forestry based on the management practices and the status of the forest.

Since both the forest and agricultural land use information is in a GIS format it is now possible to search the database for all combination of conditions and then extrapolate information from the known sites to those with only partial information.

4 Scaling-out by comparing watersheds and learning from each other

One of the most fruitful research activities is to scale-out and conduct watershed comparisons. With the advances in information technologies (IT) it is now possible to develop research networks and use the Internet and multi-media tools to conduct collaborative research that can then be compared. An example of this is the recently completed Himalayan-Andean Watershed Comparison Project (Schreier et al. 2002). Many researchers have studied individual watersheds over many years and

have gained great insights about the dominant processes that impact water resources in their own local setting. However, questions are always raised as to the extent to which we can extrapolate from one watershed to another. A collaborative watershed project between four watershed teams in the Himalayas and four watershed teams in the Andes was initiated in 2000 with the following aims:

- Use IT tools to produce an integrated assessment for each watershed and produce a multi-media CD-ROM that serves as an information systems
- Develop a common framework to be used by all teams that integrates all resources information in the watershed in a comprehensive manner
- Identify common indicators that can be used for comparison
- Highlight successes in each watershed that address improvement in resource management and evaluation techniques.

Table 3 provides a summary profile of the four Andean watersheds located in Ecuador, Peru (2x), and Bolivia, and the four Himalayan watersheds located in Nepal (2x), Bhutan, and China. All these mountain watersheds are hazardous, have climatic restrictions, high population pressure, and experience extensive poverty. More details on the project can be found at: www.ire.ubc.ca/himal/index.htm. As shown in Table 3 all eight watershed are in mountains and subsistence agriculture is the dominant activity in each. Poverty is widespread and high population growth and high population mobility are characteristic features of all watersheds.

In each watershed the water and soil resources, the socio-economic conditions, and the forestry and agricultural land uses were evaluated and resource degradation rates were quantified. At the same time methods to prevent degradation were highlighted and successful rehabilitation projects were identified. The key natural resource management issues were identified and training was provided to each research team on how to incorporate the data into a multi-media CD-ROM format. An Internet bulletin board was used to assist each team in the development of the multimedia material and in sharing information. Two workshops were held to develop the framework and to identify quantitative watershed indicators, and to review and critique the CD-ROMs. The integrative framework and details on the approach used can be found at www.ire.ubc.ca/himal/index.htm

Table 3: Summary of watersheds used in the comparative study.

Watersheds	Elevation Range (m)	Average Rainfall (mm)	Subsistence production (%)	Food shortages weeks/year	Population age <18 yrs (%)
Nepal 1: Jhikhu Khola	800–2200	1100	70	4	40
Nepal 2: Yarsha Khola	930–3030	1700	90	12	40
Bhutan: Lingmutey Chu	1200–3000	713	90	12–16	40
China: Xizhuang	1640–3000	1250	40	1–2	24
Ecuador: El Angel	1500–3600	1046	31	0	51
Peru 1: La Encanada	2900–4400	750	70	16	48
Peru 2: Ilave-Huenque	3840–5550	650	99	16	38
Bolivia: Desaguadero	3810–5000	600	91	16	41

The results of this experiment were most encouraging because despite the large differences between the watersheds many common issues were identified. The methods uses to address these issues varied from watershed to watershed but many of the successful methods to address the problems can readily be transferred from one watershed to another. At the same time key differences that emerged between the two mountain regions can also be used as learning experiences. As shown in Table 4 there were differences in the biophysical setting of the watersheds, the socio-economic conditions, and the land use activities. In each case it is possible to identify what valuable lessons can be learned between the regions and between watersheds.

What is apparent form all the comparisons is that water resources are of greatest concern and this is reflected by a relative ranking of priority issues (Table 5) as determined by each research team. Access to irrigation and drinking water was considered critical in all but one watershed followed by concerns over soil fertility, productivity and how to access markets.

What have we learned from such a comparison and how can we benefit from scaling-out from one region to another? The value of this study can be grouped into three categories: a) Sharing analytical methods, b) research successes in improving livelihood, and c) successes in resource conservation and rehabilitation.

4.1 Sharing analytical methods

Some of the key issues that were of concern in all watersheds were how to determine pesticide impacts on human health, how to determining a water balances, how to calculating nutrient budgets at the farm level and how to scale it up to the watershed, how to assess the workload of women, and how to evaluate community managed forests. Watershed research teams addressed these issue using different methods and techniques. For each issue the most successful analytical technique was identified and highlighted in the comparative CD-ROM, so that the other research teams can test the applicability of these techniques in their own watersheds.

4.2 Improving the livelihood

Research into water harvesting, low cost drip irrigation, how to improve water equity, improving forest production in community forests, introduction of fodder trees and grasses to improve fodder shortages, and improving food security using rustic greenhouses, were conducted in several watersheds and those with the best results where highlighted as examples to be tested in other watersheds**.**

4.3 Research into conservation and rehabilitation

Different rates of natural resources degradation was evident in all watersheds and successes in reducing soil erosion, nutrient depletion, and rehabilitating degraded sites using nitrogen fixing fodder trees and grasses were highlighted so that similar effort could be initiated in other watersheds.

4.4 Using a common integrative framework.

The framework was initially developed in the Nepalese watersheds and was then modified in a team effort. All teams used a similar integrative framework tha allowed the integration of all information in a comprehensive manner. In all cases it became evident that there were large knowledge gaps. This was most evident in terms of water resource information which was identified as one of the major issues in all watershed, but until recently had been given limited attention. Research in water management issues was most advanced in those watersheds where the problem has been most acute (Jhikhu Khola-Nepal) and El Angel-Ecuador). The GIS techniques used to conduct water supply and water quality assessment, how to store water and how to use it in a very efficient manner as developed in the Nepalese watershed can now be duplicated in the other watersheds so as to fill the gap in knowledge and to improve availability and use of water resources. Another very pertinent problem is how to resolve water use conflicts between upland and lowland residents in the watershed. The El Angel team in Ecuador embarked on a multi-stakeholder process of negotiation and complemented this with scientific documentation of supplies and demands. This approach has met with some success and similar methods could now be used to address the same type of problems in other watersheds.

Table 4: Differences between the Himalayan and Andean Watersheds.

Population Indicators	Himalayan Watersheds	Andean Watersheds
Population density	1.2–4.4 people/ha	0.1–0.7 people/ha
Infant mortality	10–20 per 1000	60–70 per 1000
Land Use Indicators		
Land owned	<1ha	1–26 ha
Irrigated land in watershed	3–9%	0–3%
Forested land in watershed	32–89%	3–32%
Grazing land in watershed	1–30%	28–55%
Mean number of crop rotations/year	1.5–2.7 per year	1–1.7 per year
Average manure input in agriculture	2–12 t /ha /year	1–5 t /ha /year
Average fertilizer input in agriculture	20–200 kg N /ha /y	4–10 kg N /ha /y
Income from milk production	$ 0–70.– / year	$ 55–720.– /year
Agri-biodiversity: Potato variety used	3	13–40
Environmental indicators		
Average annua precipitation	713–1700 mm	600–1046 mm
Frost free days	270–365 days	105–350 days
Dinking water shortagesM	3–4 months /year	0.3–1 month /year
Irrigation water shortages	1–4 months /year	0–3 months /year
Farmers owning irrigated land	30–85%	0–57%
Dominant rock formation	Mainly sedimentary	Mainly volcanic

Table 5: Ranking of priority issues in the eight mountain watersheds.

Priority Issues	Jhikhu Nepal	Yarsha Nepal	Bhutan	China	Bolivia	Ilave Peru	Enca. Peru	Carchi Ecu.
Irrigation Water	1	3	1	1	3	5	1	1
Drinking Water	2	4	8	2	3	4	8	2
Adverse Climate					2	1	3	
Food production	4	2	2	5	4	8	9	9
Animal Fodder	3	6	7	10	1	3		
Health/ Pesticide	5			3	6		6	3
Land Tenure/Access		9	10			6		4
Market Access	8	1	4	6	7	7	4	7
Education/Extension	10	5	9	7	10		5	6
Soil Fertility/Erosion	7	8	3	8	5	2	2	5
Workload for Women	6	7	6		8	10		
Forest Degrad.(fuel)	9	10				10	7	10
Rehab. Degraded land			5					
Migration	10			9	9	9	10	8
Community invol.				4				

Ranking of priorities: 1= most important, 10 = least important

4.5 Research into conservation and rehabilitation

Different rates of natural resources degradation was evident in all watersheds and successes in reducing soil erosion, nutrient depletion, and rehabilitating degraded sites using nitrogen fixing fodder trees and grasses were highlighted so that similar effort could be initiated in other watersheds.

All these experiences and results were incorporated into each of the individual CD-ROMs and the most successful research methods and actions were featured in the comparative CD-ROM. Plans are under way to feature much of this material on the WEB so as to make it more widely available by scaling out at the global scale.

5 Adaptation of land use in mountains due to greater climatic variability

The last major issue to be addressed in this paper is climate change and adaptations needed to mitigate impacts resulting form greater climatic variability. Mountains are often more sensitive to climatic variability than lowland systems. Increased rainfall in the mountains can result in devastating effects in lowlands in term of flooding events. Similarly, lack of rainfall can result in the destruction or alteration of aquatic organisms, reduction of supplies for urban and agricultural use, and reducing the recharge of aquifers downstream. A number of major changes are needed in the management of mountain watershed and many reflect an almost complete reversal from tradition. The key reversal include: a) reservoir construction vs. reservoir removal, b) soil compaction vs. Soil quality enhancement,, c) wetland creation vs. wetland drainage, d) water harvesting vs. drainage, e) flood irrigation vs. drip irrigation.

5.1 Reservoir construction vs. reservoir removal

It is vital that we improve the water storage capacity in mountains if we hope to be able to supply sufficient water to the lowland for urban and agricultural use. Building new reservoirs in mountains is currently most unpopular in the developed world, because of the many impacts reservoirs have on the environment. As noted by Gleick (2000) we are actually in a phase where more dams are destroyed annually that are build in North America. Table 6 provides a number of reasons why reservoir construction is being questioned.

The aging of dam structures is one of the main reasons why dams are demolished. In many cases the upgrading cost is higher than the limited benefits obtained from dams that have lost a large portion of the reservoir capacity due to sediment accumulation. In the next 20 years some 85% of all dams in North America are exceeding the average life expectancy and will be in need of upgrading or removal (Gleick, 2000)

The second argument that has become of public concern is the increasing environmental awareness of the aquatic biota, particularly fish, that are heavily impacted by reservoirs. With the concern about the rapidly declining stocks of migrating salmonids it is now almost impossible to initiate new reservoirs due to the opposition on environmental ground.

Table 6: Advantages and disadvantages of reservoir construction in mountains.

Advantages	Disadvantages
Regulating extremes in streamflow	Impacts local climate
Water release during dry period	Obstructs fish passage
Reducing floods downstream	Retains sediments that affects water quality downstream
Producing Hydropower	Modifies channel morphology upstream and downstream
Increased recreation potential	Loss of habitat and at reservoir site
Improved navigation downstream	Displaces people
	Loss of productive bottomland in reservoir
	Poor long term benefit-cost analysis due to
	Navigation problems upstream
	Risk of failures and its impacts downstream

The third argument is that most of the advantageous sites have already been used and any new sites is likely requiring the displacement of people which is highly unpopular from a political perspective in most democratic countries. Also, new reservoirs can pose greater risks because most optional sites are already used, and past hydrological records are likely inappropriate as a base for designing dams.

5.2 Soil compaction vs. soil quality enhancement

Globally the amount of freshwater contained in the form of soil moisture is twice that of all freshwater in rivers and lakes. Lavkulich 1992 has estimated that a 10% reduction of the soil infiltration rate in the world could reduce the short and long term storage of water by $4x10^{12}$ m^3. This is larger than all the freshwater transported annually in all rivers in Canada. All land use activities impact infiltration rates and most traditional agricultural and forestry practices have resulted in soil compaction. The soils in mountains are generally shallow and highly sensitive to erosion but the climatic conditions are conducive to carbon sequestration. Organic carbon has excellent water adsorption and water holding capacity and facilitate infiltration rated by improving the soil structure. Given these observations it is clear that our focus in mountain watershed should be to improve soil quality and to minimize compaction which means we have to alter some of our forestry and agricultural practices (Kimble et al, 2002).

5.3 Wetland creation vs. wetland drainage

To improve land access many wetlands have been drained. We have lost more than 50% of all wetlands in North America due to drainage. Many wetlands in mountain systems have been drained to make room for agriculture or to build infrastructure. Some of the largest high mountain wetlands (Paramo-Ecuador-Venezuela) are threatened by expanding agriculture and tourism. A new effort is under way in Europe and North America to create new wetlands not only to increase wildlife habitat and biodiversity but mainly because such systems are excellent water storage reservoirs and also serve as water purification systems. In order to improve water storage capacity the maintenance, improvement and creation of wetlands in mountains should be given a new incentive. While we have lots of experience draining wetlands, our knowledge of creating wetlands is still poor and this poses a considerable challenge in order to improve water storage in mountains.

5.4 Water harvesting vs. drainage

In most infrastructure development in mountains drainage of land and stormwater management has focused on piping water away from the site and into streams. This results in increasing peakflow and often reduced baseflow. Water harvesting by collecting roof water and surface runoff and storing it in dispersed collection systems or infiltrating it into the soil is now a viable option that is being implemented in a number of new recreational development and urban centers in mountains. Creating permeable pavements in parking lots and limiting impervious surfaces is one of the key initiative to reduce stormwater impacts and to temporarily detain water.

5.5 Flood irrigation vs. drip irrigation

Irrigated agriculture covers about 16% of all agricultural land and produces 40% of all food globally. However, the irrigation efficiency is very poor because flood irrigation, particularly in mountains (e.g. Nepal, China, Philippines), is the dominant practice. Low cost drip irrigation is now offering a cost effective alternative that needs to be promoted in the mountains because it uses water more effectively during the dry periods, it can reduce terrain instability, and can reduce the workloads (von Westarp, 2002).

5.6 Maximizing vs. minimizing buffer zones

Science has shown that in order to effectively protect rivers from land use activities requires vegetated stream buffer zones in the order of 60–100m (Castelle et al. 1994). Due to the high productivity and desire to access water for recreation and other uses, buffer zones have remained small (<30 m) and these zones are proving to insufficient to detain sediments and nutrients and prevent them from entering streams. Efforts are under way on the West Coast Mountains of North America to increase the size of protective buffer zone in mountain watersheds to reduce flow variability, minimize water pollution, improve the habitat of wild salmon, and to detain water in ponds and wetlands within the buffer in an effort to conserve fish species.

No single activity will be sufficient in order to adjust to increasing hydrological variability, but a combination of approaches is needed as a precautionary approach. Agricultural, forestry and engineering initiative need to become aware of these issues and a concerted effort is needed the change traditional management practices. In many cases these new initiatives represent a complete reversal from the traditional practices.

6 Summary and Conclusion

The four issues addressed in this paper relate to the importance of integrated watershed assessments, the challenges face with scaling-up, the opportunities to scale-out using information technology, and the adaptations needed to adjust to greater climatic variability in mountain systems. Combining GIS, information technology and modelling tools allows us to arrive at a more integrated approach to managing mountain watersheds and to address cumulative effects. While it is difficult to scale-up processes from headwaters to watersheds several GIS-modelling methods hold some promise as shown in the case of nutrient budgeting at the farm and watershed scale in two case studies in Canada and Nepal. The scaling- out approach pursued in the Himalayan-Andean watershed study shows the greatest promise, because sharing experiences and information in a multi-media format (via CD-ROMs and the Internet) is highly effective, since it allows collaboration at a distance. Sharing innovative assessment techniques and conservation methods that have been successfully applied in one watershed can be shared easily and tested in a collaborative manner in different watersheds. Improved communication and knowledge sharing at a global level holds the greatest promise in watershed management.

Adjusting to increased climatic variability is particularly important in mountain watershed activities because these environments are much more sensitive and responsive to climate change than most lowland systems. It is postulated that many of the traditional practices such as building large dams, compacting soils through land use activities, flood irrigation, draining wetland and engineering stormwater into piped system needs to be reversed. Retaining water in the soil, improving infiltration through carbon sequestration, creating new wetlands, using pervious pavement, initiating water harvesting plan, using low cost drip irrigation, and maximizing the size of protective vegetated buffer zones along the rivers, are a few of the measures needed if we hope to adjust to increased climatic variability.

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4 The Tricky Question of Equilibrium

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1 The Equilibrium Slope

The equilibrium slope of a gravel-carrying river or torrent refers to a slope where an exact balance is maintained between bedload supply and bedload transport. The bed of an equilibrium slope is neither lowered nor built up, that is, it maintains its base level. It would be interesting to trace the original use of the term «equilibrium slope» and the idea behind it in the relevant hydraulic engineering literature. In Switzerland, the term was included casually in 1875 in a memorandum written in French by Adolf von Salis (1818–1891), who was at the time the chief federal official of road- and riverworks. He described this slope, on one hand, as «la pente correspondante à l'équilibre» (the slope that corresponds to the equilibrium) or «la pente qui leur convient» (the slope that is convenient to the rivers)[1]. A similar philosophy was taken further in 1880 by ETH Professor Karl Pestalozzi (1825–1891) in a document entitled «the bedload movement and the natural slope in mountain rivers»[2]. He postulated that by its nature, every river strives for this equilibrium of slope or natural slope, thus linking it with the concept of a standard width. He suggested, in consequence, that the correction of channels of rivers and torrents be carried out as far as possible in correspondence with the equilibrium slope and the standard width. Pestalozzi nevertheless considered it unlikely that these parameters could ever be calculated; one would have to rely on observations made from nature. And then in 1883, in a chapter on «the development in accordance with the laws of nature of the longitudinal profiles of river courses and the possibilities of their modification», von Salis once again grappled with the equilibrium theory. At the same time he also dealt with the effect of size reduction of bedload particles.

The first bedload formula also originates from this period, developed by a Frenchman named Paul François Dominique du Boys (1847–1924). It did not receive much notice at the time, and it was not until much later that a bedload formula first found admission into use in Switzerland. The ETH professor Meyer-Peter (1883–1969) published it in 1934, in collaboration with his colleagues Hans-Albert Einstein (1904–1973), Henry Favre (1901–1966) and Robert Müller (1908–1987), and again in a refined version in 1948. However, 50 more years were to pass before usable formulas for the quantification of the natural sorting and the size reduction of bedload particles were put forth.

It is significant here that the equilibrium slope, as a function of the discharge and bedload data, and a particular river width, can be calculated using these bedload formulas. In this sense the formulas provide a means for measuring river and torrent corrections. Their essential message was summarized in 1955 by the American, Emory W. Lane (1891–1963) by means of a very impressive diagram. It is known as the Lane scales and is depicted in Figure 1 in a simplified form. When the pair of scales is in complete balance, it illustrates the equilibrium slope. If it is not in balance, then the tare must be determined accordingly. The influencing factors consist of the representative values of the bedload transport, the water flow, the particle size, and the slope. The concept of natural balance states, then, that for given sediment supply and inflowing water, the riverbed adjusts its slope until balance is

achieved. This means that the river aggrades and increases its slope, or it lowers and decreases it until the longitudinal profile corresponds to the equilibrium slope.

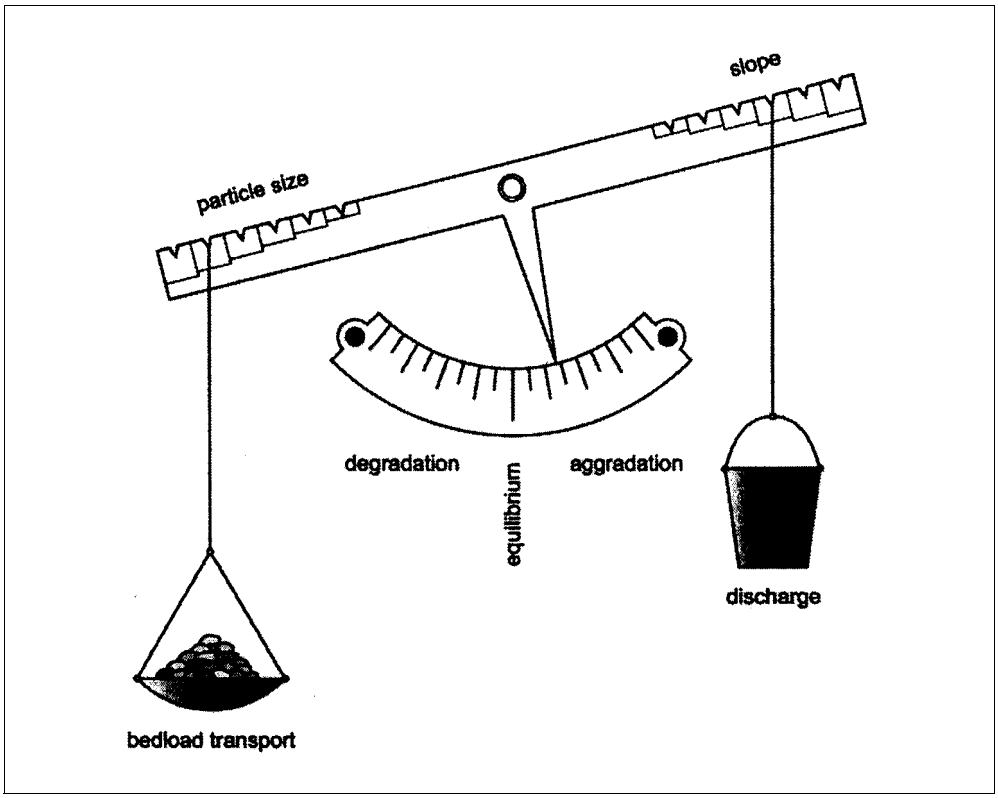


Figure 1:
The Lane scales (simplified version) to illustrate the concept of equilibrium.

2 The search for the equilibrium of rivers

The correction of the Linth River of 1807 to 1816 was the first modern-day river correction to be carried out in Switzerland. It was necessary because the level of the Linth riverbed on the Linth Plain was getting ever higher, resulting in an increased equilibrium slope, a process which seems to have occurred in the 17th and 18th centuries. The question of why the Linth Plain was, for over 4,000 years, so stable that settlements with agricultural land were able to be established at the edge of the Plain at least, will not be treated here. Nevertheless, there are two reasons currently being cited for the subsequent disruption of this balance: The traditional interpretation places the primary blame on deforestation of the catchment basin. This caused the bedload supply into the Linth to increase drastically, and a noticeable accumulation of floodwaters accelerated the aggradation. A new interpretation, recently put forth by ETH professor Conrad Schindler (b. 1926), states that the slope of the Linth riverbed diminished in the lower reaches of the river, where Lake Tuggen, formerly connected with Lake Zürich on the east, was filled in by the Linth, between 1450 and 1550. In this way, the lower part of the Linth was extended by 4 km in a relatively short time, which caused the Linth riverbed to rise continually in an upstream direction[3].

A look at the Lane scales reveals that both an increase in the bedload supply, and the reduction in slope as depicted, inevitably lead to the aggradation of the riverbed. It is possible that both of these two phenomena were at work. The counter-measure consisted in the diversion of the Linth into Lake Walen. The Molliser Canal (now known as the Escher Canal) was dug, diverting the Linth from Mollis for a stretch of 5 km into the lake. In addition, the 17 km long Linth Canal was built along the former Maag and the old Linth riverbed, thus ensuring the outflow from Lake Walen into Lake Zürich. In this process, the level of Lake Walen was lowered by more than 4 m, enabling it to function from then on as a floodwater retention basin for the Linth. Its mean surface area is now 24 km^2.

Thus the attempt was made through this impressive alteration of the hydrological network to re-establish the former stability of the Linth Plain, a measure that has been successful to date. A certain amount of follow-up work was of course necessary, in order to keep within the channels the equilibrium slope, whose existence was, at the time, presumed rather than known. Because the Linth Canal flows without bedload from Lake Walen, there was a risk of erosion, but this was prevented by reinforcement of the banks. There was no channeling of the tributaries into the canal. All of these streams empty into the drainage channels situated on both sides of the canal, which made it necessary to hold back their bedload.

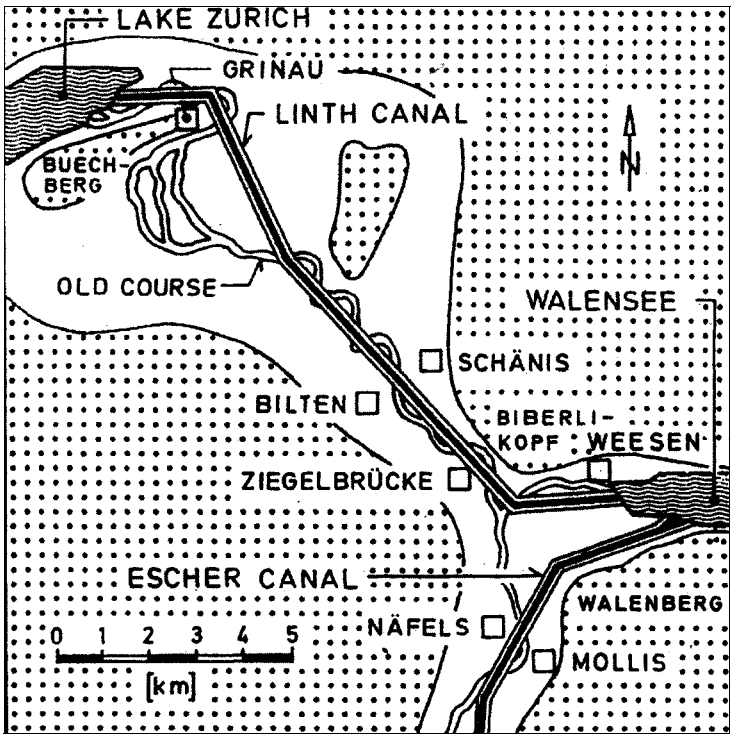


Figure 2:
The Linth Plain before and after the Linth correction of 1807 to 1816.

The situation at the Molliser Canal was more precarious. It had to take up all of the Linth bedload and deposit it to form a delta at Lake Walen. The annual sediment load amounted to 200,000 m^3 (as compared with 130,000 m^3 today[4]). If the canal

were widened too much, the riverbed would become higher, the free-board disappear, and the risk of flooding increase; and if it were made too narrow, it would lower and endanger its banks, thus fostering outbreaks. The initial canal measurements proved to be amazingly good, occurring at a time, as mentioned above, when the bedload theory had not yet been developed. Nevertheless, construction of the canal was followed by several years of adjustments in a process of trial-and-error. There was, in fact, a situation that in any case required continual adjustment, namely, the Linth Delta in Lake Walen continued to grow! This occurred more quickly than anticipated and caused the Molliser Canal to be extended so much (up to 1.5 km at present) that its slope decreased and there was a risk of the bed rising. For this reason it was important to ensure that the supply of sediment to the Linth be decreased over the medium and long term.

3 Measures to reduce erosion in the basin

The Linth correction was, therefore, the starting point for a whole range of measures for the reduction of the bedload supply from the catchment, and thus for the prevention of erosion. The Linth works had even received the right to require such measures, and to instruct the population «to reflect on ways to hold back the bedload in the mountains by artificial means»[5]. This duty was imposed in particular on the Canton of Glarus.

The first step taken was the setting up of sediment retention basins. The new situation in the Linth required swift action at certain places, particularly at the Mollis and Linth Canals. The village of Mollis, located on the alluvial fan of the Rüfi gully, formerly protected itself against flooding simply by canalization of the torrent, that is by digging a chute to transport the bedload further along into the Linth. However, when the Linth correction was undertaken in 1807–1811, the Linth was channeled and dammed at this location, causing the discharge of bedload into it to be hampered, and on top of this, even declared undesirable. This meant that a sediment retention basin was needed in addition to the chute. Nevertheless, this sort of removal process proved to be more and more costly and tedious, added to no doubt by the increased occurrence of flooding events in the 19th century. In the age before mechanization of construction activities, this debris had to be removed by hand and hauled away in carts.

In view of this and other difficulties encountered elsewhere, further solutions were sought. At first it was planned to hold back the bedload above the alluvial fan along the gorge that was generally found there. Yet it was soon recognized that the bedload production, and thus the erosion in the entire catchment, had to be prevented or drastically reduced.

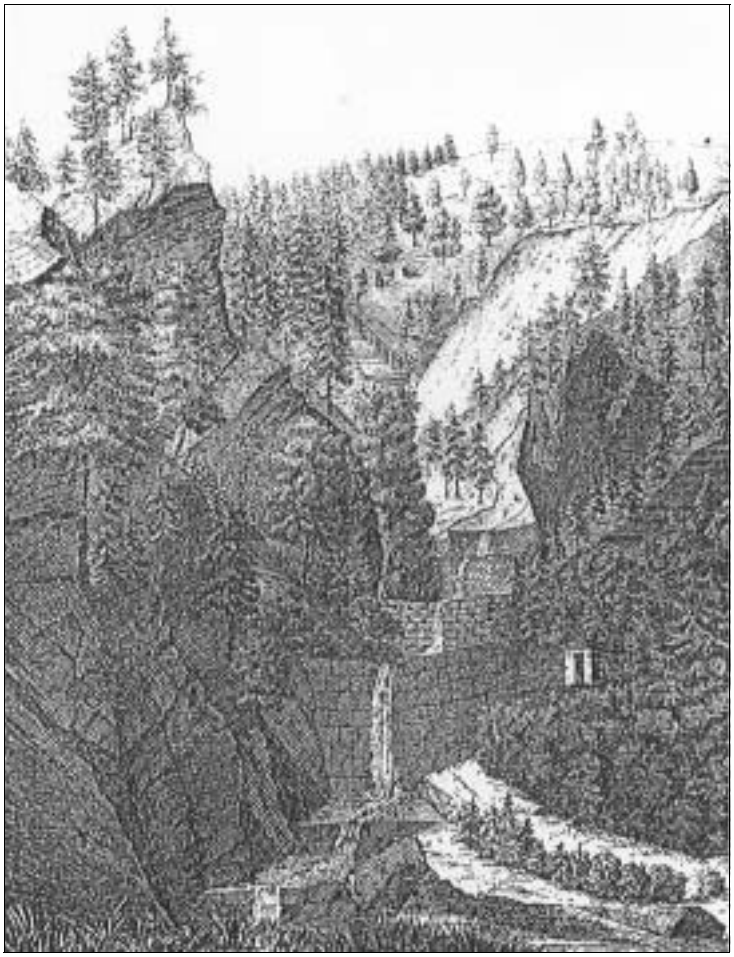


Figure 3:
Alterations to the Rüfi gully, 1831-1854, acc. to Legler /7/.

A measure much favoured at the time was taken in 1838 by the community of Niederurnen. Under the direction of Conrad Jenny (1800–1870), the gullies which only occasionally contained running water in the catchment of the Niederurnen village stream – a real torrent – were altered by artificial means to such an extent that reforestation could be undertaken. This was carried out by placing a series of wicker fences at right angles to the gully, at 3 m intervals. Functioning as a sort of standing grid, this had the effect of draining and slowing down the minor debris flows. Even though such debris flows knocked down the first 6 to 8 fences, they nevertheless lost so much water in the process that they dried up and hardened, and new fences were built on these earth masses. After this cycle had been repeated many times the gully was filled up enough to permit the planting of trees[6].

It was in this manner that, here in Niederurnen, the first debris-flow brakes were developed in Switzerland. In addition, wicker fences and similar retaining structures were built at other places where it was necessary to consolidate the sediment sources.

Due to the numerous problems that torrents posed also in other ways, in 1841 the government of the Canton of Glarus commissioned the Tyrolean engineer, Joseph Duile (1776–1863) to undertake an investigation. His report described the causes of the torrent damage, named the worst torrents in Glarus in this regard, and proposed restorative measures. He pointed out that the Durnagel stream was the biggest supplier of bedload in the Linth, and declared Mollis and Niederurnen as the two villages most seriously threatened by torrent outbreaks. He urgently recommended that the measures taken at various places on the alluvial fans be supplemented by similar ones, further upwards, that is, along the course of the torrent, in the form of a series of check dams, and further up again, by installing slope retaining structures. Duile also issued written and verbal instructions on how to build check dams, in particular verbal directions for measures concerning the Rüfi gully near Mollis.

As a result, the first modern torrent restraining structure in Switzerland was built at the Rüfi gully. Construction began already in 1842 for the larger check dams (smaller ones had already been built), and culminated in a series of check dams consisting of 11 steps made of dry-stone pitching. The largest of these attained the notable height of 18 m.[7] Through this achievement, the concept of the equilibrium slope was, so to speak, carried from the lowlands to the mountains. This means that torrents that flowed over their own bedloads were no longer likely to rise or lower in level.

As early as 1864, the ETH Professor Culmann[5] was able to ascertain that in Canton Glarus, not only were torrents being artificially changed where this was required by the Linth works, but the usefulness of such measures had also been recognized for those living directly adjacent to the torrents. He also identified this as a prerequisite measure for the needed reforestation of barren, deforested slopes, legislated by the Swiss government as of 1876.

4 Long Live Equilibrium?

One could present Swiss river correction measures and the subsequent torrent alterations as a triumph for the concept of equilibrium, and in this sense, erect a monument of the Lane scales on the Linth Plain to attest to this. Such a monument could, however, also be put up at a number of other locations, for example anywhere near the alpine Rhine, the alpine Rhone, the Ticino, or next to other alpine rivers, as these locations also witness to the relationship between river correction and torrent alteration measures.

Has a state of equilibrium thereby been achieved? By no means! For there is a higher process at work, which is not and cannot be in a state of equilibrium at all: erosion of the mountains, and sedimentation of the lakes! In other words, nature is not in equilibrium, because incoming solar energy is constantly at work. Thus the Lane scales are valid only for a relatively short span of time, and then the tare must be determined anew, or, said differently, the equilibrium slope of the river changes over a long period of time. Climatic changes also trigger further fluctuations. Envi-

ronmental history teaches that flooding events are not distributed randomly over the centuries. There are periods with a great deal and periods with very little flooding, and flooding events often occur in clusters. In fact, it is human beings, living adjacent to a river or torrent, who would like to have them in a state of equilibrium. And it is also the man-made correction measures that promote this equilibrium and even produce this state over the short term, and sometimes extend it. However, it is impossible to create a permanent state of equilibrium!

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5 The lessons learned from past natural catastrophes

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1 Introduction

Processes in the natural world are usually not a topic of public discussion; they tend to be disregarded. Sociologist Niklas Luhman has pointed out that such events are only noticed and communicated if they interfere with daily routines. Extreme events in the natural world become disasters through communication. The Swiss writer Max Frisch has stated: «It is just human beings who speak of catastrophes, if they survive. Nature itself is not aware of catastrophes».

If longer time scales are taken into consideration, natural disasters may no longer be seen as extraordinary events. They are processes that are bound to physical laws and, at least in principle, may occur again in some form or another. However, the response of society is different. Nowadays in Switzerland, there is a certain routine in disaster management and relief. This routine is the result of institutional learning. And this learning is related to the experience of natural disaster.

After a natural disaster there is always a window of opportunity for implementing novel solutions. The authorities are expected to take action to bring relief and also to take measures to prevent the recurrence of such an event in the future. In such a situation, processes of fundamental learning may be initiated. If the authorities jump at the chance, the preconditions for the successful management of a subsequent disaster will be improved.

2 Floods and the deforestation paradigm

In the course of the nineteenth century, the assumption that deforestation in the upstream area of a river leads to more frequent and more severe floods in the downstream area came to be adopted as a scientific paradigm. This «deforestation paradigm», as it shall be called here, emerged in Western and Central Europe during the period between the late eighteenth and the late nineteenth centuries. In the mid-nineteenth century it became the object of public debate, which resulted in legislative action requiring reforestation projects, first in France, then in Switzerland, Italy and in Austria, and subsequently, in other parts of the world. The history of this paradigm can be explained within the framework of a theory of communication:

- **Latent phase:** The topic is only well-known to insiders
- **Formation:** An interest group calls the attention of the public to the topic
- **Discussion:** The topic is discussed and policies are developed
- **Implementation:** Legislative action is taken to anchor the topic
- **Loss of attraction:** The topic is no longer attractive for the media and the public

Sociologist Niklas Luhmann (1970) convincingly demonstrated that issues in the public debate follow a kind of typical «career» in which several phases are [distinguished = distinguishable]:

- In the *latent phase* a theme has no relevance for the public debate. It is just known by a few insiders and specialists.

- Under certain circumstances, the theme is taken on by some lobbies who invest time and resources to put it on an agenda (*formative phase*).
- In the public debate, the theme competes with others for the attention of the media, which is limited and rather short-lived. If the theme gains enough attention in the public, it becomes part of public opinion (*phase of discussion*).
- During the discussion phase, the theme is often adopted by political interest groups and included in the legislative process (*phase of implementation*).
- In the final phase, the public gets tired and bored of discussing the theme (*phase of satiety*).

Most themes remain in the latent phase and never become the object of a public debate. Only very few of those which come into the formative phase ever reach a phase of political materialization.

In order to be taken on by the media, an issue must fulfil a set of rules and conditions (Russ-Mohl, 1981):

- It must be perceived as something novel, striking, something which differs from everyday experience.
- It should endanger the basis of material life and jeopardize symbolic values of society.
- The sender of the message needs to be recognized in his/her field and should be empowered to act as a representative.

Major floods undoubtedly fulfil most of these conditions. They are likely to produce the greatest behavioral response because they tend to generate collective stress and disrupt community life, thereby resulting in substantial damage.

A single disaster is likely to generate collective stress, disrupt community life and result in substantial damage. However, all societies expect such events to happen from time to time and therefore they will not be perceived as something novel and threatening. In order to understand why this paradigm was successful, the changes in the frequency and severity of floods must be considered:

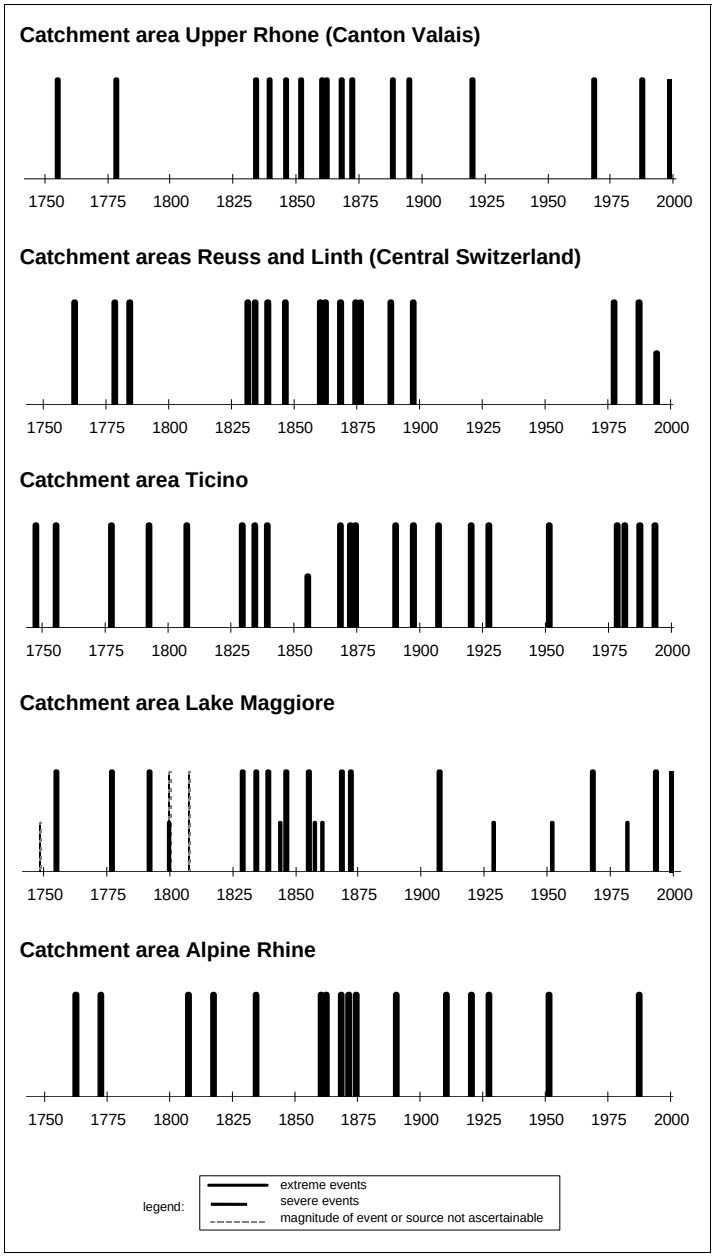


Figure 1:
Floods in the Central Alps.
Source: Pfister 1999.

This figure displays the frequency of severe floods in the four major river basins – Rhine, Reuss, Rhone, Ticino – around the St. Gotthard pass in the Central Alps during the last 500 years. Every bar represents a severe flood. The magnitude and severity of floods are estimated from damage reports prior to the onset of gauge records. In addition, the floods of the Lago Maggiore (in the border region between Switzerland and Italy) are a given factor. This is based upon continuous gauge readings from 1829 in Sesto Calende (Italy).

Extreme floods in the catchment basins of the Central Swiss Alps are related to the confrontation of cold air flowing to the Alps from the North and colliding with the warm and humid air masses from the Mediterranean.

The distribution of floods over the course of time is very uneven: Severe floods were relatively rare from 1760 to 1830. An unusually large number of floods was recorded from 1830 to 1880 in most of the Alpine Arch. It needs to be stressed that this pattern [became also = also became] manifest in the lowlands of Western and Central Europe including the Po Valley.

By the mid-eighteenth century, the scientific debate on the deforestation issue had already begun in France and England. Both the Royal Society and the Académie des Sciences discussed the issue with reference to the island of Mauritius, where large parts of the forest had been removed.

The origin of the «deforestation paradigm» seems to be located in the French Pyrenees. In the 1770's, the villages situated near the River] Têt were repeatedly affected by major floods. From 1761 to 1770, the Têt flooded its banks seven times, from 1771 to 1780, nine times. As a consequence, many communities situated along the river faced ruin. Generally, a part of their losses was compensated by charitable gifts from other communities. But as the number of floods multiplied in the 1770's, the willingness and the resources to help became exhausted. As a result of this situation, the royal administration dispatched engineers from the newly founded «Corps des Ponts et des Chaussées» to investigate the causes of the disaster. The experts concluded that the floods were the consequence of new clearings on steep slopes alongside the river, allegedly because in the decades before – when these hills were still covered with forests and shrubbery – the floods had been less frequent and less severe. Their arguments were taken up in a printed memorandum in 1778 and copied again and again until the Revolution. Engineer Jean-Antoine Fabre argued in a separate essay that forests were able to prevent the generation of flush floods by storing water in the tree tops. In the German-speaking world, the considerations of French engineers became known in the 1820's, i.e. immediately preceding the novel pattern of floods.

A first severe flood occurred in September of 1834. It was still interpreted within the given scientific framework. The experts were hydraulic engineers and they related the event to the extreme amount of precipitation, to the fact that the channels of many mountain torrents had been obstructed by debris, and finally to the inadequate construction of protective dams. Deforestation was not mentioned as a possible cause though [iat = it] had been discussed for centuries in the context of shortages of timber and fire wood.

Only five years later, in autumn 1839, the Central Alps were devastated by another severe flood. This event was conceived in a very different context. The occurrence of two once-in-a-century events within a decade was perceived as a threat because it included the danger that this might be the beginning of a novel flood regime. For-

esters, who had become sensitive by reading the work of their colleagues in France, became sensitive to the issue of deforestation. Alexandre Surell, prefect of the department of the Hautes Alpes, argued that the floods were the *sole* consequence of deforestation. French historian Andrée Corvol points to the ideological overtones of the debate. The advocates of afforestation were conservatives who blamed deforestation on liberal ideas and legislation. Deforestation was portrayed in terms of a recent and unique feature which had not been known under the Ancient Regime. It is true that deforestation got new momentum from the 1830's both in France and in Switzerland for two reasons: The first was population pressure which resulted in an increased demand for fire-wood and the keeping of ever larger herds of goats. The second was the privatization of forests which lead to an unbridled cutting of timber for export.

3 The novel interpretation was adopted by Swiss foresters.

In 1843, the experts joined the Swiss Forest Society, which in subsequent decades became a powerful lobby. Between 1846 and 1855, the enhanced rhythm of floods mainly struck the lowlands. During this time the deforestation paradigm was repeatedly brought forward as an explanation by the forestry society and it became known to the public. During this time the paradigm entered the phase of discussion.

In 1856, the (executive) Federal Council entrusted the president of the Forest Society, Professor Elias Landolt of the Federal Polytechnical University (ETH), to assess the situation of the forests in the Swiss Alps. In his report, Landolt suggested promoting reforestation through subsidies, probably inspired by the French reforestation law of 1860.

In autumn 1868, the Central Alps were again devastated from a huge flood. The material damages were between 1.4 and 4 billion actual Swiss Francs, depending on the kind of estimate. This outstanding disaster put the deforestation issue on top of the political agenda. It its true that the experts pointed to the excessive rainfall as the primary cause in their report. Deforestation was mentioned as a secondary cause.

However, through public communication, the Forest Society clung to its former position that the disaster was connected to the deforestation of mountainous areas as a cause of floods in the lowlands. Its leading members wanted to profit from the public emotion which was known to be short-lived in order to put the issue on the political agenda, as the Society recorded in its minutes.

The quest for subsidies was not an easy undertaking for three reasons:

- On one hand, forest legislation interfered with private property, which was a fundamental value of liberalism.
- On the other hand, this legislation was a prerogative of the Cantons. It took another two severe floods, in 1870 and 1872, to further promote the institutional learning process which had begun three decades earlier.

- Finally, the budget of the confederations was still small and the allowance of subsidies was still something novel.

As the staggering rhythm of floods was maintained over the following years – the next disasters struck in 1870 and then again in 1872 – a kind of organizational learning took place and the political pressure grew for legislative action.

In 1876 a federal law was finally promulgated that provided the allowance of government subsidies for reforestation and damming mountain torrents. In this way the issue entered the phase of materialization. Subsequently, laws protecting mountainous forests and supporting afforestation were promulgated in Italy (1877) and in Austria (1884). During the twentieth century the deforestation paradigm was adopted worldwide and it is still valid in most peoples minds.

Climate change is an alternative explanation for the enhanced frequency of floods between 1830 and 1885. Indeed there is some evidence pointing to a substantial increase of precipitation in autumn which is the critical season for flood generation. Prior to 1864, there is no rainfall record available for the Northern slope of the Alps. However, such records are available for Torino (Northwestern Italy) and Milano.

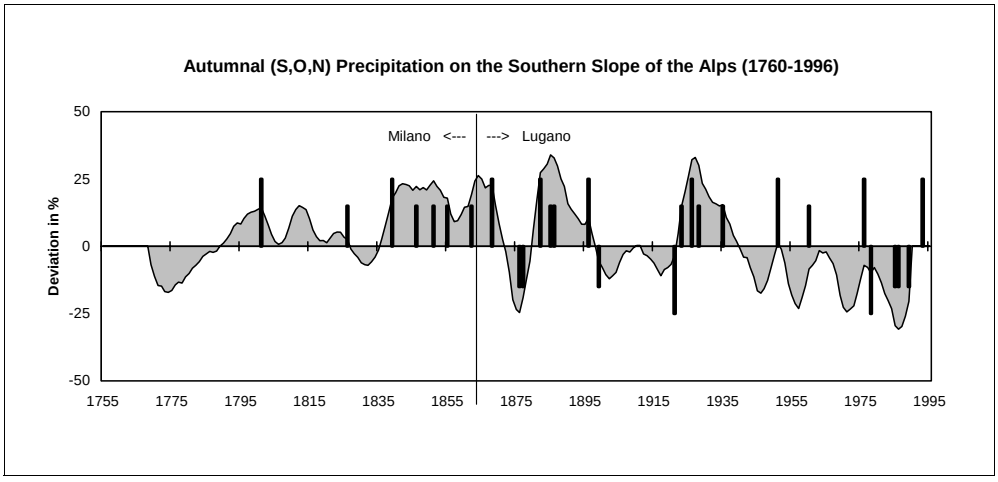


Figure 2:
Rainfall in Milano and Lugano.
Legend: Deviation from average 1902–1960 (%).
Source: Pfister (1999).

From figure 2 it is obvious than rainfall in autumn was substantially higher prior to the 1890's. This suggests that a variation in climate may be the cause of the high frequency of floods in nineteenth-century Central Europe, the causes of which still need to be investigated.

4 Conclusion

What conclusions may be drawn from this example: In the case of the «deforestation paradigm,» the images in the public mind obviously do not agree with the reconstruction of past environments and climates. The knowledge of physical

backgrounds of flood events allows getting to the bottom of arguments which were brought forward in the debate and to question the motivation of the actors. On the other hand, considering the ideas of people on past environmental processes is likely to put the present world view into perspective. Concisely stated: Though it seems that the diagnosis of the contemporaries was wrong, the therapy of deforestation control framed in terms of a «no regrets» strategy was certainly appropriate for the Alpine environment.

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6 Risk Management – A Framework to Improve Effectiveness and Efficiency of Resource Management

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1 Introduction

Since the mid-1980s statistics of the insurance industry indicate that damages due to natural hazard events have been increasing. Although public expenditures for hazard mitigation have been increasing damages could not be reduced. This raises the question what strategy could be used to improve cost-effectiveness of mitigation actions. Natural hazards have been influencing societies in mountainous areas for centuries. In Switzerland, as well as in many other countries, several professions (hydraulic engineers, forest engineers, geologists, geomorphologists, etc.) have been responsible for natural hazard mitigation, resulting in a lack of holistic problem solving, and in sub-optimal budget allocation for mitigation measures to several public agencies. To improve those deficiencies a change in policy from purely defensive measures to risk management was implemented (PLANAT, online-b). A national platform on natural hazards (PLANAT) was established in 1997 with the mandate of co-ordinating planning, prevention, response, and recovery activities. PLANAT aims to change culture from mitigation of hazards to risk management, and to promote ecologically sound, socially equitable and economically efficient measures (PLANAT, online-a).

The risk management approach emerged from nuclear power production aiming to manage risks in a holistic way. The paper aims to explain the concept of risk management, which has been implemented for natural hazard mitigation in Switzerland. This implementation started in the mid-1990s, why procedures and tools still have to been adapted and improved. The contribution will first introduce a risk management framework, then discuss the components of scientifically-based risk estimating, outline problems associated with risk evaluation, and finally provide some ideas on risk control measures.

2 Risk Management Framework

'Risk' can be defined as the absolute value of probable loss (Cool, 1999). The Society of Risk Analysis defines ‘risk’ as (SRA, online)

> The potential for realization of unwanted, adverse consequences to human life, health, property, or the environment; estimation of risk is usually based on the expected value of the conditional probability of the event occurring times the consequence of the event given that it has occurred.

Risk Management consists of a set of functions that are identified as continuous activities throughout the life cycle of a project or a geographical area (Figure 1). Each risk goes through these functions sequentially, but the activity occurs continuously, concurrently (e.g., risks are tracked in parallel while new risks are identified and analyzed), and iteratively (e.g., the mitigation plan for one risk may yield another risk) throughout the life cycle (SEI, online).

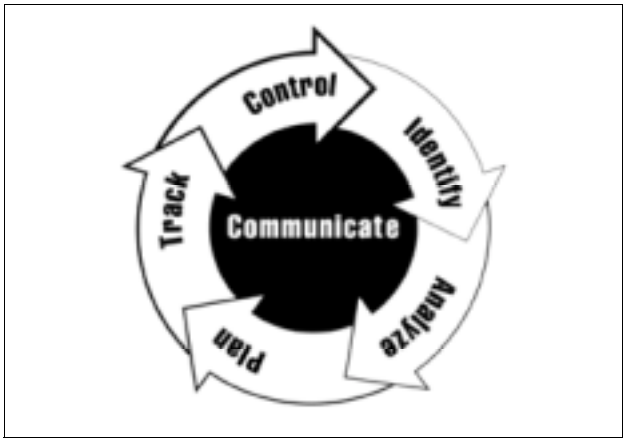


Figure 1:
Risk Management Paradigm [Following (SEI, online)]. Illustrates a set of functions that are identified as continuous activities throughout the life cycle of a project or a geographical area.

Risk management consists of the following functions (SEI, online)

IDENTIFY	Search for and locate risks before they become problems (*what can go wrong*?).
ANALYZE (ESTIMATE)	Transform risk data into decision-making information. Evaluate impact, probability, and timeframe, classify risks, and prioritize risks (*what is the expected value of all probable losses*?).
PLAN	Translate risk information into decisions (*do we need to reduce the risk*?) and actions (*what should be done*?) and implement those actions.
TRACK	Monitor risk indicators and mitigation actions (*what is the trajectory of risk development?).*
CONTROL	Correct for deviations from the risk mitigation plans *(is there a need for corrective actions CA?).*

COMMUNICATE Provide information and feedback internal and external to the project on the risk activities, current risks, and emerging risks. Communication happens throughout all the functions of risk management.

The risk management cycle (figure 1) was developed for the software industry. However, the philosophy is not sector specific and may be transferred to natural hazard problems.

3 Risk estimation

Risk estimation is defined as (SRA, online)

> The scientific determination of the characteristics of risks, usually in as quantitative a way as possible. These include the magnitude, spatial scale, duration and intensity of adverse consequences and their associated probabilities as well as a description of the cause and effect links.

Risk may be defined as the probability of the event occurring times the consequence of this event (figure 2). An occurring event (hazard potential) may be characterized by the event type E_i, intensity p (magnitude), spatial scale, duration, and probability of occurrence $\pi_i(E_i)$. The consequence of an event (damage potential) may be specified by the evaluation W of safeguard objects with money or utility, cause – effect links V(p) (vulnerability), spatial exposition π_R, time exposition π_T, and the natural regeneration potential. Damage C (loss) is the consequence of a defined hazard event affecting the damage potential. Multiplying damage times the probability of occurrence may assess risk R.

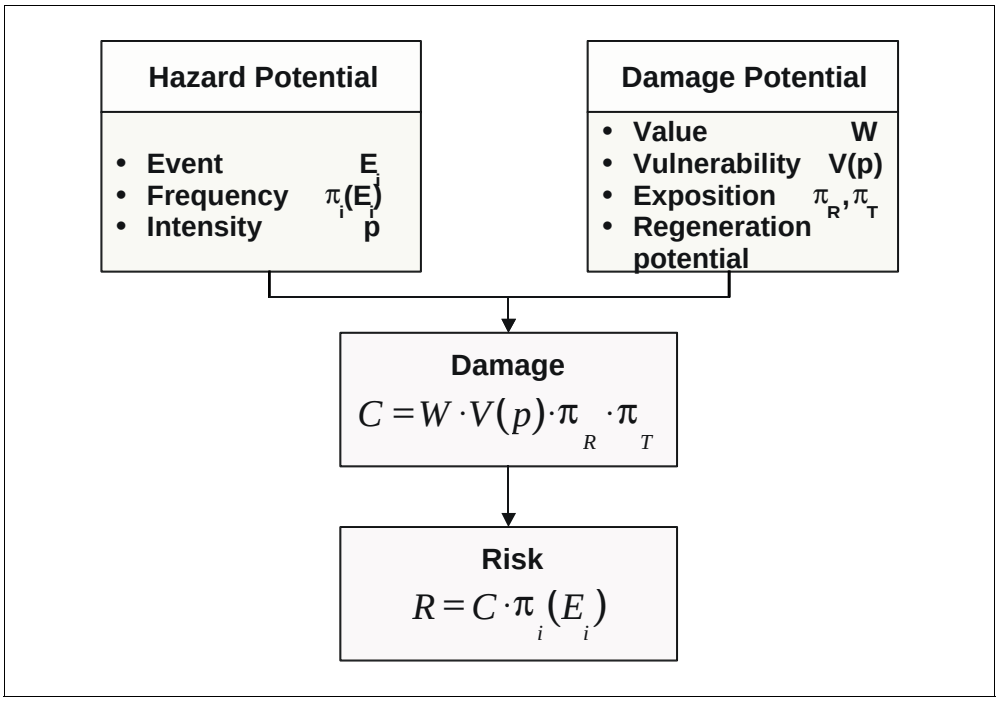


Figure 2:
Risk Estimation Framework.
Aims to answer the question «what can go wrong». There are two measures, (1) the possible damage (loss) that occurs if one known event happens, and (2) the risk expressed as the expected value of all probable losses.

A probable loss can be large because of the probability ($\pi_i(E_i)$) or because of the amount of damage (C) involved. Average Annual Loss (AAL) is a common measure for risk. It is the annualized estimate of loss to a representative spatial unit of value objects (dwellings, life lines, persons, etc.) exposure from specific sets of hazardous events.

Risk management philosophy emerged from analyzing technical risks, first of all in the nuclear industry. The application of risk management to natural hazard problems originates in a safety-planning project for the St. Gotthard train route in Switzerland. During the second part of the 1990s several studies investigated how to implement a risk management philosophy for natural hazard problems. They covered problems like the adaptation of safety science methods (Hollenstein, 1997), pareto optimal management strategies (Wilhelm, 1997, 1999), hazard analysis (Heinimann et al., 1998), and risk analysis methodology (Basler+Partner, 2001, Borter, 1999, Borter and Bart, 1999). The risk analysis methodology consists of three levels of investigation, which require different levels of analysis:

- level one: analysis of safety deficits of area, line, and point safeguard objects. Results are documented in safety deficit maps.
- level two: detailed analysis of geographical areas with safety deficits, resulting from level one.
- level three: detailed risk analysis for safeguard objects and lifelines, documented in risk maps.

All levels of investigation consists of systematically analyzing the interaction of hazardous events (hazard potential) and effects to safeguard objects (damage potential), taking into account probabilities of occurrence, and of exposition.

The Swiss federal civil protection agency initiated an investigation (BZS, 1995) on integral risk estimates for natural hazard in Switzerland (figure 3). Earthquake is the main risk with a share of about 50 percent. Those natural hazards that are managed by specific government agencies (floods, avalanches, mass movements) share only about 25 percent. The results of this investigation were one of the reasons why a change from hazard mitigation to risk management was initiated.

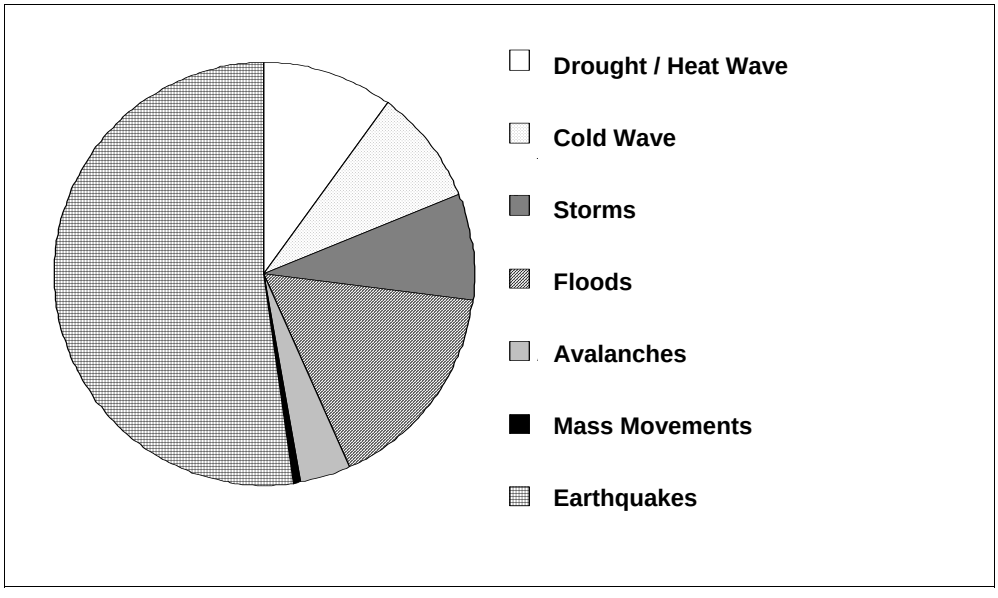


Figure 3:
Integrated Risk Estimate for Switzerland (BZS, 1995). Earthquake risk shares more than 50% of the overall natural hazard risk. However, the average annual loss (AAL) weighted with an aversion factor.

4 Risk Evaluation

Risk evaluation is defined as (SRA, online)

> A component of risk assessment in which judgments are made about the significance and acceptability of risk.

Risk evaluation consists of two aspects (Sandman, 1999). The technical side of the risk focuses on the magnitude and probability of undesirable outcomes (risk estimate in Figure 1). The non-technical side of the risk focuses on everything negative about the situation itself, which Sandman called «outrage» (risk evaluation in Fig. 1).

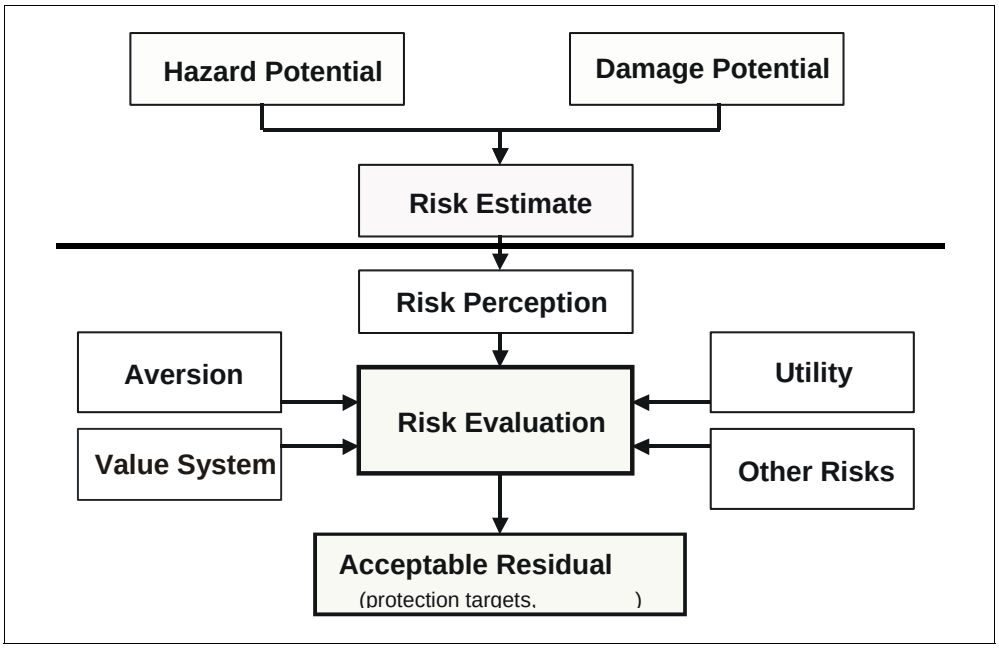


Figure 4:
Risk Evaluation Framework.

If one makes a list of risks in order of how many people they kill each year, then lists them again in order of how alarming they are to the general public, the two lists will be very different (Sandman, 1987). Or, in other words, risks that kill persons are not necessarily the risks that anger and frighten them. Sandman created the formula: *Risk = Hazard + Outrage* to consider risk aversion, which is a concept to understand the difference between the expected loss and person's judgment of the loss (negative utility). There are more than 20 «outrage factors (Sandman, 1987), such as:

VOLUNTARINESS: A voluntary risk is much more acceptable to people than a coerced risk, because it generates no outrage. Consider the difference between getting pushed down a mountain on slippery sticks and deciding to go skiing.

CONTROL: Almost everybody feels safer driving than riding shotgun. When prevention and mitigation are in the individual's hands, the risk (though not the hazard) is much lower than when they are in the hands of a government agency.

FAIRNESS: People who must endure greater risks than their neighbors, without access to greater benefits, are naturally outraged – especially if the rationale for so burdening them looks more like politics than science. Greater outrage, of course, means greater risk.

PROCESS: Does the agency come across as trustworthy or dishonest, concerned or arrogant? Does it tell the community what's going on before the real decisions are made? Does it listen and respond to community concerns?

MORALITY: American society has decided over the last two decades that pollution isn't just harmful – it's evil. But talking about cost-risk tradeoffs sounds very callous when the risk is morally relevant. Imagine a police chief insisting that an occasional child-molester is an «acceptable risk.»

FAMILIARITY: Exotic, high-tech facilities provoke more outrage than familiar risks (your home, your car, your jar of peanut butter).

MEMORABILITY: A memorable accident – Love Canal, Bhopal, Times Beach – makes the risk easier to imagine, and thus (as we have defined the term) more risky. A potent symbol – the 55-gallon drum – can do the same thing.

DREAD: Some illnesses are more dreaded than others; compare AIDS and cancer with, say, emphysema. The long latency of most cancers and the undetectability of most carcinogens add to the dread.

DIFFUSION IN TIME AND SPACE: Hazard A kills 50 anonymous people a year across the country. Hazard B has one chance in 10 of wiping out its neighborhood of 5,000 people sometime in the next decade. Risk assessment tells us the two have the same expected annual mortality: 50. «Outrage assessment» tells us A is probably acceptable and B is certainly not.

Safety (the complement to risk) is a public good and therefore is a matter of public decision-making. Early work on natural hazard risk analysis and evaluation (Troxler et al., 1989) mentioned that acceptable risk is a normative result, being an outcome of a public decision-making process. Such a process is not only based on rational arguments, but also on perceptions, and valuations resulting in controversies. A typical risk controversy emerges when the hazard is low and the outrage is high (Sandman, 1999). He identified four stages that lead to controversy

- The controversy begins when some group complains that something is dangerous. Experts investigate the hazard and determine that it is low.
- Having failed to ignore critics into oblivion, experts try to bury them in the data.

- Having failed to ignore them into oblivion, having failed to bury them in the data, experts now look for a way to attack their motives. If they're professionals experts call them mercenaries; if they're amateur experts call them ignorant.
- Then, experts get a phone call from top management. «This is getting serious,» they are told. «These people used to be just a minor irritant. But now regulators are asking awkward questions, newspapers are running embarrassing stories; politicians we thought were on our side are putting some distance between them and us. I don't care what you have to do, get these people off our backs!»

Sandman's four-stage model raises the question how the collaboration of experts, stakeholders, and policymakers could be improved. Figure 1 represents a model of possible collaboration.

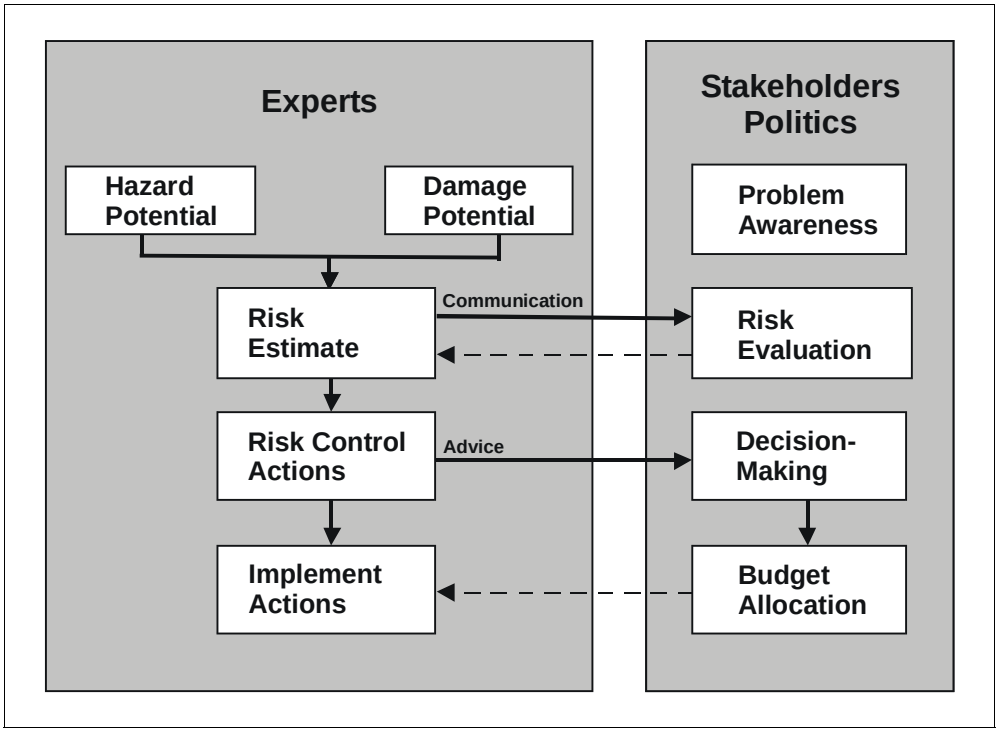


Figure 5:
Collaboration of Experts and the Lay Public.

The question of how experts and the public lay should collaborate in this evaluation is still under debate. One point of view requires more rational power (Schuh) whereas another point of view demands a coexistence of common sense and intuition (von Randow, 1996). Expert analysis and perception of the public lay may be combined according to Sandman's formula «risk equals hazard (risk estimate) times public outrage (aversion)».

5 Risk Control

Risk control aims to design and implement sustained actions to reduce or eliminate the long-term risk to people, property, public infrastructure, and natural resource

values. It consists of the whole range of prevention and intervention measures (figure 6). Traditional prevention strategies focus on hard measures such as building hazard resistant structures (lifelines, facilities) and structures for hazard control (e.g. avalanche and torrent control measures). Since the introduction of the risk management philosophy there has been a shift to soft prevention measures covering risk mapping, disaster warning, land use zoning, emergency training, etc. Intervention consists of developing organizations for fast response, such as civil protection and emergency services. Finally, strategies for recovery measures should be prepared.

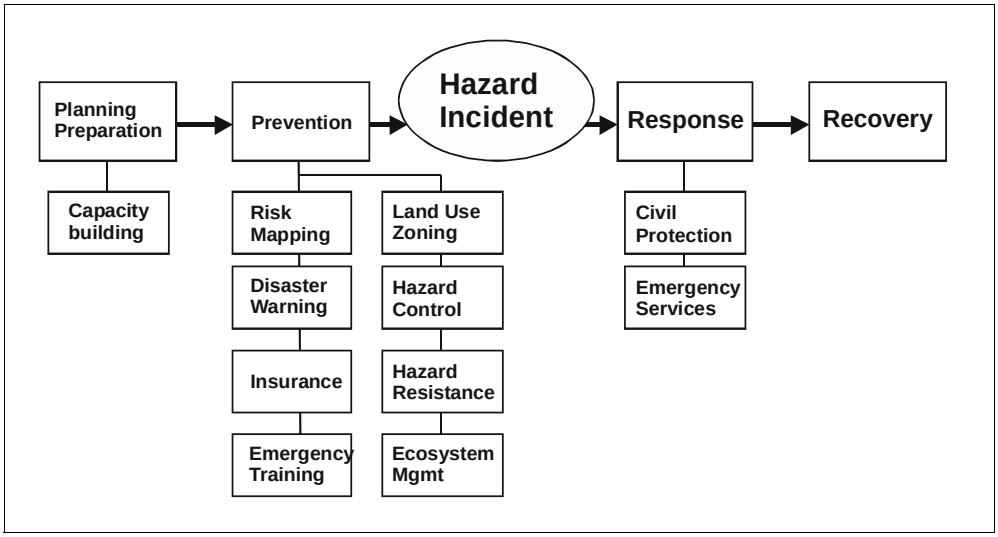


Figure 6:
Possible Courses of Action. There is a trend to strengthen preventive actions.

To find a near-optimal measure mix decision-making has to apply quantitative or semi-quantitative optimization strategies. Those are:

- PARETO-optimal: a strategy to optimize social welfare by evaluating trade-offs between probable losses (risk value), probable benefits (benefit value) and probable costs.
- MINIMAX: a rational strategy that promises to minimize the maximum possible losses (risk value).
- MAXMIN: a distribute justice strategy, whereby the just rule is to maximize the welfare of the least well-off person. Originates in the work of a philosopher (Rawls, 1979).

For long time, MINIMAX strategy was the dominating paradigm for natural hazard management. Recently, there have been efforts to apply and improve PARETO-optimal strategies such as cost-benefit, and costs-effectiveness analysis (Wilhelm, 1997, 1999). Following the debate of sustainable development, a new strategy, MAXMIN, came on the agenda aiming to promote the principle of social equity.

6 Conclusions

The present paper started with the question of how a risk based approach for natural hazard management has been implemented in Switzerland. The investigation resulted in the following findings: (a) Risk is a function of both (1) the probability of something undesirable happening and (2) the magnitude of the impact of that hazard. (b) Tools for risk estimation, evaluation, and the design of control actions are available; but implementation still needs attention. (c) Decision-making on acceptable risks and courses of action requires the interaction of experts, stakeholders, and policy makers

Although all components of a risk management framework (figure 1) were adapted to natural hazard problems, implementation still needs attention. Risk estimation depends on understanding dose-effect links for all relevant types of hazard. Recently, those relationships rely on expert opinions and best guess. The challenge for risk management research is to improve our understanding of dose-effects links (vulnerability functions) and of risk perception, and risk aversion, respectively.

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7 The influence of different land uses in a catchment area on natural hazards

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1 Introduction

In most catchments areas many different land uses (settlements, roads, acres, meadows, pastures, different forest types, etc.) interact with different natural hazards (rock fall, landslides, snow avalanches, flooding, earthquakes etc.). As it is almost impossible to describe all potential influences of land use on natural hazards in one study, especially if the influence of land use practices (e.g. what type of machine is used for harvesting) shall be considered too, most publications focus on certain aspects of the general theme mentioned in the title.

This is also the case for the publication in hand. First of all the variability in land use will be reduced to the very simple classification forest - non-forest with the goal to describe typical influences of forests on natural hazards rarely observed with other types of land use. Further more the publication will not treat natural hazards that are not directly related to the catchment (e.g. earthquakes). It will discuss the processes rock fall, landslides, snow avalanches, torrent channel processes such as sediment transport and debris flows and will put special emphasis on flood generation. The paper will close with some remarks on the influence of other types of land use and of land use practices on natural hazards.

2 How do forests influence natural hazards?

Forests influence natural hazards directly or indirectly above or below the surface. An example for the direct influence above the surface is the stopping of a falling rock behind a tree. Direct influences below the surface, e.g. the armouring of soils by roots, are much less obvious. The fact that the snow cover is generally thinner and less homogeneous than outside of the forest is an example for an indirect influence above the surface. This reduces, together with the direct stabilization effect of the trees, the probability of large avalanches in forests. Indirect influences below the surface are normally related to a change in soil properties. As such changes take place over long time periods and because the occurrence of a forest cover is only one of many factors influencing soil properties, these influences are most difficult to assess. In the following sections the different influences of forests will be discussed process by process.

3 Influence of forests on rock fall

The main influence of forests on rock fall is related to the interaction of a falling rock with a tree. Depending on the block size, it's velocity, the stability of the tree, the height above ground of the impact and the angle of impact a certain part of the kinetic energy of the block is absorbed by the tree. Eventually the block is stopped completely or it changes it's path. E.g. Jahn (1988) showed that the number of blocks stopped on a slope depends on the number of trees on a slope and that much fewer stones cross a forested slope section than a similar slope section without forest cover.

In most cases it is not the first contact between a tree and a falling rock that stops the block. Only the continuous «consumption» of the kinetic energy of the block will slow it down enough that it can be stopped. Therefore the influence of a forest on rock fall highly depends on the density of a forest. Because the capability of trees to absorb kinetic energy is limited, the effect of a forest decreases with increasing block kinetic energy. With very large blocks moving at high velocities the effect becomes negligible. A model to evaluate this direct influence of forests on rock fall has been developed e.g. by Zinggeler et al. (1991).

Forests also have a direct influence on rock fall in the starting area. They can keep a rock in place with their roots or a block may be stopped for long time behind a standing or even a fallen tree. A minor indirect influence of forests in the transit area on a moving block can result from changes in soil properties therewith influencing the contact interaction between the ground and the block.

4 Influence of forests on snow avalanches

Forests stabilize snow cover on a slope with the trunks of the trees by carrying a part of the weight of the snow. However this effect is limited to a sector immediately adjacent to the tree and therefore the reduction of avalanche probability is highly dependent on the size of the gaps between the trees (Meyer-Grass and Schneebeli, 1992).

Forests also have an indirect impact on the avalanche probability by changing the properties of the snow cover. On one hand the snow cover is generally thinner in a forest than outside of it. This is because some of the falling snow remains on the trees where from it sublimates more rapidly than from a compact snow cover on the ground because of the much larger surface area. On the other hand the snow cover below trees is rather inhomogeneous due to the shading of the trees, snow packs falling from trees during melting periods, etc. This inhomogeneosity reduces the risk of large avalanches further more (Bebi, 1999).

Forests not only reduce probability and size of starting avalanches, they also have an influence on moving avalanches because the trees have the effect of additional friction. However, this influence is in many cases rather small (Stöckli and Pfister, 1997).

5 Influence of forests on landslides

Normally the influence of forests on landslides is discussed mainly under two aspects: the direct influence of trees and their roots and the indirect influence of changing hydrologic conditions (see e.g. Greenway, 1987, Rickli, 2001). While the mechanical effects of the roots are generally stabilizing, the influence of the weight of the trees is comparatively small and may be positive or negative. The hydrologic influence is somewhat ambiguous because forest soils tend to enhance infiltration which results in slope destabilizing rising ground water levels. Conversely, inter-

ception and evapotranspiration lower the soil water content. Another indirect aspect, which is not well understood, is the altering of soil properties under the influence of the trees and mainly of their smallest roots (Böll and Graf, 2001).

Forest have a stabilizing effect mainly on shallow landslides on not extremely steep slopes. In analyzing a severe thunderstorm triggering about 400 shallow landslides, Rickli (2001) showed that above a slope angle of about 39° no difference in landslide probability between forested and not forested areas could be found, whereas more landslides were observe in non forested areas below 39°.

The sliding plane of a deep-seated landslide is below the reach of the roots and therefore only changes in the hydrology might have a certain impact. However as mentioned above, this influence is ambiguous.

6 Influence of forests on surface erosion

Very high rates of surface erosion normally occur on bare land. The typical example for this is ploughed land just before or after seeding. Surface erosion is initiated by water flowing on the soil and also by falling raindrops. In many cases the latter, called splash erosion, has an important impact as it also decreases infiltration capacity. Splash erosion is most effectively prevented with ground vegetation. Therefore, in a forest with tall trees and bare soil between them, the ground may also be highly susceptible to soil erosion because the drops falling from high trees have almost the same erosive force as outside of a forest. E.g. on a steep slope (about 35°) in the Bernese Oberland surface erosion was found to be 6 times higher inside a forest with little ground vegetation than on a site outside of the forest but covered completely with grass (see Hegg, 1997: 135).

When surface erosion is mainly related to flowing water, gully formation is often observed. Tree roots effectively prevent the formation of gullies as they stabilize the soil. They may also have a similar function as check dams in a mountain torrent.

7 Influence of forests on floods

When discussing the influences of forests on the water cycle in general, interception and evapotranspiration are the most important factors to be considered. Due to these factors, runoff from forested catchments is generally smaller than the one from catchments with little forest cover (see Fig. 1). Due to the higher evapotranspiration, soil water contents tend to decrease faster in forested catchments resulting in more free storage capacity for water in a subsequent rainfall event. How far this helps to reduce floods is highly dependent on the weather evolution (sequence of dry and wet periods) and the character of a rainfall event (duration, intensity, etc.). The influence becomes more important with higher storage capacities of the soil.

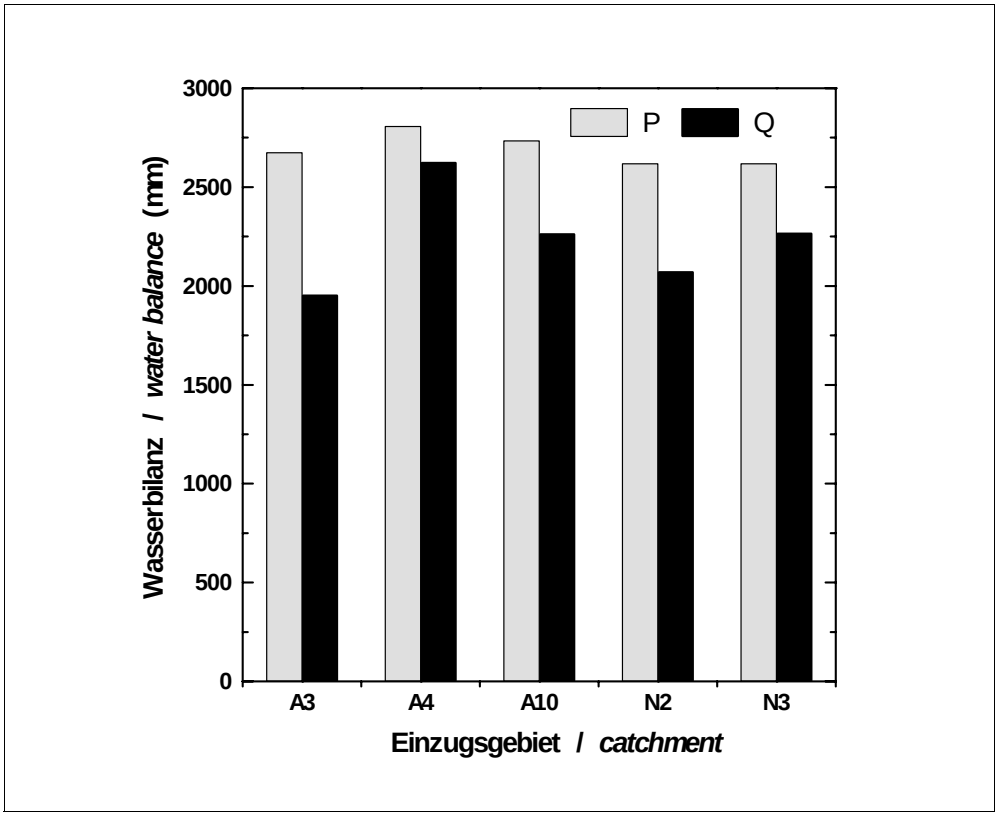


Fig. 1:
Water balance between precipitation (P) and runoff (Q) for five catchments in the Alptal.
Catchment characteristics:
A3: 155 ha, 63 % forest
A4: 93 ha, 19 % forest
A10: 70 ha, 39 % forest
N2: 0.15 ha, 100% forest
N3: 0.17 ha, 0 % forest

Floods are normally caused by intense rainfall. During such periods the air is very humid and therefore almost no evapotranspiration takes place. Furthermore the influence of interception is very limited. In forests the maximum interception is around 4 to 5 mm per event (Dyck und Peschke, 1995) which is very small compared to typical rainfall events causing damaging floods which are often higher than 40 or 50 mm for thunderstorms or as high as 700 mm in three days for the most extreme long lasting event observed in Switzerland in recent years (BWG / WSL, 2002).

Therefore the most important factor influencing flood generation in forests is the capacity of soil to store water. Because many forest soils tend to have high infiltration capacities, these storage capacities also can be used. Very limited infiltration capacities occur only with a hydrophobic organic layer on top of the soil.

As mentioned above, the storage capacities for water tend to be higher in forests because of evapotranspiration. However well developed forest soils often have higher pore volumes and therefore higher water storage capacities than soils e.g. below ploughed land. As described in the section on land use practices further below, this difference is not necessarily related to the difference in land use but to the land use practices associated with a certain land use.

However, not all forest soils have a high water storage capacity. E.g. in the Alptal region, mostly gleyic soils have developed due to the Flysch geology which consists mainly of impermeable marls and schists. If the highest floods observed in the three catchments A3, A4 and A10 shown in Fig. 1 are analyzed, no relation between flood peak discharge and forest cover can be determined (see Fig. 2) (Burch et al. 1996).

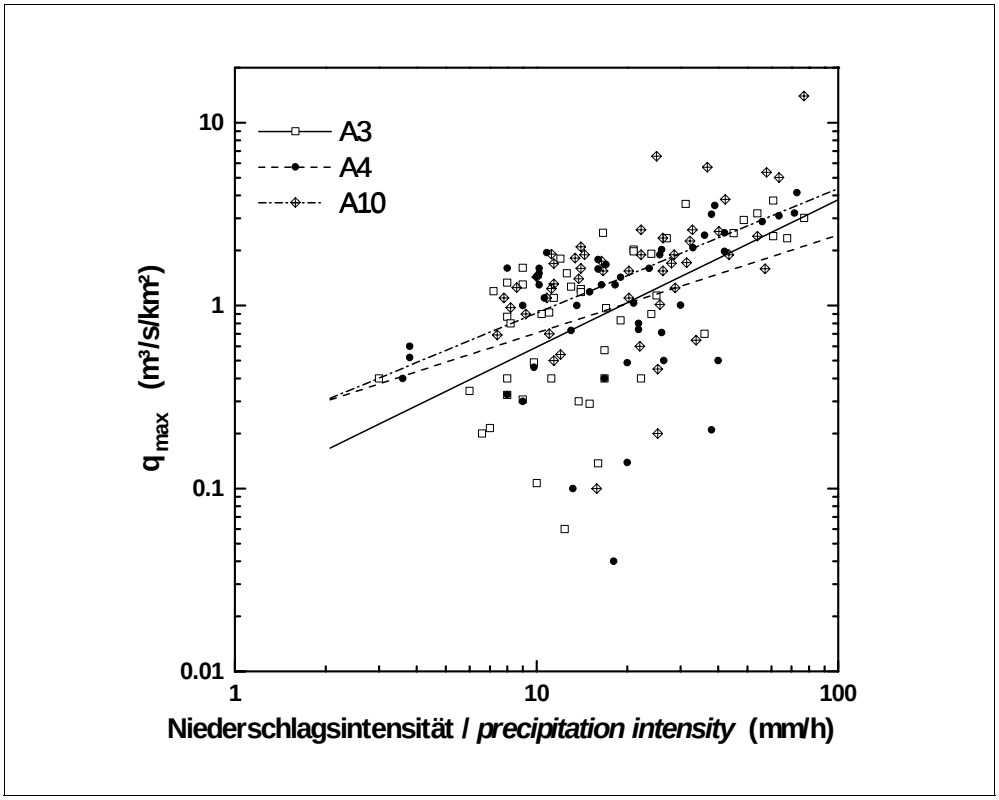


Fig. 2:
Runoff coefficients observed in the three Alptal catchments A3, A4 and A10 with very different proportions of forest cover (see legend Fig. 1)

These findings are somewhat contradictionary to many other results in other areas, beginning with the oldest measurements of Engler (1919) in the Swiss Emmental region and many other studies that showed an influence e.g. of clear cutting (amongst others Bates and Henry, 1928 or Bosch and Hewlet, 1982). It is also not obvious why in the catchments in the Alptal the proportion of forest coverage has a considerable influence on the water balance but not on flood generation.

As mentioned above, forests, mainly due to their increased capacity to store water in the soil, have the potential to influence flood generation. Theoretically the influence of this additional storage capacity can be explained as shown in Fig. 3. Only runoff due to saturation excess is considered. The dotted line in Fig. 3 shows the development of the runoff coefficient with increasing rainfall amount for a specific site. If at this same site the capability to store water in the soil is increased, the relation will follow the solid curve in Fig. 3. As long as the total amount of rainfall remains below the increased storage capacity no saturation excess runoff will occur

and the runoff coefficient will remain zero. It will start to increase quickly after the rainfall exceeds the storage capacity. The factor by which the increased storage capacity reduces the runoff coefficient is represented with the dashed line. It progressively decreases with increasing total amount of rainfall and at a certain point, e.g. when the reduction becomes smaller than 5 %, we will no longer be able to recognize this influence in nature because of other factors causing variability in the measurements.

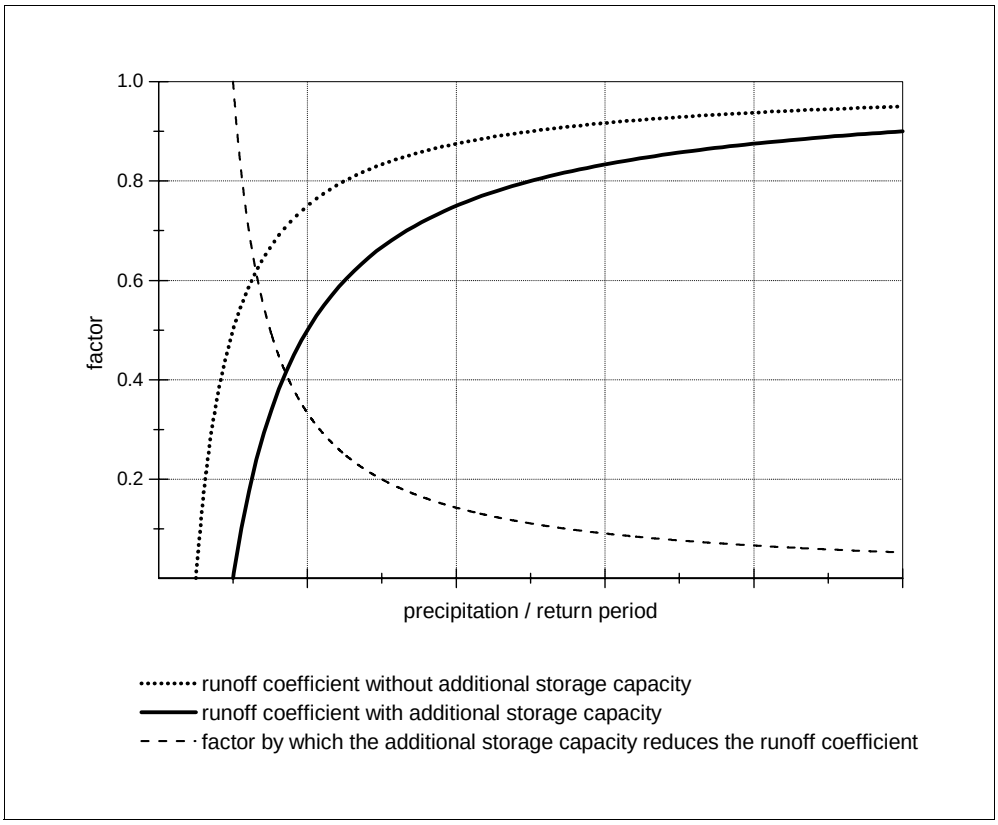


Fig. 3:
Schematic representation of the saturation excess runoff plotted against total rainfall amount. The total rainfall amount at the crossing of the axis is equal to the water storage capacity of the soil.

How far the influence of an additional retention due to forests can be detected depends mainly on the storage capacity of the soil. If this capacity is small compared to usual rainfall amounts, the influence of soil storage will be limited to relatively small but frequent rain fall events. And because the additional storage due to forests cannot completely change soil properties, also this influence will only have it's effect with frequent events. Therefore, forest on very wet sites, as e.g. the one in the Alptal, only have an influence with frequent rainfall events. The sum of these influences can be detected, together with the influence of snow interception, in the water balance. With very intense rare rainfall events, however, the influence is too small to have a considerable influence on the size of the event. Therefore such forests do not have a significant protective influence against floods.

Figure 3 also demonstrates that the influence of any additional storage due to forests is limited. The influence of additional storage will decrease with increasing rainfall as represented by the dashed line, and at a certain point it will become too small to have any considerable influence. That is the reason why Engler (1919) stated that no difference between a forested and a non-forested catchment can be detected with long lasting rainfall events.

8 Influence of forests on channel processes

Here sediment transport and debris flows are considered as channel processes, even if debris flows may also occur outside a channel in their initial phase. The influence of forests on channel processes is normally limited to the borders of a stream or mountain torrent as only there trees can survive. There trees can help to stabilize banks against erosion. However as soon as this stabilization fails and the tree itself becomes eroded, the effect of a forested bank may become negative. Driftwood can block the channel at narrow places, e.g. at a bridge, and therewith cause substantial damage. Therefore rather small trees are preferred for channel banks.

Not only living trees have an influence on channel processes, trees that have been fallen into a channel may also help to stabilize a channel bed. E.g. it found that dead wood played a major role in more than 50 % of the steps in the Erlenbach catchment. As the long term development of such steps has not yet been analyzed, no answer can be given up to now what influence this has on a long term perspective.

9 Influence of other types of land use on natural hazards

The influence of land use other than forests on natural hazards is normally indirect by changing the properties of the soil. The changes in soil properties, e.g. on ploughed land because it is ploughed land and not a forest, cannot be separated from the methods the land is treated with. In many cases the influence of land use practices may be more important than the kind of land use. Therefore, these influences will be discussed in the next section discussing these practices.

Only human constructions (e.g. settlements or protection work) may have a similar or even a higher direct impact on hazardous processes than forests. Typical examples for the direct influence of human constructions are rock fall nets or snow bars in avalanche starting zones. An example for a negative direct influence by human activities is the sealing of surfaces in human settlements that result in higher runoff volumes produced very quickly.

10 Influence of land use practices on natural hazards

In this section only the influence of human land use practices on land uses other than settlements and infrastructure will be discussed. It is well known that in human settlements significant results can be obtained in reducing processes normally called natural hazards. However this is not the theme of the present publication.

On agricultural land the main concern is erosion control. Preventing erosion means maintaining a sustainable base for production in future years. As erosion is mainly a problem on ploughed land, many studies in industrialized and in developing countries have been carried out in this respect. For an overview see e.g. Liener (2000).

Less attention has been given to the influence of land use practices on meadows and pastures as these land uses are much less prone to erosion. However, if flooding is discussed, it is well known that heavy cattle grazing may cause decreasing infiltration capacities on pastures. For flood prevention, therefore a meadow might be the second best land use after forest. The difference might even not be too large,. especially if different forest use practices are considered. It is well known that clear cutting may result in erosion rates similar to ploughed land and also runoff may be increased considerably with unsuitable forest practices.

11 Conclusions

The influence of land use and the related land use practices cannot be separated in most cases. Because many combinations of land use and land use practices exist, up to now no comprehensive study including all or at least many different land use practises on different land uses is known to the author. This would also require very long duration comparisons as some land uses only influence soil properties very slowly. Therefore at the moment questions and not answers dominate a discussion of the influence of all different land uses on flood generation. In practical applications experts often rely on their experience and sometimes probably also prejudices rather than on profound scientific knowledge.

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8 Mapping and characterizing mountain catchments using gis and earth observation data

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1 Introduction

The rapid socio-economic changes occurring in the mountainous areas of Europe are as well influencing the environmental conditions in the mountain headwaters. As a consequence of changes in land use, mainly due to declining population and agricultural production, also land cover changes; pasture and rough grazing lands grow into forest and other wooded land. Theoretically, this change in land cover should have a stabilizing effect on run-off and thereby have a moderating effect on flash-flows, whether it will also have a long-term positive impact on flooding in the lowlands remains yet to be seen. These changes may further lead to a reduction in (public) services in mountain communities, making tourist industry less sustainable.

The EU has, as part of its Rural Development Measures, decided to subsidize mountainous areas and other areas of less favourable natural conditions for agriculture – the so-called less favoured areas (LFA). These subsidies are for a large part given in support to afforestation. The objective is not just to support farmers economically, but also to help environmental development and to facilitate the maintenance of a critical population number in the LFA.

In order to study the development and especially the impact of legislation on the economy and environmental development in mountainous areas, integrated studies will have to be implemented. Networks under the 6th Framework Programme for Research and Development (6th FWP) could be a facilitator for such research and development studies. The Landscape Tomorrow Network (http://www.landscape-tomorrow.net) is an example of a network that is targeted at such problems. The Land Management Unit of the Institute for Environment and Sustainability has been contributing to the study of catchments in mountain areas for several years (Paracchini and Folving 1994, Paracchini *et.al*. 2000), in order to demonstrate the potential of using in-house data sets to derive «value added products». Within the Catchment Characterization and Modelling (CCM) activity of the EuroLandscape Project (http://eurolandscape.jrc.it), a Pan-European catchment and river network data base has been produced together with a landscape stratification (Vogt *et.al.* 2002a). The result of this activity and the developed methods could provide significant input to the studies on and development of efficient catchment management practices in headwaters, not least in high relief areas and mountains.

In this paper the undergoing CCM activity is described, the methodology for the extraction of the European river network from digital data is explained and the use of land cover and elevation data for an initial characterization of mountain catchments is presented. The information provided is spatially distributed and can be summarized at the sub-basin level so that statistics over thousands of mountain catchments are obtained with automatic procedures.

2 Data

Hydrological datasets currently available at the European level range from 1:10.000.000 to 1:1.000.000 scale. For fulfilling the requirements of new EC environmental regulations and for carrying out new integrated studies there is, however, a need to use more detailed datasets. The aim of the CCM activity of the EuroLandscape Project is to produce new layers of information (river network and catchments) at a scale of 1:250.000 to 1:500.000, that will be integrated in the Eurostat-GISCO database (Geographical Information System of the EC).

Data layers are obtained with a procedure that is to a large degree automated, so that it is possible to repeat the whole exercise when new areas need to be covered or more detailed input layers become available. At the moment the area covered by the study includes the West and Central Europe as well as a part of Russia.

The methodology is based on the analysis of digital elevation data, using techniques from morphological image analysis (Soille 1999). It makes further use of information on climate, pedology, lithology and vegetation cover for modeling the natural variation in drainage density.

In particular:

- Digital Elevation Models (DEMs) at a spatial resolution ranging from 100 to 250 m were acquired and mosaicked in order to cover the study area. In areas where medium resolution DEMs were not available (e.g. Iceland, Russia) data from the HYDRO1K at 1000 m were used;
- CORINE Land Cover (CLC) data (Eurostat-GISCO) in grid format, with a resolution of 250 m; in areas not covered by Corine, IGBP landcover data (1 km resolution) and Pelcom data (1 km resolution) were used;
- Information on climate was derived from the daily meteorological database of the European MARS project, which covers the period 1977–1999 on a 50 km grid (Van der Voet *et al.* 1994, Terres 2000);
- Data on soils and lithology were extracted from the European Soil Database (ESBSC 1998).

In the validation procedure the Bartholomew river network at 1:1.000.000 scale, data from the Eurowaternet station network of the EEA (Nixon *et al.* 1998) and detailed river networks for sample catchments have been used (Colombo *et al.* 2001, Vogt *et al.* 2002b).

3 Method

3.1 Deriving drainage network

When analyzing hydro-morphological characteristics at a continental scale, it is a major challenge to take the variability of the landscape into account. While landscapoe characteristics are strongly conditioning drainage density, so far, most of

methodologies proposed apply a fixed contributing area threshold for determining the channel heads (i.e. Verdin and Verdin 1999).

In this study, we attempt to consider those variables that drive changes in drainage density and to code them into parameters that can be used as inputs in a GIS model.

Based on literature, the following five factors that are influencing the variability of drainage density have been identified as the most important ones: climate (in particular rainfall), relative relief, vegetation cover (for its effects on critical shear stress), soil characteristics, and rock erodibility. These have been parameterized in the following way:

- mean annual precipitation was used as climate indicator as described in Moglen *et al.* (1998);
- relative relief, defined as the maximum altitude difference in a moving 3 x 3 grid cell window, was calculated from the DEM and considered representative of terrain morphology (Oguchi 1997);
- the percentage vegetation cover has been defined by recoding the CORINE Land Cover data into 14 classes and assigning monthly cover percentages to each class according to the scheme derived for Europe by Kirkby (1999);
- soil texture has been considered as a proxy indicator of saturated soil hydraulic conductivity, and has been derived from the European soil map;
- rock erodibility was calculated according to the relative scale proposed by Gisotti (1983) and assigned to different types of parent material, which were derived from the European soil map.

These variables have been combined using a multi-criteria evaluation technique, resulting in a Landscape Drainage Density Index (LDDI) with ten classes (Vogt *et al*. 2002a).

The assignment of a critical contributing area to each LDDI class was then based on the analysis of the specific relationship between local slope and contributing area for each class (Tarboton *et al*., 1989; Ibbit *et al*., 1999). This analysis resulted in threshold areas that vary from a few square kilometers to a few tenths of square kilometers.

The next step has been the extraction of the drainage network from the flow direction and flow accumulation matrices. One of the main characteristics of a hydrologically soundDEM is that water flows over the surface without interruptions in its hydraulic flow path. This is not always the case, as one of the main sources of errors in DEMs is the presence of spurious pits that interrupt the flow path. A new algorithm has been developed in the frame of this study, based on the concepts of morphological image analysis. This algorithm suppresses each pit by creating a descending path to the nearest point having a lower elevation value by carving the terrain elevations along the detected path (Soille, 1999). This approach also provides the basis for an adaptive drainage enforcement algorithm that can be applied in areas of low relief energy. As a consequence, river networks from ancillary data

sources are imposed on the DEM only in those areas where the automatic river network extraction deviates substantially from the reference network (Soille, 2002). Since the quality of digital elevation data is generally not sufficient for deriving a correct flow path in flat areas, elevation values are further interpolated so as to create a relief taking into account the general terrain morphology (Soille, 1991).

Lakes and lagoons were also taken into account by forcing the drainage network to flow along the center lines of these water bodies. Finally source areas were identified according to the landscape stratification and the entire river network was automatically extracted. It is fully connected and hierarchically structured (fig.1).

Basins and sub-basins are extracted accordingly, and a correction is made for sub-catchments intersecting lakes, so that their outlet is always falling on the lake perimeter.

Validation of results is performed against independent data sets. The Bartholomew river network is used for assessing the position of mapped river reaches; the size of sub-catchments corresponding to the Eurowaternet measuring stations is calculated and compared with the reported size. First results show that with reference to Eurowaternet data, 80% of the sub-catchments are mapped with an error smaller than 15%,.

3.2 Mapping of mountain catchments

The first issue to be addressed when mapping mountain catchments is to define what a «mountain area» is. The definition is varying across Europe and different Countries take into consideration different minimum altitudes ranging from 350 m to 1000 m (Copus and Price 2002). Kapos *et al.* (2000) in «Developing a map of the world's mountain forests» have identified the following six classes, based on elevation and in some cases corrected with slope: ≥4500 m; 3500–4499 m; 2500–3499 m; 1500–2499 if the slope is more than 2°; 1000–1499 if the slope is more than 5° or has a local elevation range of 300 m or more; 300–999 m if the local elevation range calculated in a 7 km radius around the processing cell is more than 299 m.

In this study, a minimum altitude of 1000 m has been considered in a first attempt and the mountain classes according to Kapos *et al*. (2000) have been mapped (fig.2).

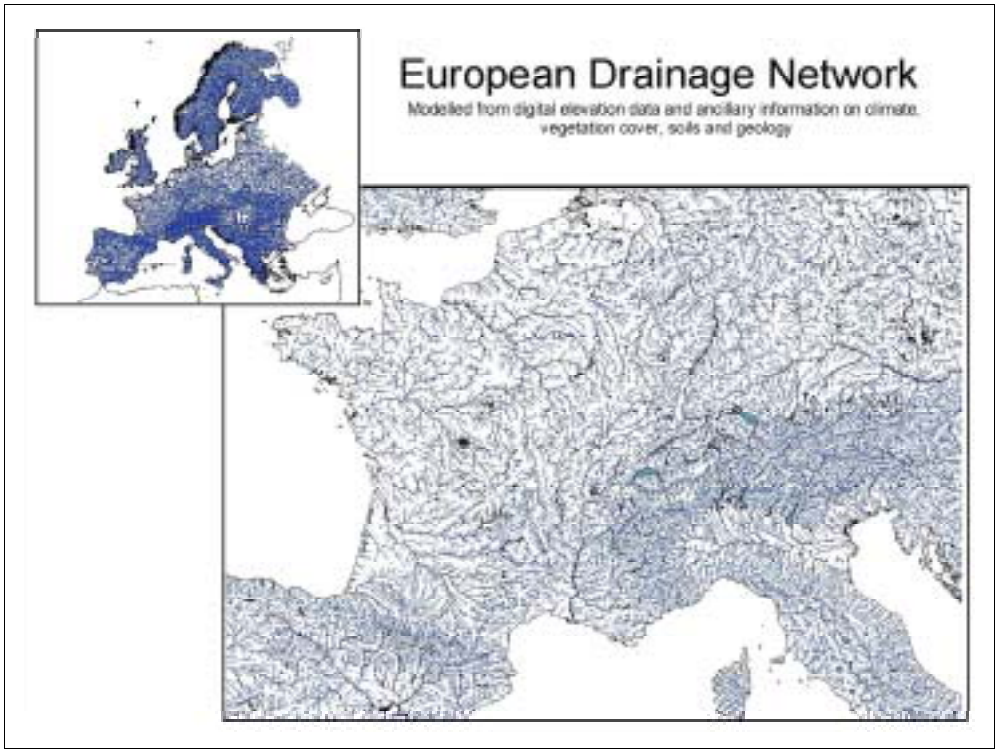


Figure 1:
European drainage network.

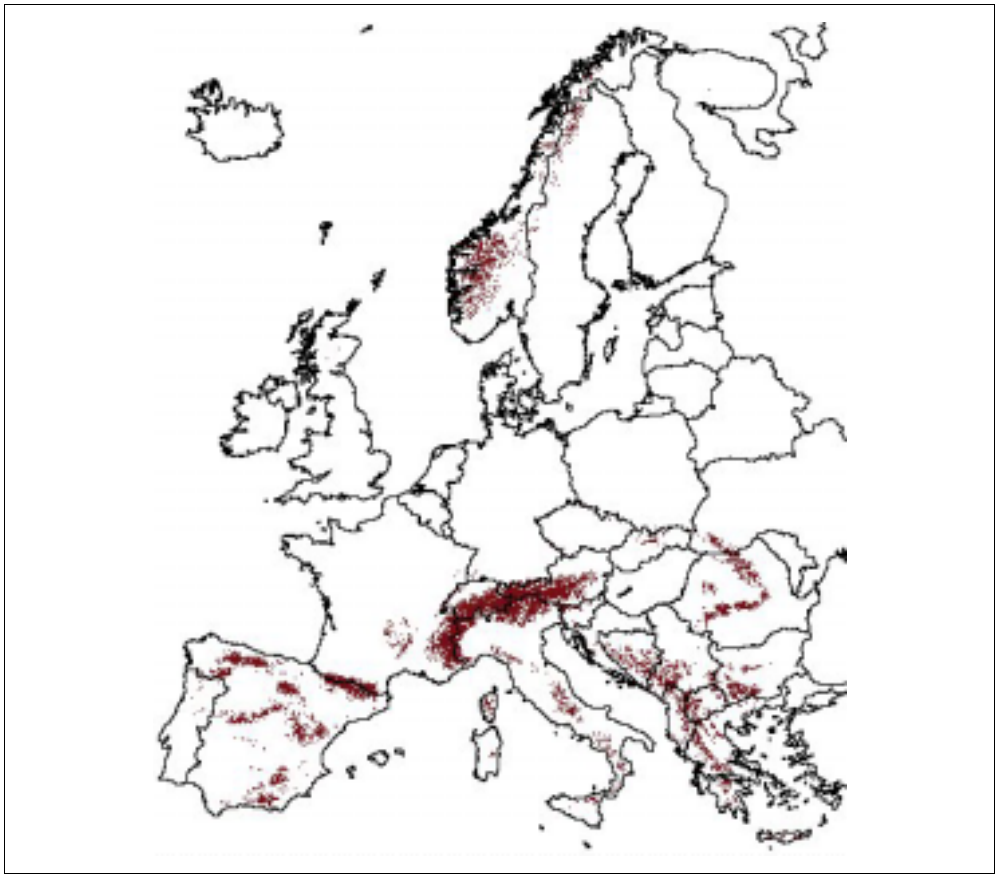


Figure 2:
Mountain areas in Europe (see text for explanation).

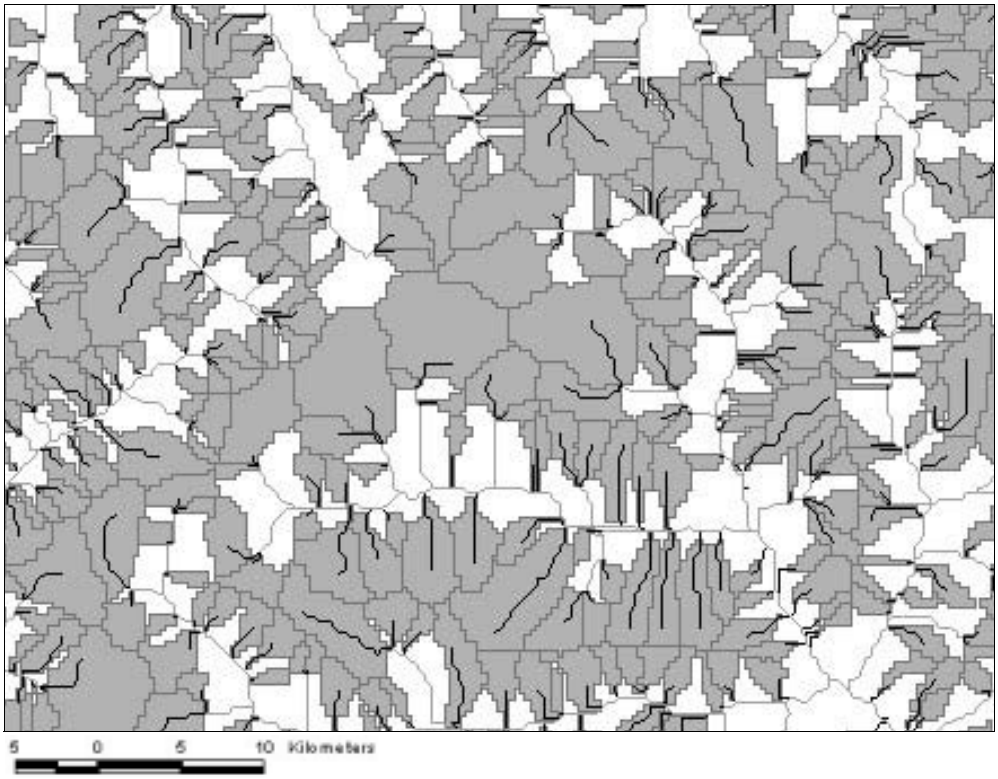


Figure 3:
First order catchments. First order streams (according to Strahler) are highlighted.

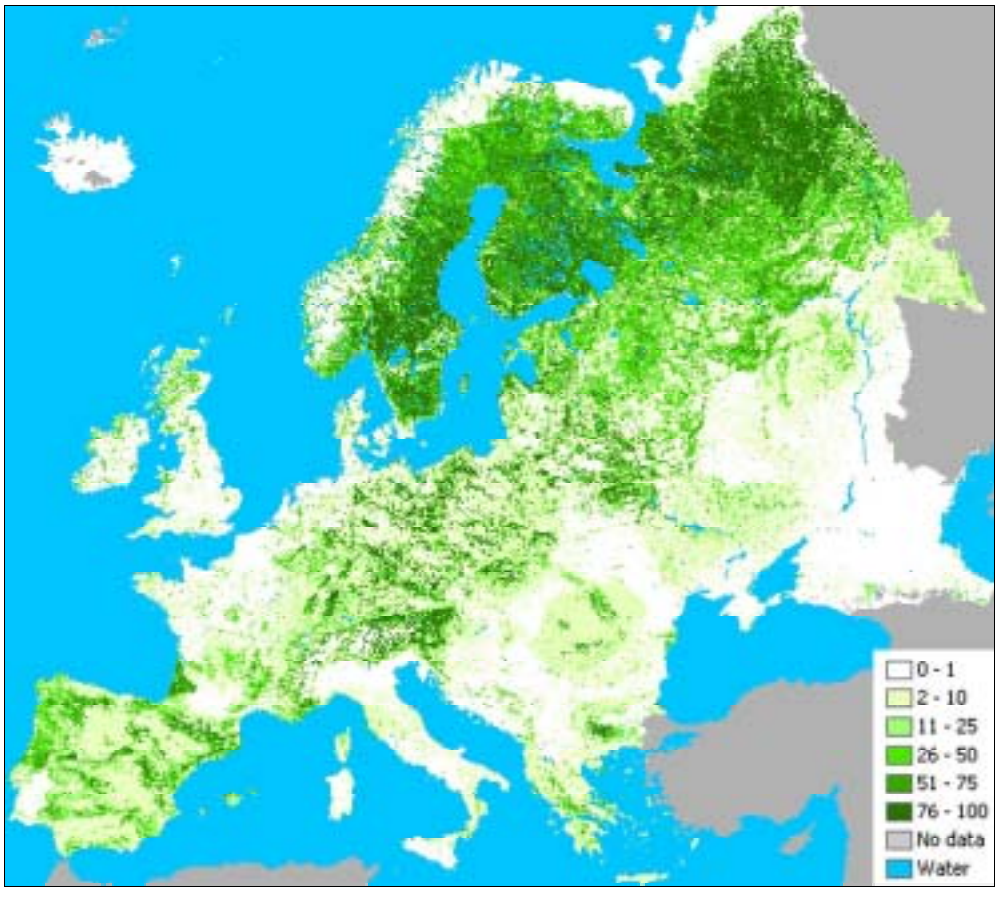


Figure 4:
Forest Map of Europe: forest proportion (% at 1km x 1km resolution)

The procedure for mapping mountain catchments is based on ordering the river network. To this end, the Strahler order has been applied and the first order tributaries have been selected and isolated. Among them only those with the outlet falling in the mountain area have been retained (fig.3). This results in a total of approximately 37,000 catchments, which cover an area of about 1.5 millions of km^2.

The mean drainage area of these catchments is 4.75 km^2, with a standard deviation of 6.3 km^2. The fact that the standard deviation is larger than the mean is due to the difference in the size of the contributing area, which is changing according to the landscape stratification. As expected, the classes with a higher drainage density and a small threshold area are mostly represented (they cover about 60% of the total area) but in some cases the critical contributing area needed to start the channelization process is larger.

3.3 Land cover

Data on land cover in Europe are available at different resolutions, but very seldom cover the whole of the continent. It is thus not always possible to produce homogeneous statistics over the whole area of interest.

In this study, land cover statistics are obtained mainly from two different sources: CORINE land cover (Eurostat-GISCO) at 250 m resolution and PELCOM at 1 km resolution. The source of information in both cases are remote sensing images: Landsat TM (30 m pixel) for CORINE and NOAA/AVHRR (1 km pixel) for PELCOM. These data provide a picture of Europe in the nineties but, due to the difference in the image information content, the legend is more detailed in the case of CORINE (44 classes versus 14 PELCOM classes). Nevertheless, a correspondence can be found between the two legends, so that it is possible to produce statistics on land cover, which are summarized in Table1.

In the case of forests, the analysis can be refined using a different source of information. In fact for this specific land cover type a data layer exists that covers the whole of Europe. It is the Forest Map of the European Union (http://eurolandscape.jrc.it; http://www.efi.fi) developed for the EuroLandscape Project's support to the EFICS regulation (EEC 1615/89). This map provides the forest proportion per square kilometer and has been created using a Pan-European NOAA AVHRR data mosaic. The spectral data have been transformed into probability values using CORINE forest classes (EEA, 1994; Häme *et al*. 2000, Häme *et al*. 2001). In a second step, the probability data set was calibrated into forest proportions using national forest statistics (Päivinen *et al*. 2001, Fig.4).

A regional «average» timberline was used in the mountainous areas for ensuring that bushes and like vegetation, which often cause a spectral confusion with forests, would not exaggerate the amount of forest cover in mountain areas.

Three layers are actually available, representing coniferous, broadleave and total forest (that is not merely the sum of the previous two classes, but contains other types of forest vegetation). Since these layers provide information on forest fractional cover at the pixel level they can be used as an input into models (e.g., hydrological, soil erosion, water and carbon exchange between vegetation and atmosphere) that require a finer knowledge on spatial forest distribution and density.

Table1: Distribution of land cover in mountain watersheds.

Land cover class	%
Pastures	20.62
Broadleaves	8.95
Coniferous	18.10
Mixed	6.83
other type of forest vegetation	18.65
Shrubland	5.84
barren land	8.88
Snow ice and glaciers	8.20
other landuses	3.90

Analysis of these data shows, that, if a threshold of 50% of forest cover per pixel is considered as an indicator of the presence of dense forest, the distribution of forests in mountain catchments has the same order of magnitude than the CORINE/ PELCOM classification (Table 2). The difference in the «total forest» class is due to the application of different criteria in the definition of classes such as «shrubland» or «transitional woodland shrub».

Table 2: Distribution in percentage of fractional cover greater than 50% in mountain catchments. Data from the Forest Map of the European Union.

	Forest Map (%)	CORINE/PELCOM (%)
broadleaved	9.36	8.95
coniferous	21.34	18.10
total forest	39.38	33.88

3.4 Morphology

As part of the characterization process morphological/morphometric indices can be calculated. One of these is the total relief of the catchments. It can be used as input in landscape characterization models and in hydrological modeling, due to its relation with drainage density (Tucker and Bras 1998) and as an indicator of sediment production (Oguchi 1997) and landslide prediction.

Total relief is defined as the difference in altitude between the elevation of the outlet and the maximum elevation of each catchment area. Data can be produced for each of the mapped 37,000 mountain catchments. Summary statistics for this vari-

able are presented in table 3. They have been calculated separately for continental Europe and Scandinavia.

Table 3: Total relief of mountain catchments. Statistics per geographical area.

Total relief (m)	Continental Europe	Scandinavia
minimum	53	119
maximun	3559	1377
mean	1114	635
std	574	243

4 Summary and Conclusions

The paper presents the results achieved in the framework of the Catchment Characterization and Modeling activity, and an overview of the use of the derived data layers in the characterization of mountain catchments.

The described activity is meant to build a bridge between the work packages of the EuroLandscape Project during FWP 5 and the work packages under definition for FWP 6. Under the present FWP, the major effort was to produce a catchment data base in support to the environmental monitoring activities of the EEA, the Water Framework Directive, and in-house landscape research. Concurrently, the project provided a forest map in support to an EU-regulation, in support to forest organizations and for public distribution. The original plan for EuroLandscape was to provide a grassland data base as well. This goal was, however, not achievable within the existing frame. It is hoped that the Forest Proportion map will be complimented with a grassland map, which will provide a much better overview and estimate of the general situation in the mountain and up-land headwaters in Europe, thus also facilitating run-off modeling and other applications.

The planned up-dating of the CORINE Land Cover map will give a good possibility to estimate the major land cover changes in European mountains. The new CORINE database, for which the IMAGE2000 (Landsat ETM+ Image Mosaic) is the basis, will make it further possible to refine both the forest and grassland mapping in environmental vulnerable areas.

Deliverables from the CCM Activity are not just meant for support to catchment studies and planning. The resulting methods and datasets are considered as basic input for the planned studies on European landscapes and their diversity. The Pan-European Biological and Landscape Diversity Strategy, PEBLDS (http:// biodiversity-chm.eea.eu.int), will be the baseline for this development, which for a large part will be developed in collaboration with the Landscape Tomorrow network (http://www.landscape-tomorrow.net).

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9 Measures and programs considering to mountains – management of natural disasters

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1 Objective and strategies of the management of natural disasters

On the basis of the nature-spatial realities, a paramount meaning comes in the Alps-countries the protection before nature-dangers. The *Republic Austria* perceives the *forest-technical service in erosion torrent and avalanche control* as department of the *federal ministry for agriculture and forestry, environment and water management* the responsibility of the *managements of natural disasters* regarding the threat of the people, their habitat and settlement-area as well as the cultural assets against torrents, avalanches and erosion done by rock-fall, landslides, debris flows and fine-sediment-erosion. In the sense of the more than a centennial tradition of the forest-technical engineering system, foundation was 1884, this organization is committed with the fulfillment of its tasks the thought of the sustainability. The concrete work purpose is to gratify the human needs, without spatial and temporal limitation, and, to respect the natural ecological limits in itself, just as to guarantee the sustainability of the achievements of the service.

The *goal* is the *complete protection for nature-dangers* in the mountain-regions, this necessitates the use of integral and sustainable acting strategies and concepts. The constantly climbing protection-demand can be only covered on the basis of an complete analysis of the risk-potential with the influencing underlying hydrological, geotechnical and nature-spatial factors and by the use of most modern technology in basic investigations plannings and implementation of countermeasures. Protection measures are subsidized in Austria as well as by credits of the Austrian Union States and from the catastrophe-fund of the Federal Republic. Simultaneously planning-instruments are put and developed to the optimization of the area-utilization into the highland and mountains.

The legal basic conditions for the management of natural disasters is given by national laws, Federal-constitution, water-law, forest-law and through international conventions, guidelines and contracts, UN Sustainable Development agenda 21, EC-water-guidelines, Nature 2000, and through the guidelines for support of the federal government, which constantly climbing requests put regarding the social, economic and ecological compatibility. The fulfillment of the decreed laws necessitates a strategic control of the protection before nature-dangers, a dynamic and result-oriented research and development, an extensive quality-management and a co-ordinated knowledge – and information-transfer within the service as well as to other organizations considering the issue of the management of natural disasters public and private facilities. Caused by the complexity of the objective and the connection with other area-utilization-interests, the transfer and implementation of protection measures necessitates a modern project-management and a long-range citizen-participation.

2 Management of natural disasters – facilities and programs of the forest-technical of service in erosion – torrent – and avalanche control

2.1 Strategic steering of the management of natural disasters

In the sense of the model, the federal ministry for agriculture and forestry, environment and water management («life-ministry») takes on the total responsibility for the lasting protection of the environment-media water, soils, forest and air and for the protection of the rural area as production -, work -, and recreation – habitat. The Federal Minister therefore established the *business-field «protections against natural disasters»* its task lies in the strategic co-ordination of all ministerial programs in this division as well as the maintenance of the supra-regional synergies. The business-field serves for the prioritization, an optimization of the application of resources, as dialogue and communication platform, as area of authority centre and has the responsibility to integrate the protection against natural disasters into different fields of politics.

The *strategic steering* of the forest-technical service in erosion torrent and avalanche control is responsibility of the department iv 5 of the section forestry division in the federal ministry for agriculture and forestry, environment and water management. A crucial point of view with it is upholding of the striking force of the forest-technical service in erosion torrent and avalanche control through maintaining the *unit of management, master-planning and implementation of measures,* which justify the area of authority of this organization since its existence.

2.2 Risk analysis, basis-plannings

The current recording and observation of the nature-dangers in catchments of torrents and avalanches as well as in risk-areas takes place by the 28 agencies (district area based) of the forest-technical service in erosion torrent and avalanche control. For the analyses of hydrological, geotechnical and nature-spatial influential factors and investigations of the risk-potential and deduced reports and expert opinions based on modern technologies *three staff offices* were established

- Staff office in EDP and planning
- Staff office in geology
- Staff office in avalanche-simulation

The recording of the risk-potential in big areas (regions) takes place in the framework of *regional-investigations.* On the basis of these studies primarily are deduced the aim of protection and prevention, area and size of concrete protection measures, their regional effects and their prioritization were derived. Regional-studies help the determination of protection and prevention measures with other planning-interests and the spatial optimization of the employment of funds.

National plannings serve the control of the prevention of risks and matches the interdisciplinary recording of the risk-relevant factors and the extensive connections of nature-dangers and potential benefits as well as the land use itself. Pilot-studies were realized in the framework of national and international promoted programs, EGAR (Interreg IIIb).

The *transfer of the EC-water-frame-guideline* takes place in supra-organizational working-groups of the federal republic and the union states. The transfer of the guideline is prepared in practice in pilot-studies.

The forest-technical service for torrent – and avalanche control is tied in into external programs of the risk-management, for example into the preparation of the (union) state based rules for *protection forest management.*

2.3 Management of natural disasters in area-utilization (area-regulations)

The *hazard mapping* of the forest-technical service was decreed in the forest-law for torrent and avalanche control and puts an authoritative observation on threated zones of torrents and avalanches and delimitates red and yellow hazard zones within the area-relevant area (settlement-area and infrastructure). The demarcation of the hazard zones takes place on the basis of strict criterions on the basis of the border-cadastre and is represented in the surface-dedication-plans of the communities. Hazard maps serve as basis of the landscape management and the construction – and security – management.

As department encroaching framework program the *land use politics* must be understood, that the creation of a common responsibility has the responsibility for the habitat, the ground-protection, the landscape-image, a protected water quality and quantity and the support of intact ecosystems.

2.4 Management and active protection measures in catchments and risk-areas

To the lasting protection of the nature spatial protective effect as well as to their substitution by active protection measures *integral management projects* are planned by the forest-technical service in erosion torrent and avalanche control and realized in the framework of the implementation of constructions and other protective measures.

Master planning of protection forests includes management-measures to the protection and improvement of the protective effect of the forest in catchments and risk-areas. *Technical and forest-biological* measures are realized in the framework of *general projects and master plans.* The support of the planning and construction implementation takes place from financial resources of the catastrophe-fund of the federal republic and the union states; the remaining expenses are distributed by the beneficiaries. Basis the support forms lawful regulation, the technical guideline for

the protection before nature-dangers, the support-guideline and the guidelines for the proof of the thrift of control measures (CBA, Cost-Benefit-Analysis).

For the current maintenance of the catchments and waters as well as existing installations, a *maintenance service* is established by the forest-technical service in erosion torrent and avalanche control. The damage-removal after natural disasters at torrents and avalanches take place as urgent control measures.

2.5 Advice and Consulting

The forest-technical service in erosion torrent and avalanche control grants *within Austria* over its agencies and staff offices an extensive *advice and expertise* for authorities, political corporations and the citizen regarding the analysis of the effect of nature-dangers and suitable preventive-measures.

The forest-technical service advices and consults *internationally* for torrent and avalanche control exactly in the area «erosion control», but also in the area of the avalanche-protection, *active consulting* with contacts into all mountain countries of the earth which are affected by these problems. The present contact focuses mainly Nepal, Bhutan, Japan, China, Turkey, Iceland, Norway, Taiwan and Sweden.

2.6 Research and development

To steering and co-ordination of research and development, a *platform for research in natural disasters* was established 1999 in the federal ministry for agriculture and forestry, environment and water management. This platform co-ordinates the activities of the forest-technical service for torrent – and avalanche control, university based facilities and public and private research institutions.

As essential projects are the development of simulation models like SAMOS, ELBA and SEDRAC, than the evaluation of methods of the nature-habitat-analysis, development of early-warning-system, the Monitoring in the catchments and the development of instruments for the documentation of nature-events (DOMODIS).

2.7 Information-recording and information-preparation

At the moment, a nationwide database is under construction to record all relevant information, the *torrent and avalanche cadastre,* which should be established as extensive information-platform to manage natural disasters. Information on nature-dangers are integrated also into the *Geographical Information System (GIS) of the union states.* Target is the nationwide network of all databases.

2.8 National and international knowledge-transference and quality-management

The preparation of authority and technology on topmost level necessitates a lasting ensuring and development of the knowledge, an extensive quality-management and a national and international knowledge-transfer.

This objective is guaranteed by current *training- and education-programs* for the employees and staff members of the forest-technical service in erosion torrent – and avalanche control, including also *national and international organizations* like IUFRO, INTERPRAEVENT, and *global contacts* on technical level. Further exists nationally a dense network with institutions and private companies working in the field of natural disasters.

In order to document the knowledge and the long-time experience of the employees of the forest-technical service in erosion torrent and avalanche control, and make it available in the sense of an expert system to hold on and keep the decision making comprehensibly projects are initiated continually, which take care the quality of the decisions in the sense of a long term *knowledge-management.*

10 Profit of watershed management for lowland areas – Experiences made in Bavaria

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1 Present situation in alpine region

In the first 50 years of the 20th century the importance of the alpine region for agricultural or industrial production was decreasing step by step, the population reduced accordingly. But about 50 years ago, a complete unknown industry arose, the business of tourism. Consequently the development of housing areas, hotels and the infrastructure for the tourist use such as skiing, mountaineering or mountain-biking was increasing rapidly. Formerly small villages changed to international holiday resorts.

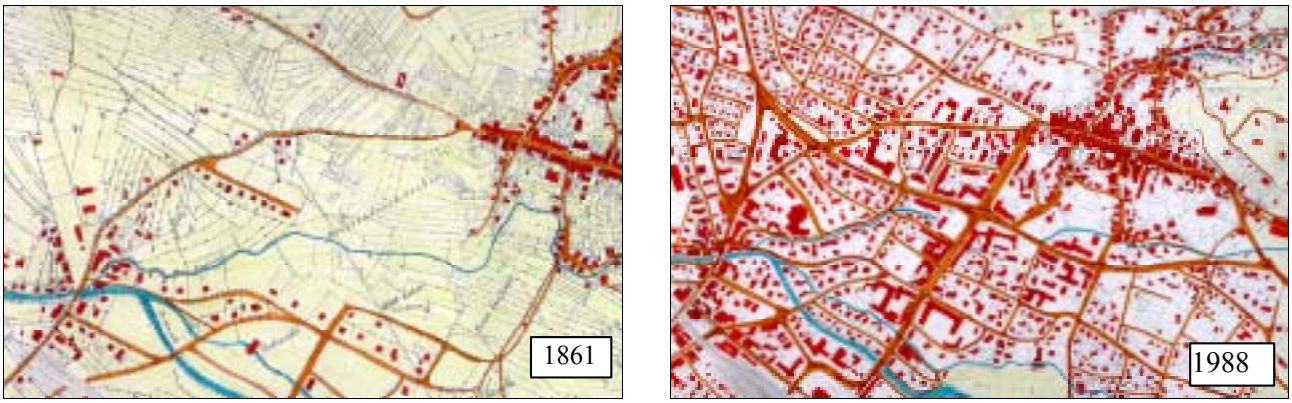


Figure 1: The city of Garmisch-Partenkirchen, 1861 and 1988

In parallel the international connections and relations of the industry became more important every year. The transport of goods increased rapidly. In 1990 about 42 million tons of goods were transported over the Alps by trucks, in 1998 it was about four times as much with about 160 million tons; a continuous increase is to be observed.

This rapid development was sometimes too fast. Settlements and hotels, infrastructures and roads were built in areas, threatened by mountainous hazards. On the other hand many of the human activities influence the natural processes mostly in a negative way. In the beginning 50 years ago there was still a lack of knowledge about the complex relations of mountain hazards and the sensitivity of the triggering factors. That's the reason why we have to face in many places nowadays the situation, that endangered areas have to be protected by rather expensive, technical measures always keeping in mind the limited level of safety and the residual risk.

2 General tools and strategies in the management of mountain watersheds

Today in general we have a long experience in the management of mountain watersheds which enables us for sustainable solutions in protection of settlements and infrastructure, human life, economic values, landscape and biodiversity.

Nevertheless at first we have to accept mountain hazards as a natural part of alpine regions. Floods, debris flow, landslides and avalanches have always been forming these landscapes. So in the end, these natural processes are becoming dangerous processes by an inadequate land use by man. Thinking about erosion control we have to be aware, that man can only influence vegetation and land use. All the other triggers are natural conditions out of reach of human influence.

In Bavaria we differentiate between two main types of erosion processes which lead accordingly to different approaches for possible solutions:

- **Torrential processes:** Torrential processes like erosion and deepening of the torrent bed and its embankments are occurring in the torrent itself or its immediate surrounding. In these cases, technical means like consolidation check dams in combination with biological measures on the slopes can be a successful approach.
- **Slope processes:** Slope processes are defined as various mass movements on the slopes of the mountains. Some of them like rockfalls or landslides can not be influenced at all, these are natural processes. For other types like erosion on the surface a sustainable land use and an adequate vegetation can reduce or even prevent the problems. So we are speaking about integral measures and protective forests.

Besides the immediate local profits of measures to reduce torrential and slope processes in the mountainous region, all local or integral measures also influence the downstream situation, especially the hydrological and morphological situation in the alpine rivers and their flood plains. Local changes in flood and debris flow patterns like mitigation of extreme situations may cause also hydromorphological instabilities. In general however rehabilitation of mountain watershed generates several positive effects in terms of reduced natural risks and a sustainable water budget. The following examples will outline some of these aspects like preventive and integral measures, flood retention, debris flow management, natural river restoration or flood forecast and monitoring systems.

3 Integral catchment management

Integral rehabilitation of mountain watersheds combining a wide variety of technical, biological, economical, agricultural, forestral and administrative measures has a long and successful history.

Although we have been doing this for several decades, this approach is to be emphasized repeatedly. We all know very well, that all the technical measures may provide a mitigation for the moment, but in most cases they cannot really solve the problems in its origin. So the integral approach was in the past, is in the present and will be in future the only really sustainable approach for protection of the mountain watersheds and the low land areas.

3.1 The «Alpenplan» (Alpine Plan)

Created in 1972 the Alpenplan was an important part of the Bavarian Land Development Plan. The Alpenplan covers the whole Bavarian alpine region and sets strict rules for the development of the infrastructure like roads, ski lifts etc. The main objective of this plan was at first to protect nature reserves from unacceptable land use. In three zones the requirements are as follows:

- In zone A basically any development is considered to be acceptable in the context of the Alpenplan. However, this does not exclude that particular projects can be refused because of other reasons.
- In zone B each single project is to be evaluated with regard to the objectives of the Alpenplan.
- In zone C any development of infrastructure is forbidden.

Even if the basic objective of the Alpenplan was nature protection, it turned out that this was a powerful tool to prevent the development of intensive land use into sensitive areas. At the moment, the Alpenplan is going to be actualized regarding the present development in the Bavarian Alps.



Figure 2:
Region planning in Alpenplan

3.2 The «Halblech» torrent

The Halblech torrent located in the western part of the Bavarian Alps covers a catchment area of about 50 km^2. Due to the unstable soil and rock formations this is one of the most active torrents in Bavaria. This region between an altitude of 800 and 2.100 m asl (above sea level) has been negatively influenced by an unfavourable utilization over a long time. As a result, erosion and landslides increased.

In 1959 integral rehabilitation measures were started for the restoration of this region; the works went on about 20 years until 1981. The main activities were:

- Control works in torrents
- Bio-engineering methods in slopes
- Construction of country lanes
- Forest measurements, afforestation
- Re-organization of mountain grazing system

The total cost amounted to about 8,5 Mio EURO.

It turned out to be indispensable to work out the project in close co-operation with the land owners and communities as well as with the forest and agricultural administration.

More than 20 years after rehabilitation of the Halblech region was completed, it turned out to be a success. Erosion and bed load transport could be reduced significantly. Also a satisfactory separation of forests from pastures could be achieved. A remaining problem still is the high stand of game in the forests causing damages by browsing and debarking damages. The reduction of the number of game to a acceptable level will be an important objective for the next years in order to ensure a natural reproduction.

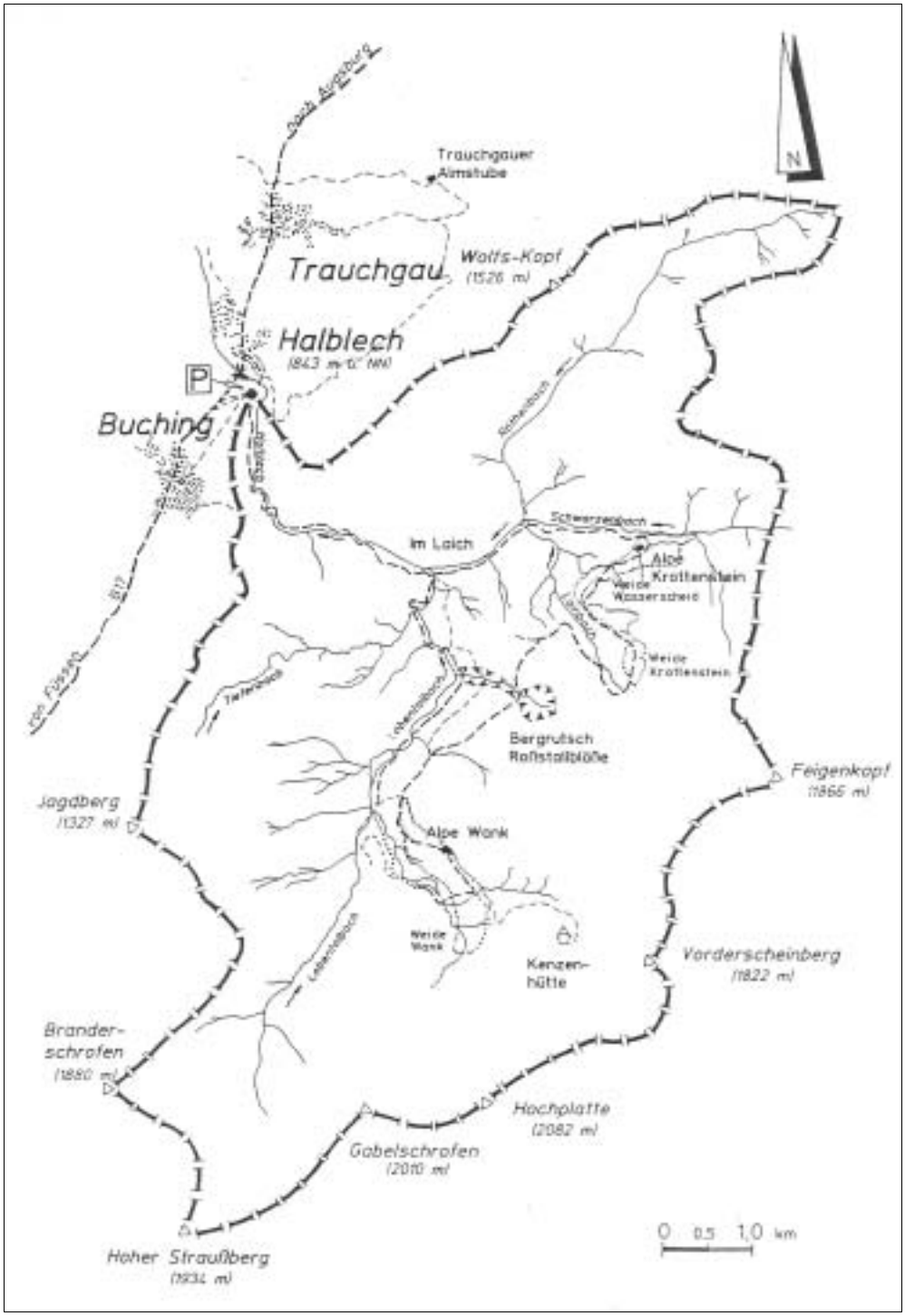


Figure 3:
Site plan for the Halblech catchment, Bavaria

4 Sustainable flood protection

Because of some disastrous floods during the last few years a program was initiated titled «Action Programme 2020». The general idea is to combine three basic strategies for a sustainable flood protection:

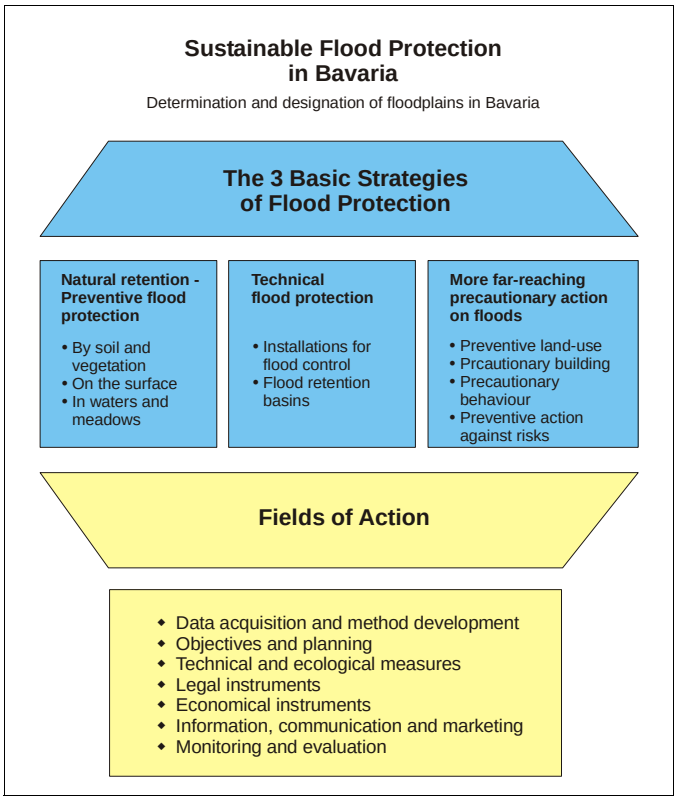


Figure 4:
The three basic strategies for sustainable flood protection in Bavaria

The program is accompanied by the determination and designation of flood plains along the rivers. This is a long term approach, over 20 years, that's what «2020» stands for. This program is implemented not only in the Alps, but all over Bavaria.

5 Survey and restoration of protection forests in Bavarian Alps

For centuries the alpine forests were not treated very well. Already in the Middle Ages there was an extensive harvesting of trees and wood for salt production, processing of different ores or for the purpose of fire wood and buildings. Already in these times the forested area in Bavarian Alps was reduced by one third. Moreover forests were burdened by pasture and a high stand of game.

But people realized very soon, that they couldn't go on this way. So already 250 years ago, when the Bavarian forest administration was established, the idea was, to balance the harvest with the natural growth. To some extent, this was the first idea about sustainability, but only in terms of production and not of protection.

With the rapid increase of traffic, population and the tourist industry during the last 50 years the potential hazards for the people grew enormously. So the indispensable value of forests for the protection purpose became evident.

In a complete survey in 1986 alpine forests in Bavarian Alps were evaluated. The result was, that about 1.500 km² of forests are to be considered as to have protective functions. From this area about 1.300 km² are in a reasonable state, but still requiring careful maintenance. About 128 km² are more or less damaged, the protection functions are significantly reduced. In a «protective forest programme» the most critical areas of about 50 km² were detected for immediate measures. Today about 50% of this area is reforested but still requires careful maintenance over years and decades in future.

These efforts have to be accompanied by a strict reduction of the game numbers. Moreover the pasture in the forests is to be reduced. Today still about 550 km² of forests are burdened with these pasture rights.

In many cases, there is a close co-operation between the forest and the water management offices. Frequently the young plants have to be protected against avalanches or snow gliding by massive steel structures, which are carried out by the water management offices.

Of course, among experts it's out of question, that the restoration of forests is an indispensable part of our integral measures for spatial protection. But nature requires a lot of time and patience, at least some decades. So there is a strong need for the information and the discussion with the public and the politicians to transfer over and keep in mind the importance of this approach.

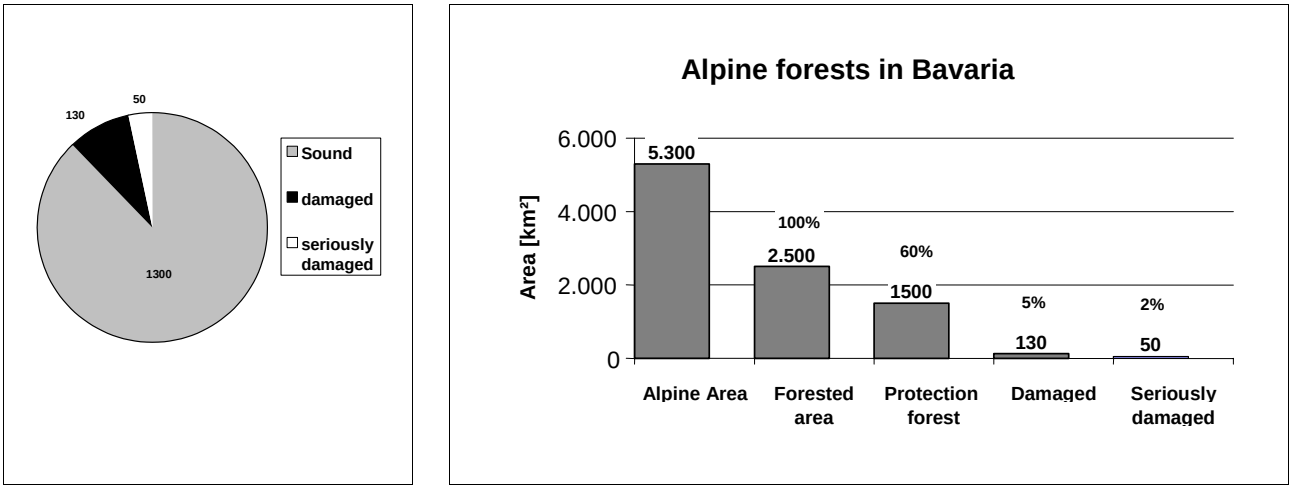


Figure 5: Alpine forests in Bavaria and the situation in protection forests

Calculations of the hydrological consequences of essential losses of alpine forests area, showed a high rise of the flood peaks in all main rivers in Southern Bavaria and increasing hazard risks.

6 Flood forecast in Bavaria

Heavy precipitation in 1999 led to extensive flooding and damage within the southern region of Bavaria running into billions of German Marks. One of the reactions for better flood warning and watershed management is the development of river basin models for flood forecast. This is part of a 5 year innovation program to improve the Bavarian flood information service. Beside the development of forecast models the program contains the establishment of a new automatic precipitation-measurement network and the optimization of the gauging station network. Costs of the program are estimated at 8.5 million €. It is part of the action program 2020 for sustainable flood protection in Bavaria, where investments are provided for flood prevention and flood protection measures. The aims of the innovation program are the development and design of forecast models for all major rivers in Bavaria, the enhancement of the data processing and transmission by modern communication methods and the improvement of the reliability of data dissemination. For operational flood forecast grid based rainfall – runoff models, hydrodynamical models (WAVOS) and stochastic models like Kalman Filter and MKF are used. The grid-based catchment model (LARSIM) for the Danube until the inflow of the tributary Lech is ready for operation. The next part down to the tributary Isar will be finished in 2003. Until end of 2004 there should be flood forecast models for all major river basins in Bavaria.

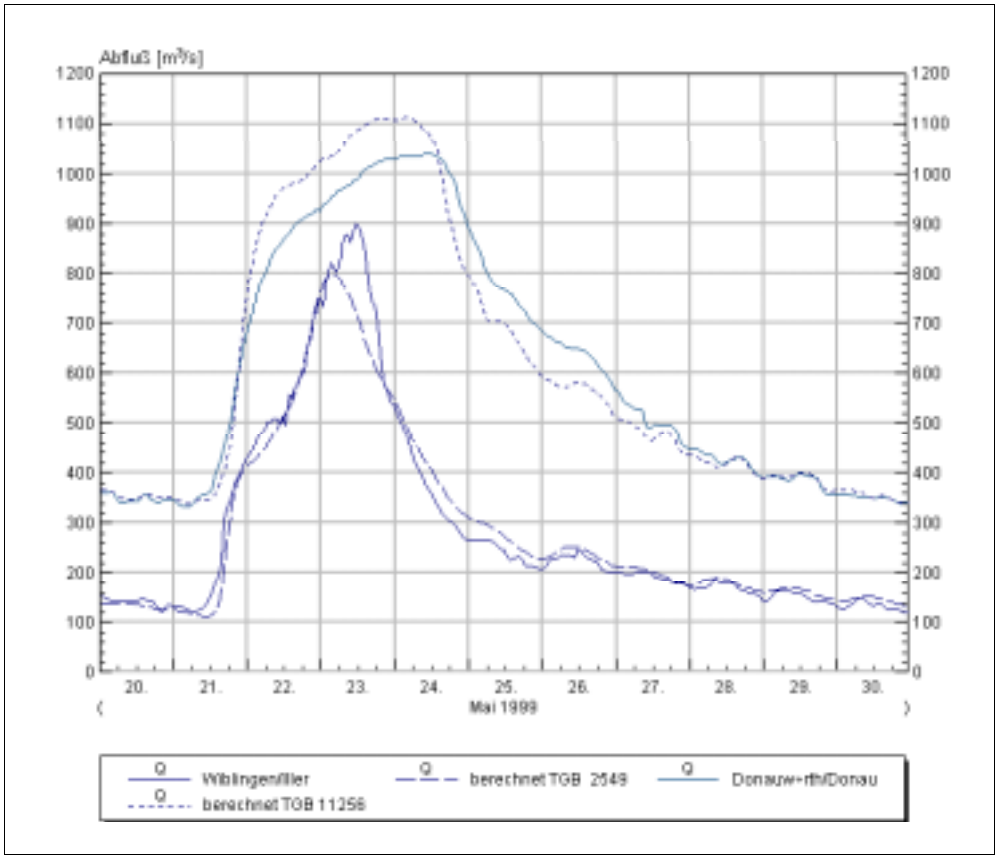


Figure 6:
Calculated and measured runoff in river Danube and Iller during flood 1999

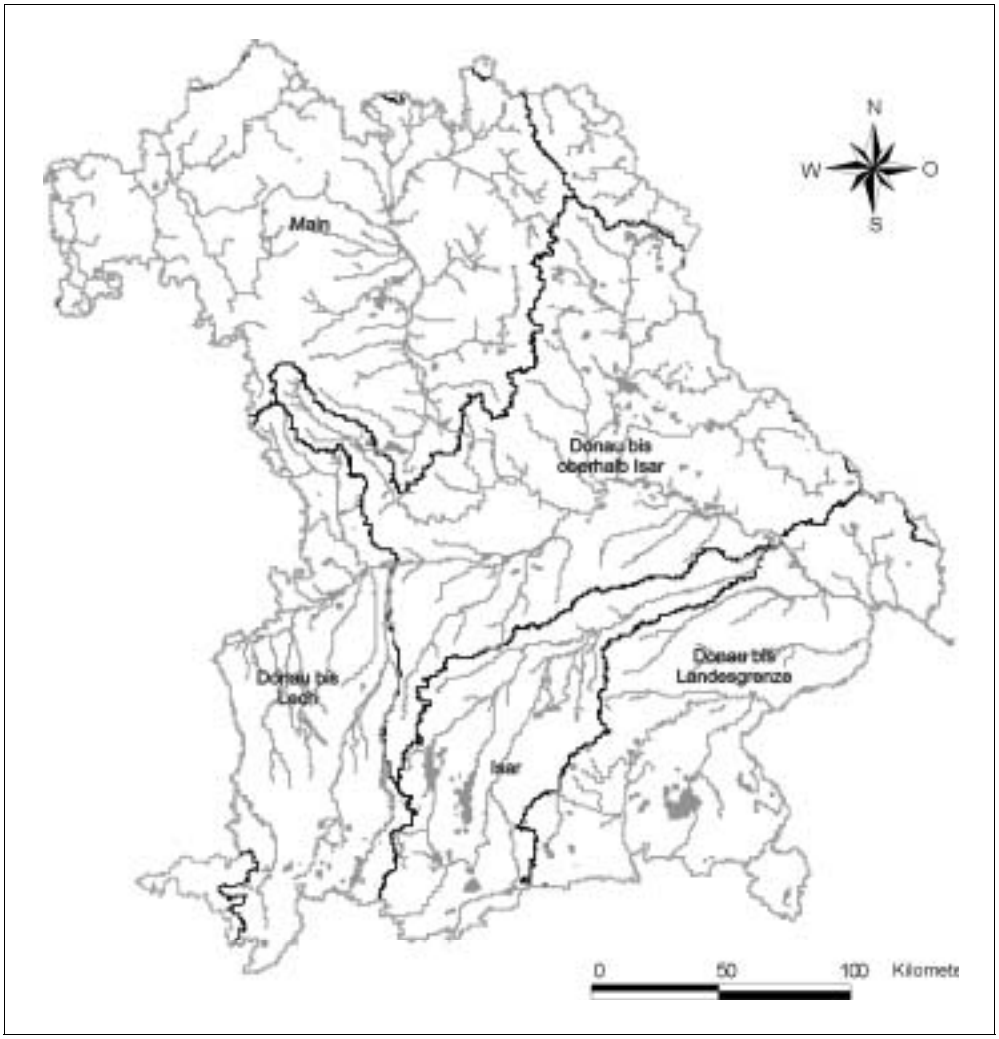


Figure 7:
Main catchments for
flood forecast in Bavaria

7 Natural River restoration – Case Study Isar

By nature the Isar (length ~260 km, area of watershed ~8000 km^2) is a braided river system with wide gravel banks during low flows within a corridor of alluvial forests from the Alps down to the Danube, only interrupted by cities like Munich and Landshut.

In the middle of the 19th century river channelization was started to improve rafting. At the beginning of the 20th century channels were built to draft water from the river into channels to run hydroelectric power plants.

The big floods of 1910 and 1954 resulted in stabilizing the river bed and the construction of dikes from Munich down to the Danube. A flood retention reservoir, the «Sylvenstein-Dam», was built at the foot of the Alps to improve flood protection along the Isar valley and particularly for Munich.

The result of these activities were:

- Loss of the hydromorphological processes, dynamic system get static
- Increasing of the flow velocity by river channelization
- Bed erosion caused by deficits in solid transport by the «Sylvenstein-Dam» and channelization of the tributaries
- Reduction of the natural flow, caused by channels where water is drafted to run hydroelectric plants
- Loss of habitats in the channelized river sections
- Loss of values for recreation.

Today the main objective for restoring channelized rivers like the Isar are:
To give back the hydrodynamical processes to the rivers, from static to dynamic systems

This includes objectives like

- to raise the retention potential by widening the bed and to increase the roughness also in the flood plains
- keep the flood plains open
- to improve and protect habitats
- to support nature vegetation
- to re-establish the lateral and longitudinal connections
- to improve the natural solids transport
- the use of biological engineering methods if bank protection is necessary and
- to improve recreation along the water edge.

In River Management Plans the status quo is compared with the reference status (natural conditions) and deficits are named. The objectives to improve the ecosystem are depending from the restrictions like land use and are shown in this River Management Plans.

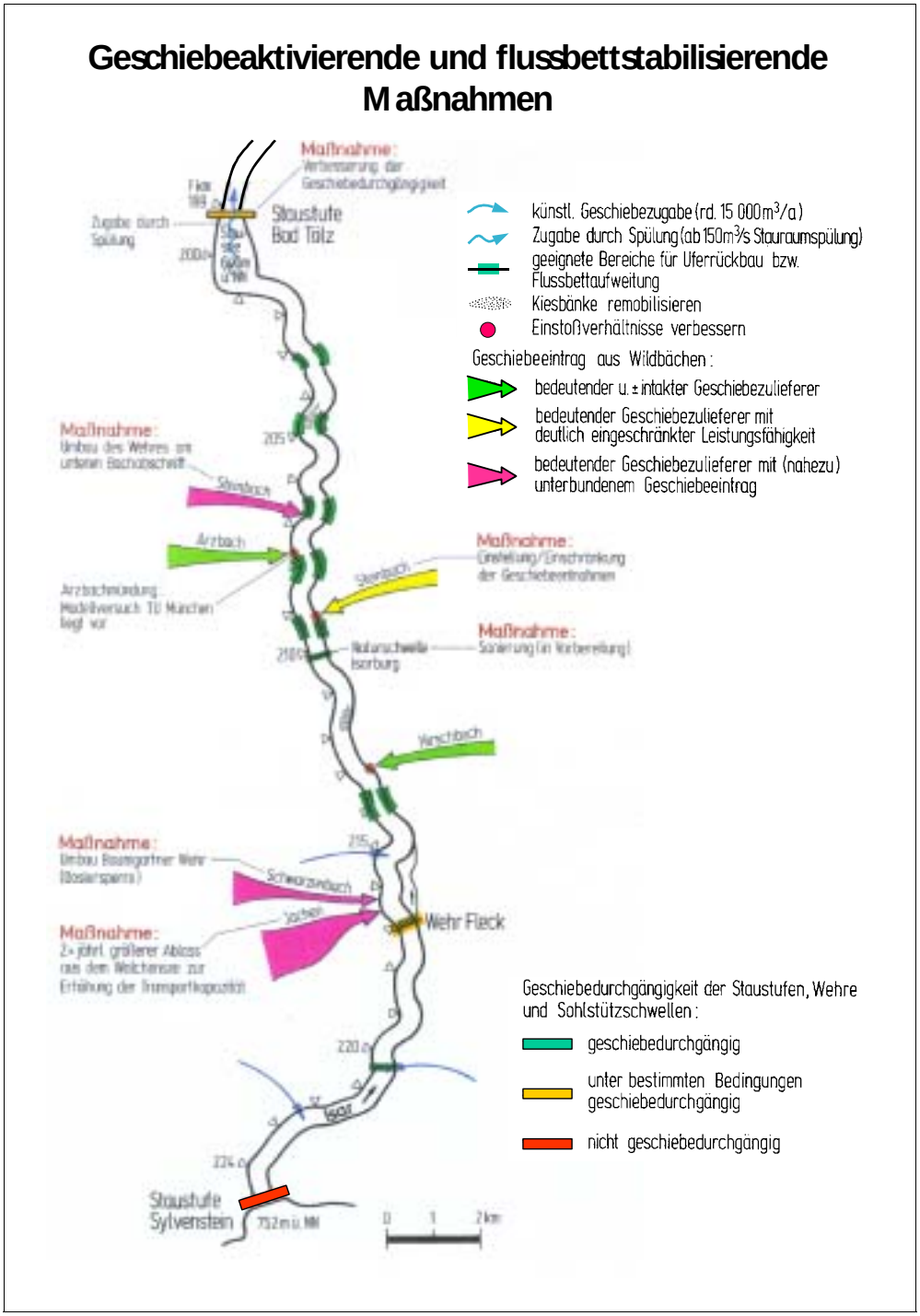


Figure 8:
Debris flow management for morphological rehabilitation

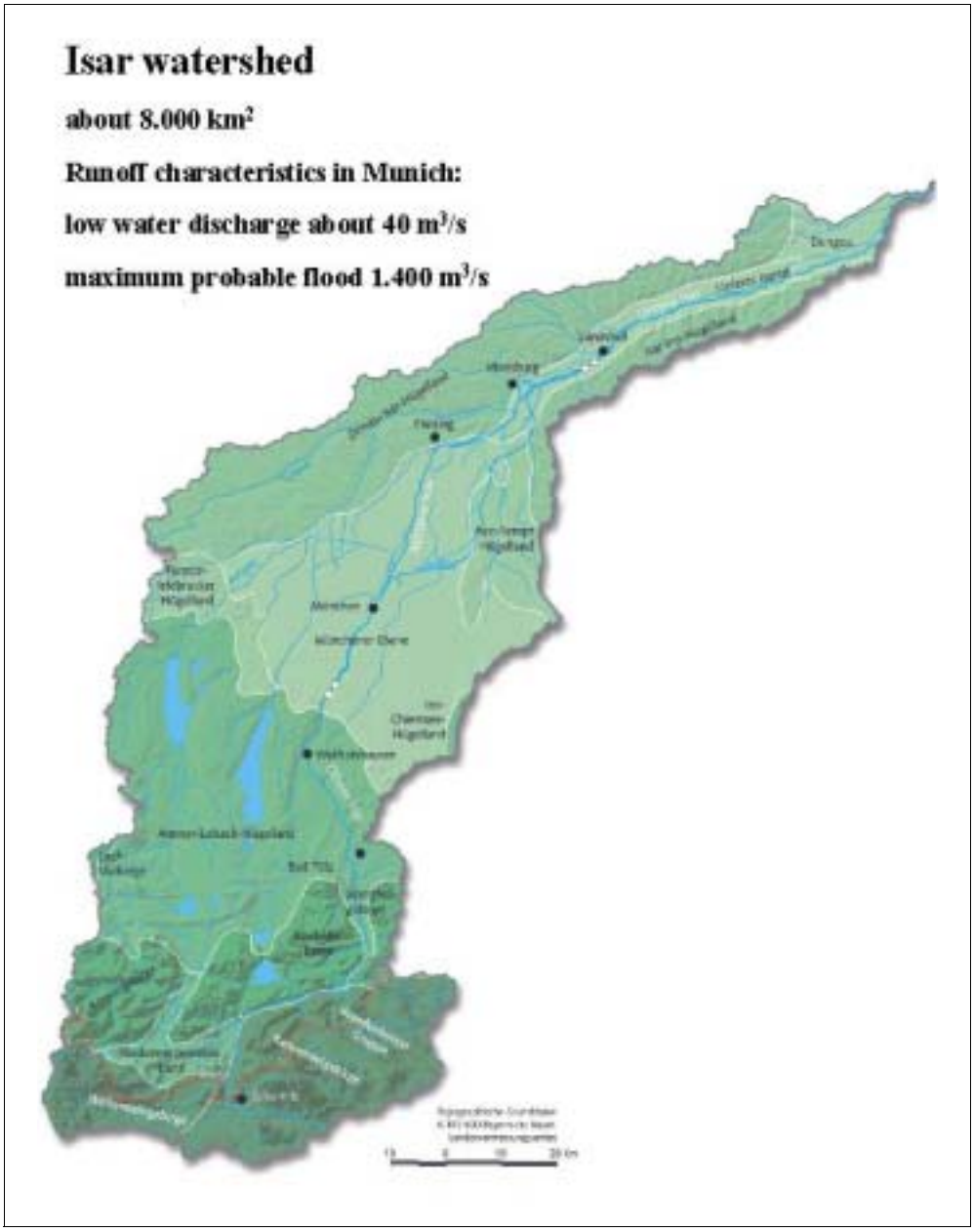


Figure 9:
Isar watershed

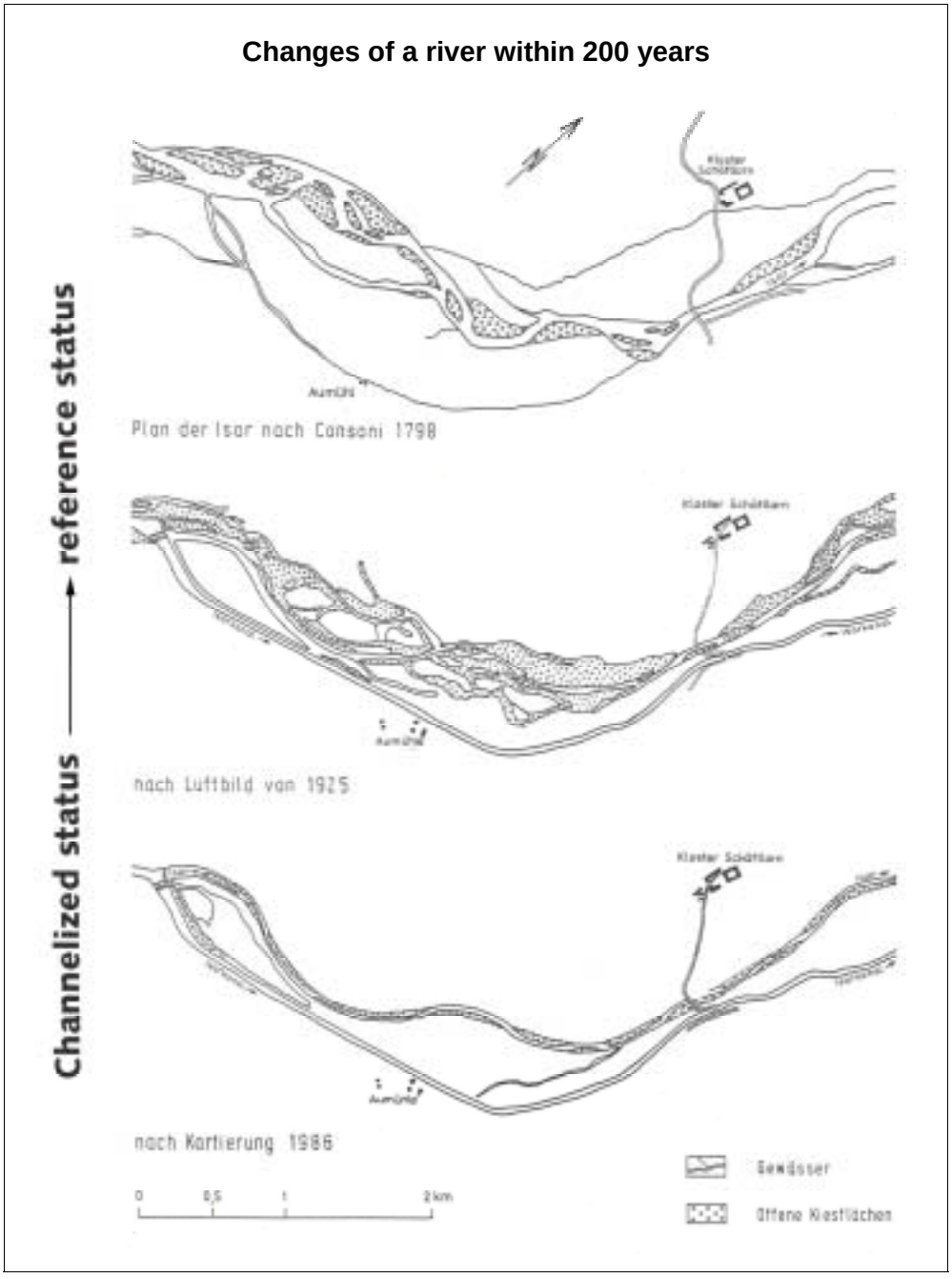


Figure 10:
Changes of the river Isar within 200 years

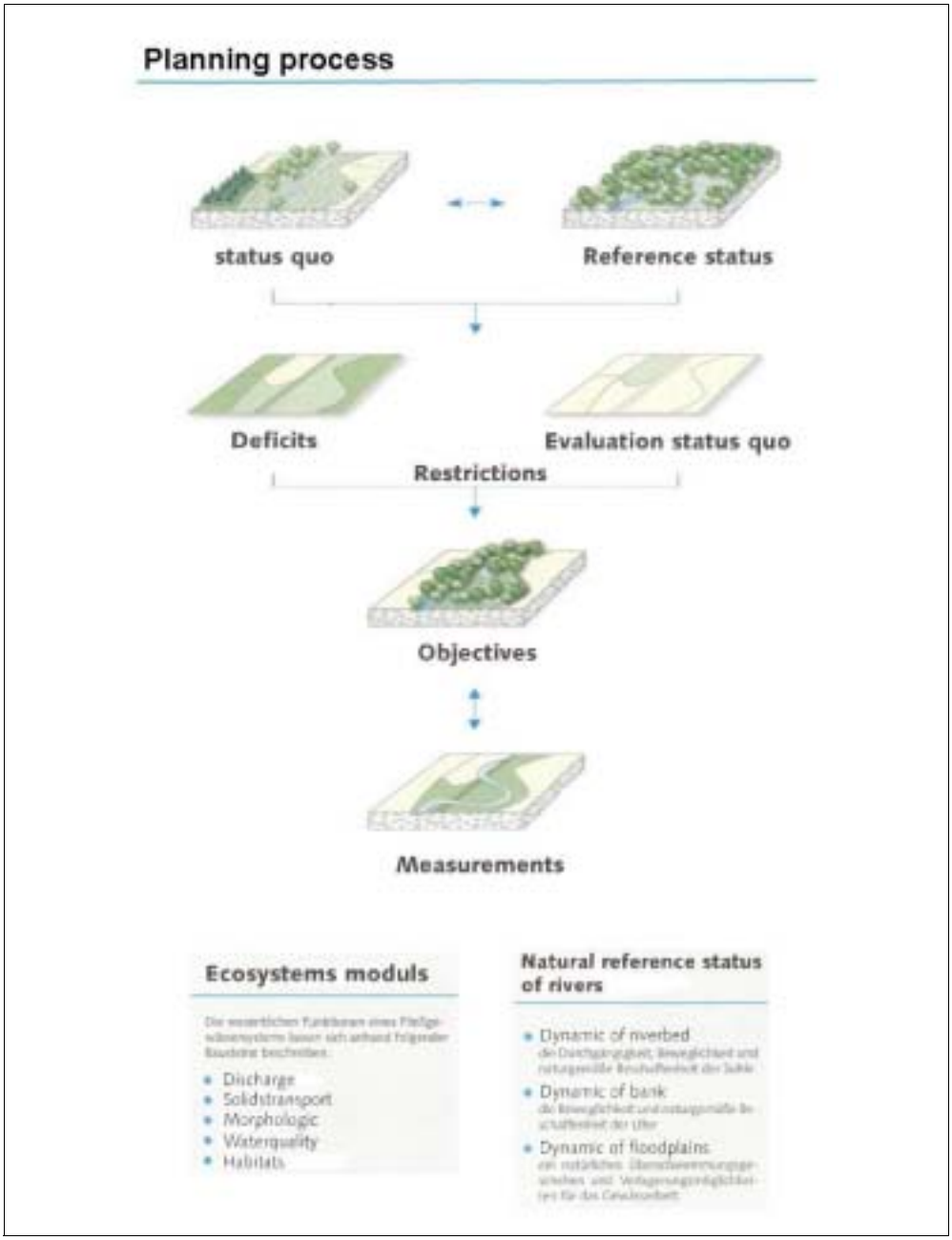


Figure 11:
Natural river restoration and river management planning

There are Management Plans for the Isar from the Alps down to Landshut with a budget for more than 50 Mio. €, to be invested till 2020. The objectives are to improve flood control for the city of Munich, but also the ecological functions inclusive the retention potential for floods and the recreational value of the river landscape. These effects are accompanied by measurements also in the smaller tributaries of the watershed. They all together bring profit for the middle and low land areas of the Isar and to the Danube, even this influence will decrease according to the increase of the watershed.

8 Flood retention by reservoirs

The rivers Iller, Ammer, Isar, and Danube experienced water levels that had never been seen in the last century. The upper Lech, the Loisach, and the upper Isar, as well as numerous smaller water courses in the Alps and their foothills suffered from extreme water levels. Heavy flooding occurred in the southern part of the Allgäu, from the Iller valley to its flow into the Danube. In the Augsburg region the Lech and the Wertach, areas along the Ammer, Loisach and Amper as well as the Danube suffered from the floods. Alltogether an area of about 20,000 ha was flooded and approximately 16,000 buildings were damaged by the flood. However, in places where reservoirs control the flow of the water, flood damage could be avoided to a great extend. The necessity and efficiency of reservoirs was thus proven impressively. On this occasion the Sylvenstein reservoir, a dam construction approx. 60 km south of Munich, Bavaria´s capital was a key factor in flood protection for the upper and middle Isar valley.

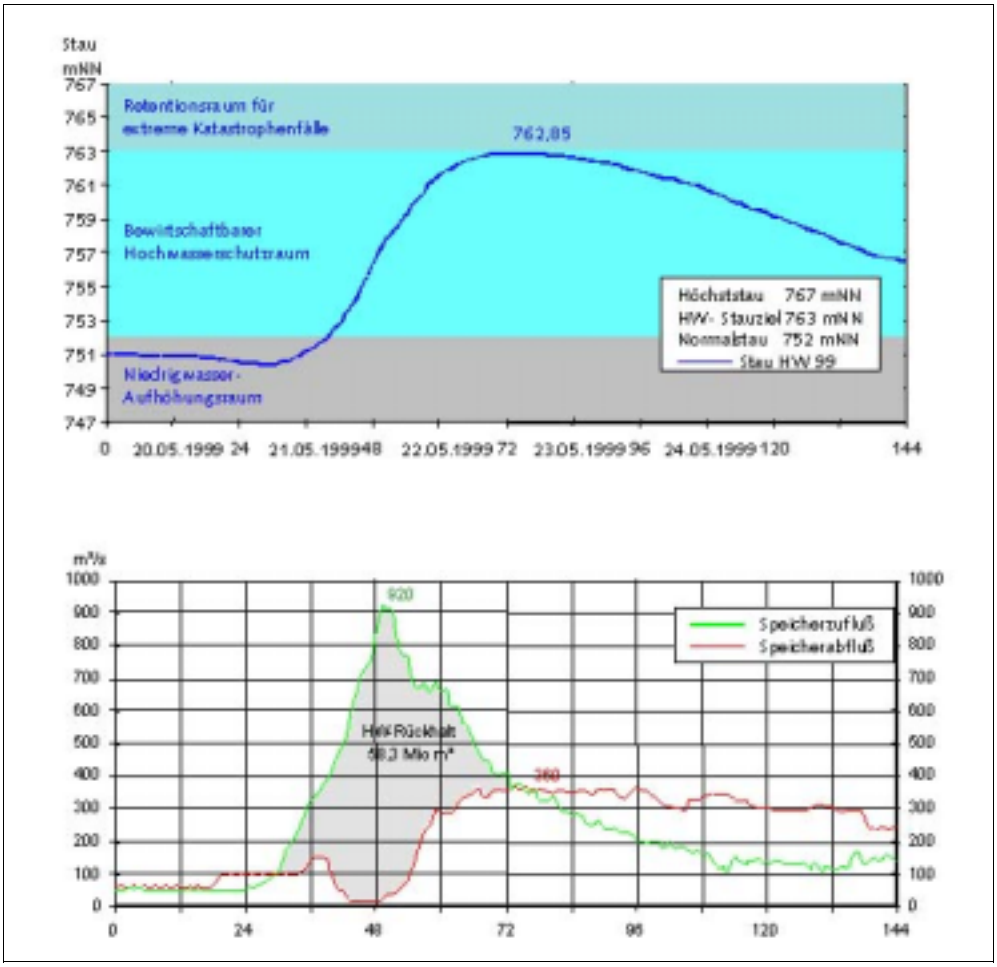


Figure 12:
Flood retention by Sylvenstein Reservoir during 1999 flood

9 Monitoring systems in alpine areas as a part of risk management in lowland areas

In suitable situations a monitoring system can be a helpful tool to govern a critical situation. This shall be pointed out with an example:

Near the village of Bad Feilnbach the largest landslide in the Bavarian Alps with a total volume of estimated about 8 mio m^3 is moving towards the valley. The triggering factors are geology and tectonic, human activities don't play a role. There is no chance at all, to stop the landslide by technical means. The experience from the past and also an intensive investigation had the result, that a rapid movement of some 10.000 m^3 of material is very likely and can happen any time. A rapid movement of several 100.000 m^3 or even more can not be excluded, but could be detected with a monitoring system early enough (weeks, may be even months before the event) to alert the people in the village. So we choose a combined system: In several retention basins about 250.000 m^3 of material can be retained, so the most likely scenario can be governed by these technical means. In addition an automatic monitoring system was installed. Every 15 minutes the movement of about 20 points is measured. The results are transferred to a computer in the local water management office in Rosenheim. If given limits of movement are exceeded a specific message is sent to the engineer in charge and in a fixed procedure the local experts will check the situation and can decide about further action.

So in combination with technical means and alert systems the monitoring can be a helpful tool in risk management. Of course, this kind of solution will be restricted to fairly slow processes such as landslides.

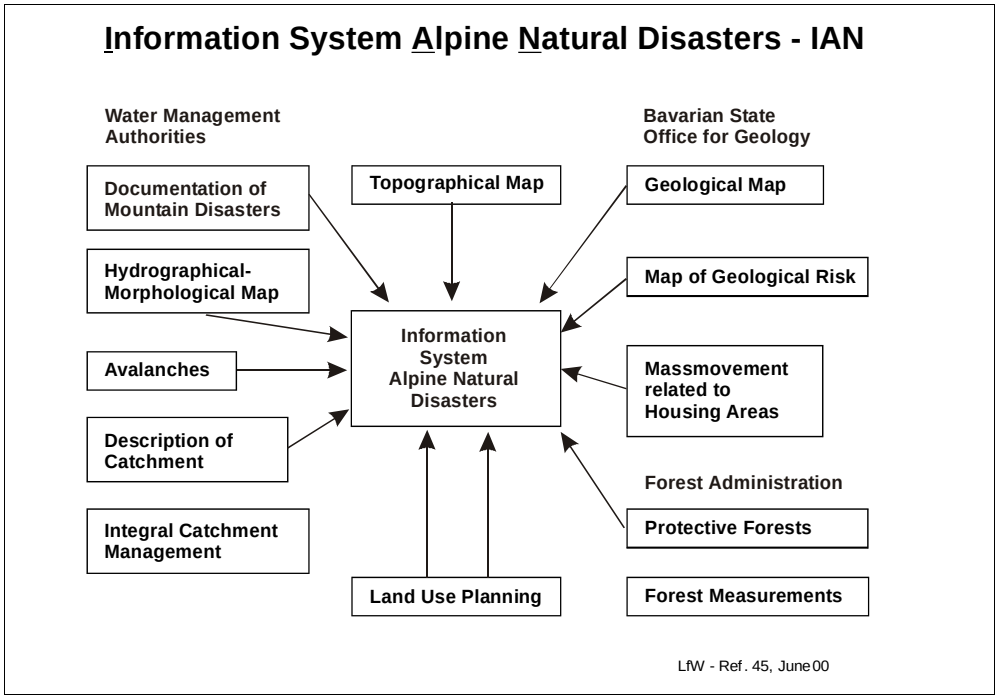


Figure 13: Information System Alpine Natural Disasters – IAN



Figure 14:
A landslide near Bad Feilnbach – 8 mio m^3 moving towards the valley

In our strategies for better awareness and information of mountain hazards and risk management in lowland areas downstream we recently implemented in Bavaria the «Information System Alpine Natural Disasters – IAN». In this GIS-based system all available data about mountain hazards are collected and accessible for the public in the internet.

10 Future developments and challenges

Looking into the future we will have to expect a further increase of housing areas and infrastructural means. Consequently the pressure and requirements of the society will increase accordingly. We haven't reached the end of this development yet, may be there isn't an end at all. So the first challenge will be to continue and even strengthen all efforts for a preventive land use planning to avoid problems in the future.

A particular topic is the climatic change which is to be expected within the coming decades. Looking back on the series of catastrophic events during the last few years all over the world and along the river Elbe in this August one might have the im-

pression, that this is a first clue of the possible development in future. Still the scenarios of the consequences for natural hazards can not be predicted exactly, but more in their tendency. E.g. the reduction of the permafrost area will trigger landslides or debris flow in places which were considered to be safe so far. But many experts agree, that frequency and magnitude of hazards will increase.

Besides the preventive measures also technical means will have their importance in future. This will remain a permanent duty, the steady maintenance of the construction works will increase as well. Here we face the challenge of a combination of traditional work types with the development of new approaches. In particular ecologically designed constructions offer the chance for sustainable solutions with only very little demand for maintenance. The implementation of a reasonable documentation of disasters is an important completion.

Another aspect is the application of flexible designs. As in some cases, e.g. open check dams, the effect can only hardly be predicted precisely, it's advisable to have a chance to adapt the works in accordance with the performance observed in nature.

Summing up, we will have to face quite some challenges in future. But I'm rather confident, that we will be able to master the coming problems especially by way of an intensified international co-operation.

11 Social and Institutional Dimensions of Mountain Watersheds

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The Story of the Beaver Brook Watershed, Colorado, USA

Mountain watersheds, especially headwater areas, are landscapes held in high esteem. They have value because they are sources of high-quality water and other renewable natural resources. Increasingly, mountain watersheds are valued for their scenic and outdoor recreation amenities, wildlife habitat, rare plants and animals, endemic gene pools, air quality, and their ability to store carbon and cycle nutrients.

Sustainable watershed management is the management of the soil, vegetation, water, and associated amenity resources within watersheds in such a way as to not diminish the value of those resources for present and future generations. Value is the key word in that definition, because values are implicit in the concepts of property, natural resources, and environmental quality. Personal values, which reflect diverse individual perceptions and perspectives, often give rise to strong emotions and conflicts over land uses.

Watershed management policies and goals are difficult to establish, particularly where there are conflicting interests or multiple landowners in large watersheds. Even where a watershed consists entirely of public lands, there are likely to be conflicts over land uses, resource outputs, and desired future ecological conditions. Setting watershed management goals involves human as well as biophysical considerations. What values do humans place on headwater areas? Who determines goals and policies for managing mountain watersheds and how are they determined? These are necessary social and institutional questions–part of the human dimension of watershed management. My purpose in this paper is to introduce the human dimension of watershed management and to discuss its implications for managing mountain watersheds.

1 The Human Dimension of Mountain Watersheds

Watershed management has traditionally dwelled on the biophysical aspects and essentially overlooked the human dimension. A watershed might be viewed as a patchwork of biophysical and human processes (Fight et al., 2000). The human dimension is divided into five elements (Figure 1). *Human actions* refer to the activities in which humans participate, such as timber harvesting, livestock grazing, firewood gathering, mushroom picking, skiing, hunting, fishing, camping, hiking, and various other recreational activities. *Information* includes the knowledge, skills, and ideas generated by people interested in the management of mountain watersheds. *Culture* refers to the sentiments, memories, and traditions held by people with respect to where they live, work, and recreate. *Psycho-emotional elements* include people's interests, perceptions, beliefs, values, and attitudes about landscapes. They tend to be closely held and deeply felt. Emotional ties may also result from personal involvement with laws, regulations, policies, voting, property rights, and other institutional activities involving land and natural resources. A related, but harder-to-describe, element is the «sense of place» that people feel about where they live or where their ancestors lived. *Organizations* are formal and informal groups such as communities, government agencies, business entities, and interest groups.

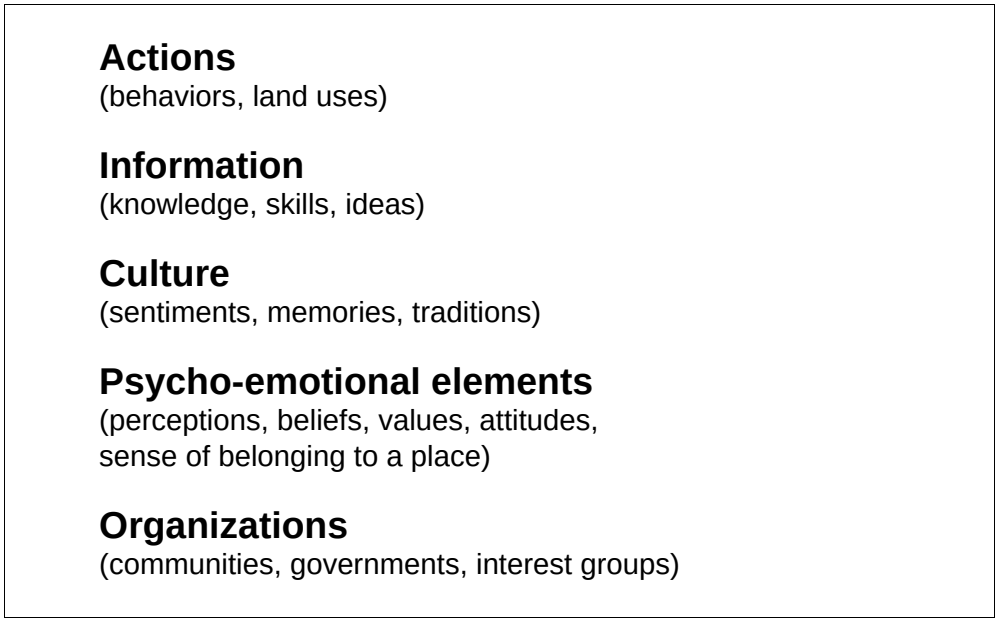


Figure 1
The human dimension of mountain watersheds

Human social systems are general social structures guiding much of human behavior and provide an alternative means of describing the human dimension. Social systems are comprised of three subsystems: *social order* (cultural identities, status, norms, beliefs, hierarchies), *social cycles* (temporal patterns of human activity or trends in human thought), and *social institutions* (Machlis et al., 1997). Social cycles significantly affect the distribution and use of natural resources. Social order involves the nature and control of interactions between individuals and groups. Institutions are formally-organized social systems created to find solutions to social challenges or needs.

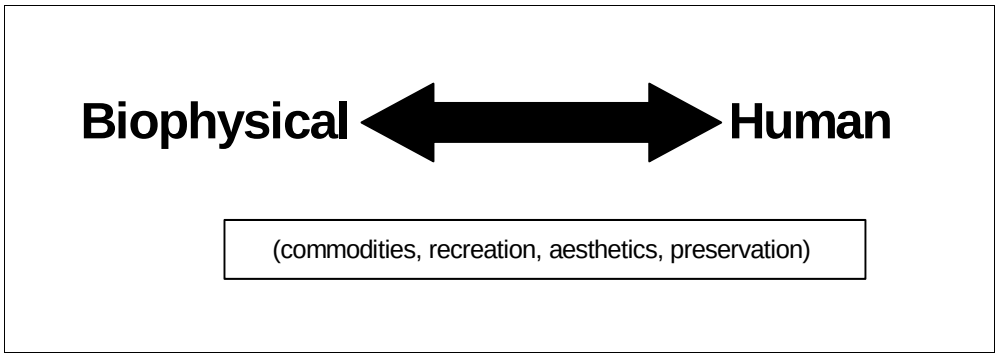


Figure 2
Biophysical-human interactions within watersheds

Watershed management objectives must consider the human dimension as well as biophysical resources and systems. Information for managing watersheds is incomplete without considering the human dimension (Lee, 1992). Interactions between the biophysical and human dimensions occur because of the myriad of opportunities provided by mountain watersheds (Figure 2).

2 Changing Landscape Values and the Public Trust Doctrine

Social values change constantly. Attitudes toward land, wilderness, and water development today are vastly different from attitudes 100 years ago (Morgan, 2002). Historically, Euro-Americans have modified the environment to fit their conceptions of property. But a greater awareness and concern for the natural environment has gradually evolved over the past four decades in the United States (U. S.). Coggins (1993) noted an increasing prominence of the preservation ethic in all varieties of natural resource issues and referred to preservation as the pre-eminent federal land value of the 1990s. Changing social values about nature have led to changes in both legal and political institutions in the U. S. According to Cortner et al. (1996), the values of the past created the institutions of the present, and changing social values will engender the institutions of the future. Now our growing understanding of natural ecosystem processes and functions is informing all of our social institutions. Social values are changing in the direction of an ecological imperative and this will create pressure for laws and policies to change (Hunter, 1988).

The public trust doctrine, a legal concept that holds that certain natural resources cannot be privately held, has its roots in English and Roman common law regarding the nature of property rights in rivers, the sea, and the seashore. Specifically, certain interests such as navigation and fishing were to be preserved in perpetuity for the benefit of the public. However, the principle of the public trust is broader than its traditional application implies (Sax, 1970). In the U. S. the doctrine has evolved within and from the context of protecting public rights in water and water-related areas and uses (Jawetz, 1982). For example, with respect to water it is incumbent upon the government to regulate water uses for the general benefit of the community and to take account of the public nature and the interdependency which the physical quality of the resource implies (Sax, 1970).

The public trust doctrine may be applied to problems of quality in resource use, such as air or water quality. In American law the public trust doctrine is expanding and reflects public attitudes about land and natural resources. Natural resources such as air, water, scenery, wildlife, and ecological functions exist for the common good (Weber, 1991). Another view is that individual members of the public are beneficiaries of a public trust that includes air, water, and public lands. The concept of public trust and public interest changes as social objectives change (Adams, 1993). The public trust doctrine has been extended to water quality (Johnson, 1989), to recreation and ecological values (Rieser, 1991), to wildlife habitat (Meyers, 1989), and to all waters that have significant public uses (Conway, 1984). The public trust doctrine might be used as a possible cornerstone of a common law of the environment (Montgomery, 1972).

The public trust doctrine has gradually crept into public land law considerations (Montgomery, 1972). Wilkinson (1980) argues that the trust notion is an appropriate description of the federal role in U. S. public land law. But Jawetz (1982) as-

serted that the public trust doctrine may be conceptually inappropriate for the inland public lands. However, there is an imposing and growing body of case law suggesting that public trust doctrine applies to certain public lands. In fact, public land law has borrowed important components from the public trust doctrine (Coggins and Wilkinson, 1987; Wilkinson, 1989). According to Caldwell (1970), the formulation of public land policy based on the management of whole ecosystems or watersheds must proceed upon the basis of the proposition that all land is in some degree, and for some purposes, public. Increasing knowledge about the role of natural systems and ecological functions is influencing public land and water law. Ecologically-sensitive land must be treated differently from other forms of property (Hunter, 1988). One example that comes to mind is that of wetlands, which were viewed as worthless swamps just a few decades ago.

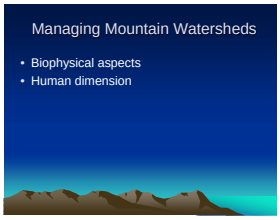
Case law supporting the public trust doctrine has been running congruent with the body of legislation that supports public land management. Even more significant in the U.S is the growing trend in using land trusts to protect land from development and retain its value for wildlife habitat, open space recreation, aesthetics, and watershed protection. Given the increasing support of the American public for the concept of open space preservation, the public trust doctrine is a potentially effective tool for shaping public land management policy. I propose that the public trust doctrine be applied to critical headwater areas.

3 Watershed Councils in the United States

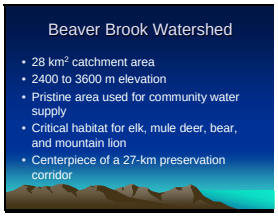
Watershed councils are community-based organizations (CBOs) initiated and supported by citizens living within or near the watershed of interest. These interest groups attempt to inform, influence, and reach consensus about natural resource issues. Over 400 watershed councils have emerged in the western U. S. in recent years (Kenney et al., 2000). Generally speaking, citizen-initiated community-based organizations, such as watershed councils, are a response to governmental deficiencies (Kenney, 1997). Watershed councils arise because landowners and governmental entities fail to resolve land-use and resource conflicts within traditional institutional frameworks. They offer alternative approaches to problem-solving and decision-making.

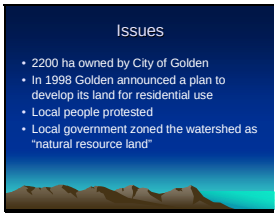
A co-operative watershed approach facilitates co-ordination among government and private entities with resource management or regulatory authority in the watershed (Natural Resources Law Center, 1995). Watershed councils are recommended especially for watersheds characterized by complex land ownership patterns. MacDonnell and Bates (1993) advocate the use of local, geographically-based organizations suited to the needs of their citizens and empowered to influence future resource management decisions that affect them. Flexible institutions, located close to their geographic area of responsibility, with open communication styles and participatory decision-making processes are well suited to serving the needs of their constituents. Institutional structures that emphasize social interactions are needed.



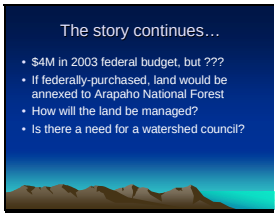












The success of watershed initiatives depends on engaging widespread participation of volunteers and preventing their burnout. Burnout is not uncommon with community-based volunteer groups. Burnout has been attributed to 1) high workload, 2) unclear goals, plans, and expectations, 3) poor monitoring and feedback processes, and 4) poor leadership or support (Byron and Curtis, 2002). Additional research is needed to ascertain the effectiveness of watershed councils as alternatives to traditional governance.

4 A Case History: The Beaver Brook Watershed, Colorado, USA

The Beaver Brook watershed is located in the central Rocky Mountains west of Denver, Colorado. A tributary to Clear Creek, Beaver Brook drains an area of approximately 28 km^2, ranging in elevation from 2,400 to over 3600 m. A 2200-ha portion of the Beaver Brook watershed, including almost 800 ha of federal land, was purchased by the City of Golden, Colorado, in the early 1900s for use as a municipal watershed. About 160 ha of land in the headwaters are designated national forest lands within the Arapaho National Forest. The watershed is spruce-fir-aspen forest with occasional open meadows. The area is important habitat for elk, mule deer, fox, black bear, mountain lion, grouse, and wild turkey. The watershed lies at the heart of a 27-km-long preservation corridor that begins in the Mount Evans Wilderness Area, runs through 18 km of national forest lands, and ends at a county open space park.

Golden ceased using the watershed as a municipal water supply in the 1940's, sold the water supply improvements and associated water rights to the Lookout Mountain Water District in 1988, but retained title to the land. The Beaver Brook watershed is still used as a municipal watershed, serving about 2,000 people. In the late 1990s Golden announced plans to sell the land to residential land developers. Golden considered the property to be worth more than US$20M. However, the Clear Creek County Commissioners zoned 89 percent of the Beaver Brook watershed as natural resource/preservation-conservation land, thereby precluding Golden from subdividing the property into residential estates. Golden subsequently filed suit against the Commissioners, citing a «takings» and claiming that the zoning reduced the value of the City's property.

Because the Beaver Brook watershed was managed as a municipal watershed for many years, it remained relatively pristine with few land disturbances. Minor logging activities occurred within the watershed in the early 1900s and small forest thinning operations, designed to benefit elk and mule deer habitat, have been conducted periodically. A few small residential subdivisions exist along the western boundary and at the lower end of the Watershed. Because the Colorado Division of Wildlife which leased the watershed for hunting purposes and established trailheads, the watershed became a well-used hiking and hunting area. Local citizens were incensed that the watershed might be developed as a residential area.

The Mountain Area Land Trust (MALT) offered the City of Golden US$6M for its land with the intention of preserving the watershed as open space, protecting the significant wildlife, recreation, and water quality values. The offer was rejected and MALT and its supporters turned their attention to lobbying the Congressional delegations for federal funding that would allow the Forest Service to acquire and manage the lands as national forest. As a result of very intense lobbying from local citizens, the U. S. Congress this year appropriated funds for the first phase of a land purchase program. Purchased lands will be annexed to adjacent national forest lands.

Clearly, the Beaver Brook watershed holds values for many groups and individuals. The biophysical values, such as wildlife habitat and water quality, are fairly well-understood. We are just beginning to appreciate the human values of the watershed. The Beaver Brook watershed story is not unique in the West. As communities expand, they require additional water supplies and headwater areas are likely sources of high-quality water. Protecting headwater areas to meet community water needs usually involves land-use conflicts. An understanding of both the biophysical and human dimensions of these conflicts is necessary for effective headwater management.

How should headwater areas like the Beaver Brook watershed, characterized by complex land-use issues, high-valued resources, and mixed land ownership, be managed? Referring again to Figure 2, it should be obvious that watershed management involves the management of the interactions between the biophysical and human dimensions of watersheds.

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B Country reports

12 Introduction to the country reports

A Forum to discuss the management of mountain watersheds in alpine regions

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The EFC Working Party on the Management of Mountain Watersheds is celebrating its 50 year anniversary during this 23rd session in Davos, Switzerland. This session also presents a unique opportunity to meet in the context of the International Year of Mountains 2002 and move issues of watershed management in Europe higher on the political agendas of countries. It is also relevant to note that 2003 has been declared by the UN General Assembly as the International Year of Freshwater. This provides an additional opportunity to highlight the importance of the Working Party in the area of water management and conservation.

This group has been an important forum for technical discussions over the years and has made significant contributions to the current state of knowledge and expertise on watershed management in Europe and beyond. The Working Party has recently been challenged by its parent body, the European Forestry Commission, to demonstrate its relevance in the present European context and to show that it is not only capable of providing a forum for technical exchange, but also is having a positive impact at the policy level within countries. This challenge is being met by encouraging member countries of the EFC to ensure that representation and participation at sessions of the Working Party includes decision and policy-makers in addition to technical experts. FAO has been facilitating this process in its capacity as secretariat to the Working Party, and in support of its Executive Committee, by contacting EFC member countries directly about this issue. The group is also challenged to take a more active role in terms of inter-sessional activities which will allow for a more continuous treatment of key issues and hopefully contribute to a greater overall positive impact of its work.

The Working Party has also evolved in recent years to embrace a more integrated approach to watershed management which considers multiple land use and socio-economic concerns to be important and complementary to the technical work it has focussed on historically. This has served to make its work more relevant in the context of Chapter 13 of Agenda 21, dealing with sustainable mountain development. The new International Partnership for Sustainable Development in Mountain Regions, launched at the World Summit on Sustainable Development in Johannesburg in September 2002, presents a further opportunity for the Working Party to enhance linkages and collaboration with other institutions within and outside Europe dealing with mountain development and watershed management.

In recent years there has been a greater focus of the Working Party on watershed management issues in countries of Eastern Europe and greater participation of Eastern European country representatives in Working Party sessions. Consequently, a more pan-European approach has been taken which has expanded the role of the group beyond its original Alpine focus. Additionally, the group in recent years has included observer delegations in its sessions from developing regions of the world. This has ensured that the Working Party is making available its experience and

important technical contributions to the widest possible audience, including to countries in Latin America, Africa and Asia.

Many challenges lie ahead for the Working Party. As issues such as water management, global climate change and interactions between highland and lowland areas become more prominent on global, regional and national agendas, the Working Party will likely have an increasingly important role to play in Europe and also beyond. It will need to maintain a determined but flexible approach to watershed management, both in terms of technical expertise and policy support. FAO stands ready to assist all member countries of the EFC Working Party on the Management of Mountain Watersheds to its fullest capacity.

13 National reports on the Management of Mountain Watersheds 2000–2002

13.1 National Report Austria

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1 Introduction

The control of natural hazards is a part of watershed management and the main aim and target of the Forresttechnical Service in Avalanche Torrent and Erosion Control of Austria. Integrated risk management can only encounter natural hazards. On the one hand an interdisciplinary co-operation of authorities concerning management of the antroposphere and the catchments and basins of a region is essential and on the other hand a «proper control technique» has to be implemented in each subcatchment of this region. Naturally the problems of the different watersheds are varying and can only be clarified individually. Therefore again and again the question arises what kind of risk management has to be applied to level down natural hazards from an incalculable to a calculable risk. First of all risks have to be analyzed and assessed by survey and investigations on a regional level. On the results of the regional investigation and survey a proper and well-based risk management has to be developed and implemented.

2 Methodology

Applying the risk-concept-method can derive a risk management.

Risk is defined as: Qualitative and quantitative characterisation and analysis of a hazard due its probability and consequences (BUWAL, 1998, S.12).

2.1 Risk-concept

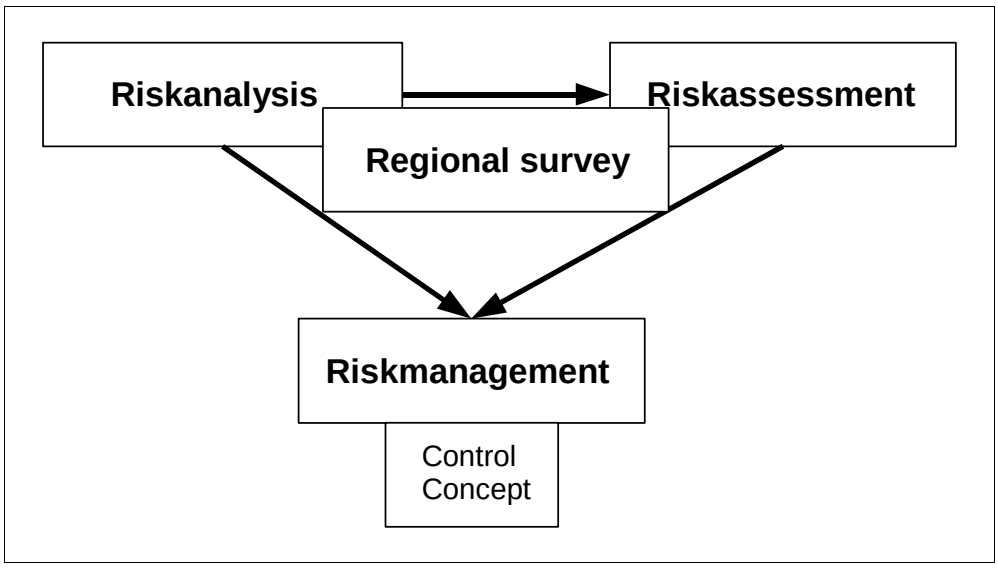


Figure 1: Risk concept.

2.2 Regional survey

Regional survey has to analyze the environmental situation of a region and its land use and contents

- Limitation of the area of survey
  - Enlisting the communities respectively catchments and areas of natural risks
- Investigation of data considering the planning of measures
  - Land use, forestry, settlements, infrastructure…etc.
- Basic investigations
  - Geology, morphology, hydrology...etc.

Regional survey is a combination of risk analysis and risk assessment

Table 1: Regional Survey (Leitgeb 2002).

RISKANALYSIS Definition of risk Analysis of consequences Analysis of exposition Analysis of risk	Characterization and/or quantification of a disaster due its probability and consequences
RISKASSESSMENT	Socio-political decision of the question: Which risk will be accepted by the claimants

2.3 Results of the regional survey

By regional survey hazard maps and hazard zone maps can be mapped and also hazardous reaches can be elected outside of the dedicated area. Further more the results of the regional survey and investigation implement necessities of integrated watershed management.

2.4 Risk management – Planning of measures

The control concept is a combination of measures, which have to be integrated in a way that the target of control will be optimally and efficiently reached.

Measures are hazard zone maps, regulations and rules and also structures and biological measures.

Table 2: Classification of functions (LEITGEB 2002).

Areas causing DAMAGES	Areas impacted by DAMAGES
Retention (debris & bedload)	Bedload- dosing and sizing
Consolidation & stabilising	Debris flow breaker
Drainage	Retention of floods
Forestry &soil-bioengineering measures	Hazard zone maps

Measures are classified by their functions and devided in measures against the damages at the area of danger origin, the tracks were danger is dislocated and the areas of danger impact

Planning of the countermeasures depends on

- Types of disaster
  - Flood
  - Bedload disaster
  - Debris flow
- Target of protection
  - Settlement
  - Infrastructure

2.5 Control technique

The so-called «**Function chain**» was developed and applied as unique integrated watershed management methodology and avalanche, torrent and erosion control engineering technique in Salzburg/ Austria.

«A function chain is an unit of function carriers with interdependency. If one necessary function is not occupied, the hole control technique has to be questioned» (KETTL, 1994, S.43).

Definition of **functions** in bedload and/or debris flow control (Fiebiger 1988)

Stabilizing:	Fixation of debris flow channels in a wanted level to stop and/or prevent depth erosion.
Consolidation:	Elevating of debris flow bed to support and/or prevent slides and slopes and lateral erosion.
Sorting & Sizing:	Filtrations and/or storage of undesirable debris flow components during a debris flow.
Debris flow sizing:	Filtration and storage the large pieces of bedload during an event or debris flow.
Wood grading:	Filtration of undesirable wood during a debris flow.
Retaining:	Storage and deposition of debris flow until aggradation of the retention capacity.
Dosing:	Parting of a large mass of debris flow in small amounts.

Debris flow Dosing: Quantitatively dosing transport of intermediate stored debris
flow and bedload by declining floods and mean floods

Breaking of debris flow: Decrease the high energy level of a debris flow to a lower level under particular energy change.

2.6 Systematic control system by integrated watershed management

A method for deducing an effective control system is to define objectives of treatment and necessary functions of the measures first (figure 2).

2.7 Hazard zone map

Object of technical preparation of hazard zone maps is the area mapping of the degree of dangers on sites by torrents and avalanches with red and yellow hazard zones and also reference (brown) and reservation (blue) areas.

The hazard zone map is basis for projecting and implementation of measures and the work as surveyor (figure 3).

An important method for hazard zone mapping is the investigation on a bedload balance by disaster documentation immediately after a hazard (figure 4).

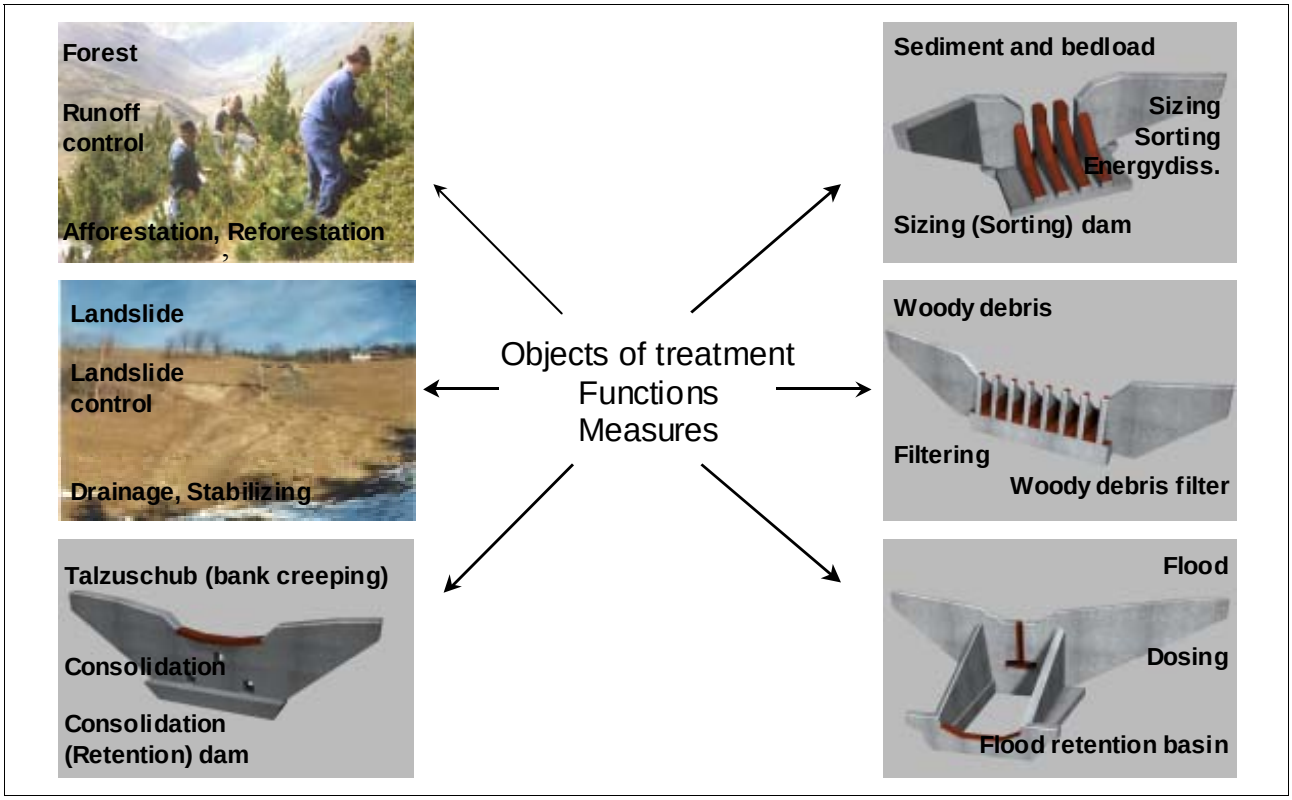


Figure 2: Overview to objects, functions and measures.

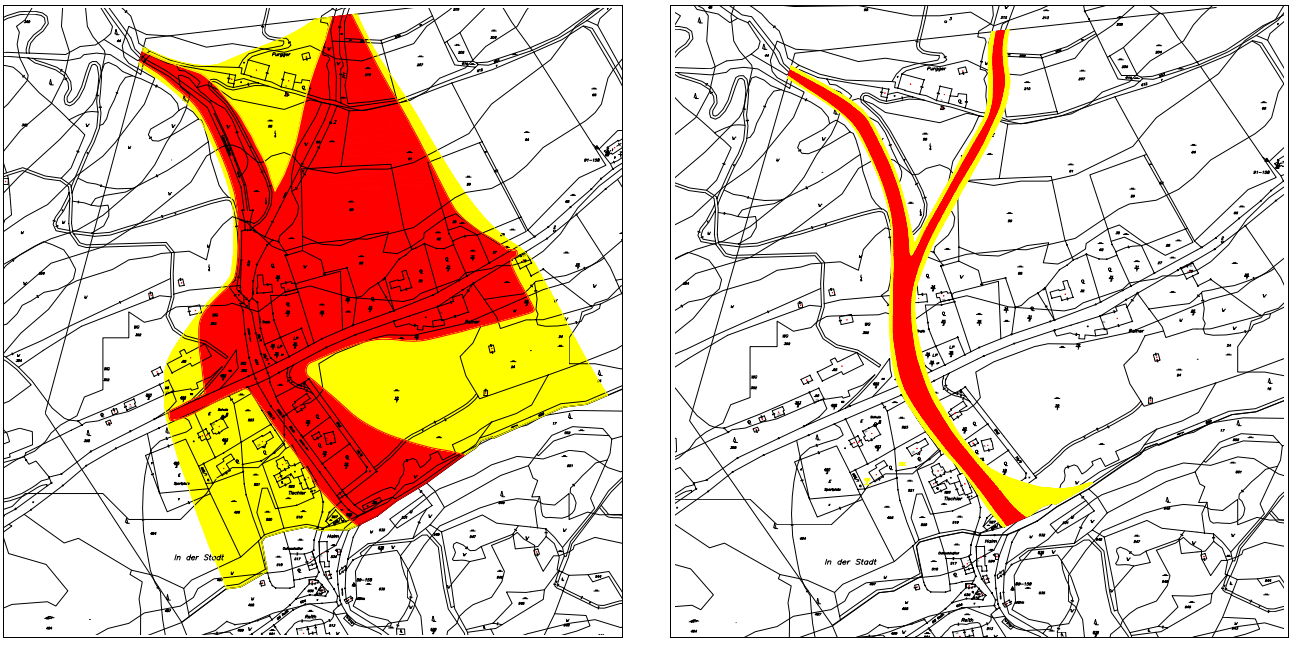


Figure 3: Left hazard zone map without technical measures and right hazard zone map after implementation of the control technique.

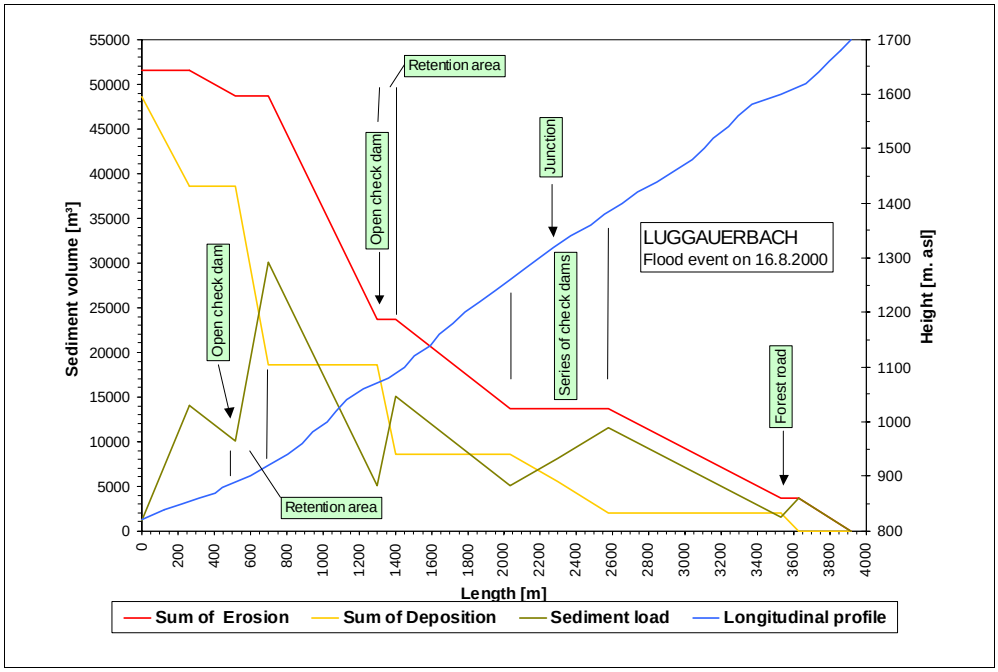


Figure 4: Bedload / debris balance (graphical) (Leitgeb 2001).

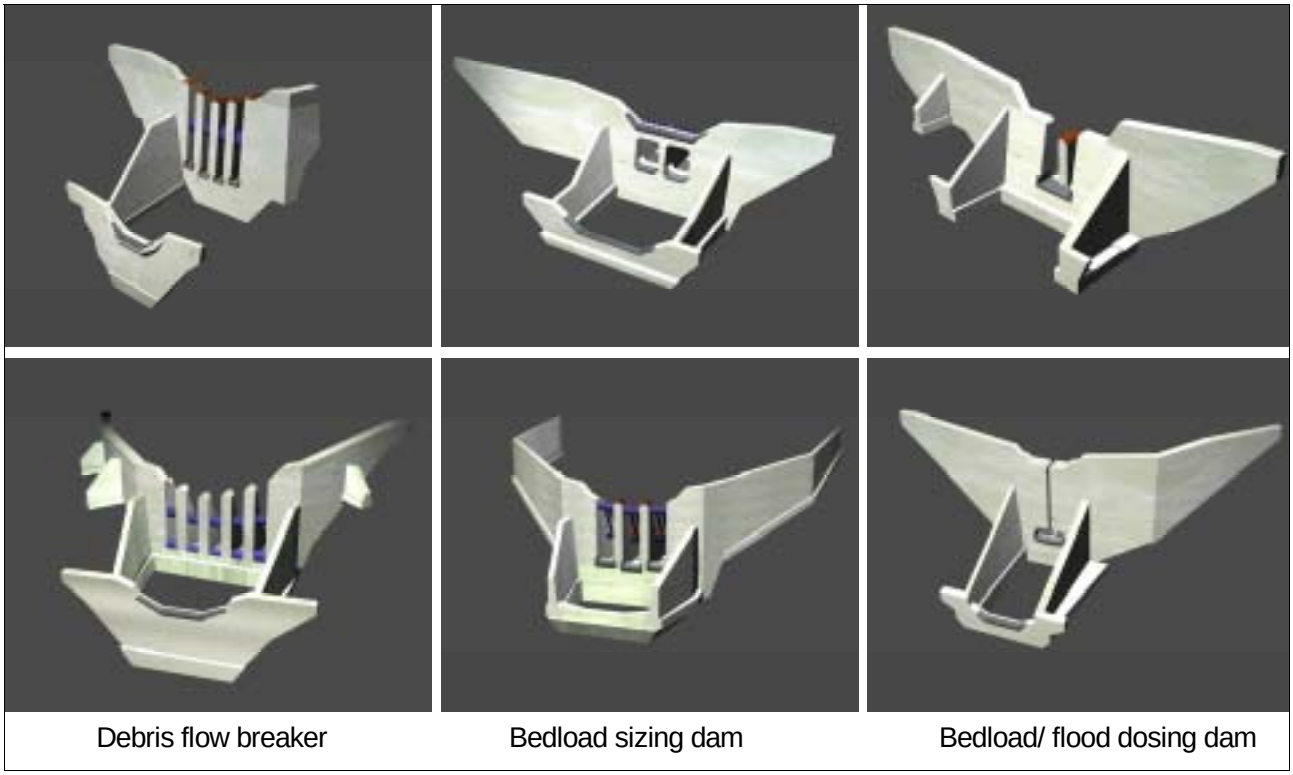


Figure 5: Structures with different functional design. Front view without surrounding terrain. (Leitgeb 2002).

2.8 Types of functional structures in the FUNCTION CHAIN used in torrent and debris flow control by the Foresttechnical Service of Salzburg / Austria

The function chain is formed as a combination of singular structures differing in their functions in combination and makes possible an individual treatment of torrent- problems (figure 5).

2.9 Conclusions

In managing natural hazards an integrated view to the anthroposphere (habitat) and the basins is essential in order to be able to define the problem properly. Deducing an effective control system demands an interdisciplinary co-operation of authorities concerning the problem of a certain region.

The necessary measures derived by the regional survey have to be combined with the local measures. Each subcatchment has to be treated individually. For example the hazard zone maps should be taken into account in land use planning.

A co-ordination of regional and local necessities in planning control systems would implement an integrated sustainable watershed management.

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13.2 National Report Bavaria

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First I'd like to mention, that in this year 2002 we had the opportunity to celebrate the 100th anniversary of the state organization for torrent and avalanche control in Bavaria. It was in August 1902, that king Luitpold of Bavaria signed a resolution for the foundation of 2 sections for torrent control in Kempten and Rosenheim.

This «birthday» gave reason to consider the situation in the field of torrent control in bavaria in 3 steps:

- Evaluation of success and failures in the past
- Consideration of the present situation
- Challenges in the future

I'd like to present my contribution according to these 3 topics.

1 Looking back into the past

A 100 years ago our predecessors believed, that by technical construction works along about 1.500 km the torrential problems could be solved. They considered this task limited in volume and time.

Nowadays we know, that this assessment was completely wrong. But in those days nobody could forecast the enormous development starting in the 50ies of the last century::

- The business of tourism so to speak exploded within a short period of time
- In combination with this development the rapidly increasing demand for touristic infrastructure and housing areas
- The extrem rising traffic caused by tourism as well as by the international trade.

2 The present situation

During the last 3 years we had to face disastrous floods exceeding a re-occurrence period of one hundred years significantly:

- In May 1999
- In August 2000 and finally
- In August 2002

From the experience of recent catastrophes a discussion arose questioning more or less all the standards and criteria valid so far for our work. Some of the topics are:

- Taking into account the high vulnerability of infrastructure and housing areas it's to be discussed, whether the safety standards are still up to date. Is a design for a re-occurrence period of 100 years still sufficient ?
- Are the hydrological data collected in the past still up to date or do we experience the first effects of a climatic change ? In some parts of Europe the absolute highest precipitation was observed since the beginning of measuring 150 years ago (e.g. 312 mm in 24 hours in Zinnwald, East Germany; 600 mm in South France).

- Can we accept the complete failure of a structure in case of overloading ? For example, may earth dams break in case of overspilling or is there a need for another construction type ?

Already in 2001 under the impression of the flood in August 2000 a basic strategy of flood protection has been developed in Bavaria consisting of 3 parts:

- Natural retention and prevention
- Technical measures
- Precautionary action

3 Challenges in the future

Still we can't be absolutely sure, how climate and catastrophes and consequently the impact on human life and goods will develop and change in future. But we are forced today, to find the right answers and strategies for these challenges in order to set appropriate rules for a sustainable protection level for coming decades.

These challenges can only be mastered in a close international co-operation to ensure comparable quality standards.

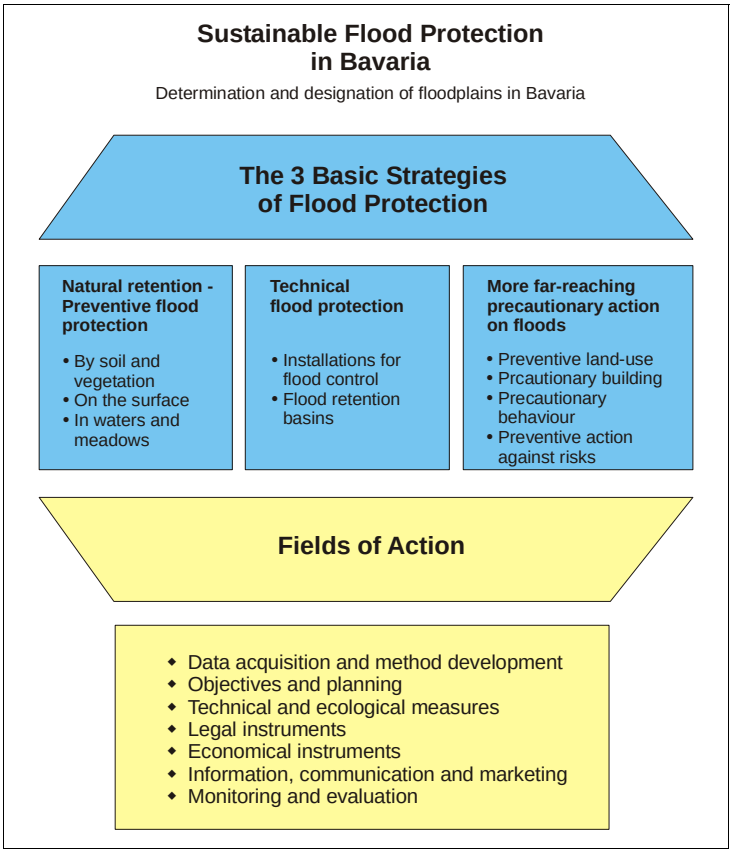


Figure 1: Sustainable Flood Protection in Bavaria.

13.3 National Report Cyprus

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1 General Information

Cyprus is the third largest island in the Mediterranean, with an area of about 9 251 sq. km. It lies in the north-eastern corner of the Mediterranean, approximately 33° east and 35° north.

Cyprus is a mostly mountainous country. Along its northern part runs the Kyrenia range, rising up to 1 000 m elevation. Its center is occupied by the larger Troodos range which rises up to 1 952 m. It is on these ranges with the very steep slopes where most of the Cyprus´ forests grow. Between the two ranges lies the Mesaoria plain which together with the narrow alluvial coastal plains forms the bulk of the agricultural land.

The climate is typically Mediterranean, with short, mild winters and prolonged, dry and hot summers. The coldest months are January and February with an average temperature of 9°C and the hottest are July and August with an average temperature of 35°C.

Precipitation is low with the average annual figures being 300 mm for the central plain and north-eastern coasts, 500 mm for the western coasts and as much as 1 000 mm for the highest peaks of Troodos. The seasonal distribution of precipitation is also uneven. The bulk of the rain falls during November to March and during the driest months, June to September, only 3,2%.

The forest and other wooded land in Cyprus cover 391 507 ha or 42,32% of its total area. About 162 574 (17,58%) of forest and other wooded land is state and the rest is private.

Almost all of the forests are coniferous growing on the steep and often rocky slopes of the Troodos and Pentadaktylos ranges. Another important characteristic is the predominance of just one species that is of *Pinus brutia* which is the only commercial species. Other species include *Pinus nigra var. palassiana* and *Cedrus brevifolia.*

2 Preventing work in the past

The main problems faced by the Department of Forests concerning the watershed management are soil erosion, rehabilitation of abandoned-mines and the filling of reservoirs with sediment. Natural phenomena, human activities, or the combination of the two often cause watershed degradation having upland and lowland impacts. The main causes of watershed degradation are the following:

- **Natural causes include:**

shallow soils

steep slopes
fire

- **Human causes include:**

Deforestation of the private forests and other wooded land
Conversion of the private forests and other wooded land to other uses
Forest fires
It is worth noting that the problems concerning the avalanches, rock-falls, mud-slides and flooding are rarely occurred.

The Forest Policy of the Government of the Republic of Cyprus, adopted and declared in 1950, includes objectives concerning the soil erosion control and protection of water catchment areas.

Furthermore, the National Forest Program for the period 2000–2009, approved in 2002, includes programs on soil conservation and watershed management. The cost of activities and projects concerning the watershed management amounts to CY£400 000.

The methods designed to reduce the soil erosion and increase the water quality are the following:

2.1 Silvicultural system

The current silvicultural system is the selection system. Tree removals are based on the biological maturity of the forest trees and they encourage natural regeneration. Artificial regeneration is used when natural regeneration fails giving, however, emphasis in methods having the least disturbance in the environment. This management practice is directed at improving the conditions of the forest watersheds, protection of flora, fauna, biodiversity and heritage sites, the promotion of ecotourism and sustainable production of wood and non-wood products.

2.2 Mechanical measures

The construction of small walls of loose stones was used in the past as a method to break the velocity of run off water and to arrest the silt loads.

Wire bolsters are constructed along the forest road to stabilize the banks of the roads.

2.3 Vegetation works

The prevailing measures used for soil conservation and stabilization are the vegetation works including reforestation of bare or burnt areas with native tree species and shrubs. The reforestation reduces run off water and enhances the aesthetics and wildlife habitat. The selection of species is based on site characteristics, climatological conditions and soil characteristics.

3 Harmful events at the regional scale

Man activities such as mining and quarrying caused significant environmental degradation. There are about 250 quarries for various materials for local use and for export (sand and gravel aggregates, limestone, gypsum, havara, clay, building stone, betonite, etc.). There was extensive mining in the past but today is limited.

The rehabilitation of the asbestos mine is the most important project for erosion control and watershed management. Restoration works include:

- construction of the necessary toe weight embankments at the base of present tips
- reprofiling of existing tip slopes
- deposition of top soil
- construction of surface drainage facilities
- planting

4 Harmful events – consequences from the point of view of the state

As mentioned above, we have not experienced serious problems from natural hazards.

5 Main problems that must be solved

The list of main problems that must be solved include issues related to the legal basis and to the valuation of the protective functions of forests.

13.4 National Report Czech Republic

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1 Introduction

The Czech Republic is a land-locked country located in the temperate zone of the Northern hemisphere in the central part of Europe. A prominent feature of its climate is a mutual penetration and mixing of oceanic and continental influences. It is characterized by a western circulation with a prevailing occurrence of a western wind. An intensive cyclonal activity is caused by a frequent change of air mass with a relatively frequent precipitation.

The area of the Czech Republic is 78,866 km^2, of which 52,817 km^2 (67%) is located at the altitude up to 500 m, while 25,222 km^2 (32%) at the altitude from 500 m to 1,000 m and only 827 km^2 (1%) at the altitude above 1,000 m. The highest-located point of the country territory is Snezka («Snow Mountain» – 1,602 m above the sea level) in the Krkonose («Giant») Mountains; the lowest-located point is the outflow of Labe River at Hrensko in the Northern Bohemia. The area of forest land is 26,370 km^2, which represents 33.4%.

2 Precautionary measures in the past, protection of citizens

In the Czech Republic, the hydrographic network is precisely delimited by so called ´hydrologic numbers of order´ in the system of demarcated watercourse catchment areas. There is total 76,000 km of water courses of which approximately 15,300 km are important from the water management point of view and about 60,700 km of other small water courses. In this way, they are named by the Water Act, each such water course has, defined by the law, a professional administration with the defined obligations that are ensured by a concrete administrator. A state company «Lesy Ceské republiky» (LCR s. p. – Forests of the Czech Republic, State Enterprise) is one of the three important administrators while it manages approximately 20,000 km of small water courses – torrents those catchment areas are predominantly forested. They are located mostly in the mountainous areas and thus forestry activities are closely associated with the erosion-control and flood-control activities and measures.

Since the year 1884 up to date, there were regulated approximately 1,300 km of torrents including the ravines. Important regulations were performed till the year 1940 while they allowed a permanent development of the mountainous areas and their use.

The impacts of every natural phenomenon – an element – can be seen in nature, as well as in the impacts on human being. Its impacts go to various amounts and a man has got an experience to which level people can cope, together with nature, with such impacts. The territory of the Czech Republic is damaged especially by a high

intensity atmospheric precipitation of an irregular occurrence. Its abnormal values lead to a local or regional damage. In the catchment areas of torrents, a damage leads to a faster soil erosion, development of ravines, landslides, moving of soil sediments and their depositing, devastation of watercourse beds and properties, flooding while the flooding rates of flow represent a danger for the life of citizens. The occurrence of avalanches or rock falling, which represents a local natural phenomenon, is quite extraordinary in the Czech Republic.

3 Management of mountainous catchment areas

Mountainous forests are located in border areas of the country. Sumava Mts., Krusne hory Mts., Jizerske hory Mts., Krkonose Mts., Orlicke hory Mts., Jeseniky Mts. and Beskydy Mts. should be mentioned. Since the Middle Ages the usage of these forests has its typical development. Originally it was the game management interests, pasture and production of grass as a supplementary activities to the developing farming to the aimed interests of the production of wood for the needs of mining, iron industry, glass industry or as a firewood. The beginnings of the intentional management in these areas could have been seen only since the beginning of 19th century. Despite of the fact that the mountainous forests at the highest altitude do not have large growing stock volume, forest owners experienced a significant damage of forest stands. With regard to the large areas, it concerned some high timber volume in total. Also, a concentrated harvesting – clear cutting – started to be used. With regard to the level of forestry management in those days when the reforestation used only a natural regeneration, a consistent attention was not paid to the artificial reforestation. In the areas bellow the tree line, the originally small clearings started to expand while pasture and production of grass only accelerated this process.

A change in the forestry management in the mountainous forests occurred only by publishing of the Forest Act in the year 1852 that regulated the procedures for harvesting and reforestation of forests at the high altitudes and on the steep slopes. Consequently, there appeared also the first determination of forest stands as a forest with a special purpose, by the way of its management and rotation period – a protected forest. These principles had a positive impact on keeping the upper tree line of forests. Together with the increasing of artificial afforestation this line was going up. The afforestation was successful on the majority of areas, although there were occurred damages in some plantations, caused by the plants getting dry, particularly from the reason of a non-suitable genetic origin of seedlings. Afforestation was performed also from the reason of erosion-control protection of soil on the turn of 19th and 20th centuries. The flooding-control protection represents another reason after a disaster precipitation at the end of 19th century in the central part of Bohemia where, however, it does not mean mountainous forests, and in the Krkonose Mts. and in the Beskydy Mts. This afforestation was performed in the public interest and was significantly supported by the state.

The forestry management procedures in those days established some significant changes in the tree species composition and in the space structure of forest stands. In the mountainous forests of the 17th century, there prevailed fir-beech forests, while spruce forests on the mountainous ridges. In the 18th century, spruce started spreading while it became a prevailing tree species on the turn of 19th and 20th centuries. However, it still meant mixed plantations of spruce, fir, beech, and pine as well as of oak. In the 20th century, spruce was continuing to get even larger area on the account of beech and fir. A result of this development, having been taken place for three centuries, there are spruce monocultures, mostly artificially established plantations with some small remaining parts of beech or pine stands. Vast spruce plantations are, however, endangered by wind, snow, insect pests and, after the World War II in a visible manner, also by the air pollution (but this problem in fact began much sooner). The most damaged by these were Krusne hory Mts., but also Krkonose Mts., Jizerske hory Mts., Orlicke hory Mts. Norway spruce stands disrupted by the calamities were, beginning 70th and 80th, replaced by the so-called substitute tree species. There is assumed a gradual restoration of so called «transitory stands of substitute species», when spruce is the main tree species of the natural species composition of the mountainous forests at its 60% target share.

4 Important elements of research

Research of climatic elements, particularly of precipitation is being performed with the aim to get a deeper knowledge of the hydrologic function of forests. In particular its relation to the runoffs in the small mountainous catchment areas with the forest stands restoration and influenced by the air pollution is of interest as well as the water ampleness and the quality of water sources and flood-control protection. A forestry-hydrologic monitoring of forest environment has been taking place since 1928 on two localities in the Northern Moravia aimed at the precipitation-runoff course, and since the year 1953, on three localities in relation to the simultaneous purpose changes of taxonomic characteristics of the forest stands.

On the territory of today's Czech Republic, the existing share of forests has generally decreased in comparison with the historical state of forest area share (in spite of the fact that from the beginning of the 20th century the forest area is steadily increasing). This change could have influenced a water yield of the catchment areas and watercourses; however, direct evidence materials are missing. The process of precipitation-runoff is taking place in the open and a very dynamic forest environment, with the complex internal relations, with a very different course of time. For example, a sudden fluctuation in climate with a decrease in temperature from 10ºC to -22ºC occurred in the period of time beginning the evening of December 31, 1978 till the morning hours of January 1, 1979 with a critical impact on beech stands in the mountains. On the contrary, a critical regional precipitation with the flood rates of flow occurred in the Northern Moravia in June 1883 and again only in July 1997.

Forest represents a natural environment with the impact on the creation of runoff from the mountainous catchment areas, however, the precipitations, that are the most important factor of the runoff regime, are influenced by the forest stands minimally concerning the volume of water. Spring areas of the mountains are sloppy terrains that support a faster runoff. Here, forest is a factor that helps to prolong the length of time of water flow into the network of concentrated runoff.

Forestry-hydrologic research has, up to date, provided background materials, that there is not taking place any provable change in the runoff despite the situation when reforestation is speeded-up. It means when felled mature stands are replaced by the cultures and young stands of the first age class in comparison with catchments where a high share of the higher age classes stands is maintained and only a sanitary cutting is performed. Different ways of management, i. e. methods of clear felling and, on the contrary, sensitive treatment do not prove any impact on runoff from the precipitations as, after main felling, a continuous cover of grassland is being developed in a short period of time. However, these weeds increase costs of a more difficult reforestation and the following protection and management of young cultures.

The research in a concrete catchment has provided results that after the complete exchange of main economic «timber tree species», (e. g. spruce instead of beech – but it should not be a recommendation!) there is a certain change of water runoff from the catchment area. Particularly during the precipitation-rich periods it can be higher.

But this is not quite clear conclusion and it requires proving by the another and long-term research verifying.

Increase in minimal runoffs can relate to a decreased evapotranspiration and a lower ability of the root system of spruce to soak in the infiltrated water from the deeper layers of soil. But any exchange of tree species has, first of all, to respect site conditions, forest stability, and protection against damaging agents. It is reflected by a trend of a return to the close-to-nature forest management, which is currently preferred.

In general, forest soils of the mountainous catchment areas delay runoffs in a limited scope only, their retention capacity is in the range from 20 to 50 mm of precipitation in accordance with the saturation of forest ecosystem with water and in accordance with the thickness of such soil layer. From the point of view of the accessibility of forest stands, it is important to perform a correct marking of forest transportation network and safe drainage of the concentrated precipitation water from its objects and facilities.

5 News in the general documents

A protection of citizens and territory endangered by the torrents has, in the Czech Lands, 120 years tradition. Its subject has been always complemented with water management, either by the independent purpose laws or the Water Law in the period from 1884–1960 or Forestry Law or Water Law after the year 1960.

The same situation exists also at present: a New Water Act took effect in the year 2002, while since the year 1996, there is valid a New Forest Act. Both acts regulate flood-control protection of the mountainous catchment areas of the torrents. However, in relation to the Directive 2000/60/EC and to the stable conditions in the countries of EU (Austria, by its conditions, is the closest country for the activities in the Czech Republic) it is still necessary to gradually adjust the respective Czech legislation.

Besides the legal changes regarding torrent and ravine control and for the protection of their catchment areas there was issued a Czech Technical Standard CSN 75 2106 «Torrent and ravine control» in 1998. It also includes biological and technical measures against flooding damages and fast erosion, for taking care of their natural parts or maintenance works for their regulated parts. In the year 2001, there was issued a Decree of the Ministry of Agriculture that defines basic technical requirements for such constructions. There will be issued a recommendation to the CSN 75 2106 that will make some of its provisions more detailed in 2002.

6 Damages in regional scale, places of damage

Damages in regional scale are caused by a natural disaster of an extraordinary scope when particularly transportation possibilities, public transport services, housing, supplying inhabitants, water and energy distribution are disturbed. Their fast removal is necessary to restore the territory to the state existing before the disaster. The law in the Czech Republic regulates solution of these matters.

Damages of this character and scope are a consequence of natural disasters and the course of flooding. In the catchment areas of water courses – torrents, that are associated with forestry management, such developments occurred and were assessed at the level of the knowledge existing in the past in the following way:

- March 1845 in the catchment area of the lower Labe River and its tributaries.
- May 1872 in the catchment area of the Berounka River and its tributaries.
- June 1883 in the catchment area of the upper Morava River and its tributaries.
- August, September 1890 in the catchment areas of the lower Vltava River and lower Labe River and their tributaries.
- July 1897 in the catchment areas of the upper Labe River, Upa River, Jizera River and their tributaries.
- July 1903 in the catchment areas of the Jeseniky mountains.
- August 1925 in the catchment areas of the Southern Sumava Mts. – Brdy Mts. – Luzicke hory Mts.

- March 1941 in the catchment areas of the Svratka River, Jihlava River, Dyje River and their tributaries.
- 1954 in the catchment areas of the Vltava and Otava Rivers.
- July 1987 in the catchment area of the «Jilovsky potok» stream (District of Decin).
- July 1997 in the catchment areas of the Morava River, Odra River, Orlice River, the upper Labe River and their tributaries.
- July 1998 in the catchment areas of the Dedina River and its tributaries.
- July 2002...
- August 2002
  16 people lost their lives,
  Together 43 districts and 446 municipalities has been affected,
  Destroyed: 282 km of rails including 19 bridges, 73 road bridges, and unknown number of houses and kilometers of roads,
  Damaged sewage systems and polluted drinking water sources,
  Thousands people without electric power, gas, phone,
  225 000 evacuated, 70 000 homeless due to flooding (as on August 21, 2002),
  Loses of farmers above 2.5 bill. CZK, etc., etc., all together 90 bill. CZK (~ 3 bill. USD).

Out of the above listed disaster flooding situations, 5 situations occurred explicitly in the mountainous areas of the territory of the Czech Republic (1883, 1897, 1903, 1997, and 1998). The other occurred in the spring parts of watercourses, up to the altitude of approximately 600 metres. In all cases, consequent impacts of flooding were visible in the areas along the rivers and in their beds.

7 Scope of damage

A scope of damage, besides the flooding from the years 1997 and 1998, were assessed particularly with regard to the origin and course of precipitation, their values, while a damage to properties was described mainly with regard to its subject with listed casualties. These records are mostly supported by a chronicler's description of these situations. The culmination state level influences a flooding damage scope. Also a rate of flow, length of flooding situation, various speeds of decrease in flooding wave and a particular season of year plays an important role.

However, the flooding from May of 1872 in the catchment area of the Berounka River from Plzen to Beroun, consequently up to the Vltava River, surpasses all other ones. It concerned a flooding repeated once a thousand years, 200 people were drowned, a fast increase in the water levels happened in the very late evening and at night from May 25 to 26.

The flooding from 1997 and its direct damage on forest management were calculated by the individual activities at the value of 1.5 billion CZK (48 364 mill. USD). The flooding in the year 1998 caused a damage in forestry at the value of 106 million CZK (3,418,000 USD).

Unfortunately it seems that 2002 floods overcome everything what ever happened before.

8 Reasons for damages

The assessment of collected and evaluated data of the last flooding situations allows finding out real and critical reasons for the origin of the extraordinary disasters. It is a huge amount of precipitation that is prominent by the fact, that the mountainous catchment areas of the Czech Republic are located in the temperate climatic zone. A daily sum of precipitation here, with a rate of repetition once every one hundred years reaches 160 mm, while this value is exceeded in the course of disasters. A professional effort of specialists to find out a connection with the similar historical flooding in the Czech Lands gives, in essence, the same results. Over-saturation of the catchment areas originated from a very substantial precipitation in a short period of time has a direct impact on the origin of disasters.

Forest environment is a dynamic system those elements has influence only within the natural boundaries. Soaking ability of forest soil, keeping waters in soil and runoffs delaying have limited possibilities with regard to time. Hydrologic measurements of occurrence, volume and culmination of damaging flooding waves have still not clearly proved relations between the disturbed forest stands, air pollution and increase in the flooding damage. Forestry-hydrologic research gradually documents that a favourable flood-control performance of forest is limited. If there is created a critically intensive rain, in addition, covering a large area, then the consequences are a result of nature.

However, this must not be a reason for not taking care of flood-control measures in the mountainous forested areas, rich for precipitation. Erosion-control measures and importance of forest for the protection of soil on the mountainous slopes are unambiguously historically verified and justified.

Secondary damages in lowland areas are usually of antropogenic origin due to non-respecting experiences, knowledge gained and sometimes also respective legislation. Also disregarding of preventive measures in relation to lack of funds can be mentioned.

9 Consequences from the state point of view

If there occurs a disturbance of the basic use of territory for the activities existing before the disaster, it is only a possibility of the state to provide assistance during the restoration of the area. As the assistance of the state after the course of disaster is financially demanding, it is the interest of the state to prevent from such states or to limit their course. A forecast service is used just only for the extreme flooding situations. There can be created a forecast for the areas at the lower parts of rivers in accordance with the news on the facts how, in the upper part of a water course, water levels are changing depending on the precipitation occurred. However, such

solution cannot be used in the mountainous terrain for a fast occurrence of a high precipitation, fast runoff from the catchment area. Such catchment areas are not, in the majority of cases, monitored and a measurement of precipitation is not performed in them. Such phenomena in the mountainous catchment areas are subject to the principles of precautionary measures with the stabilisation of the originated sediments at the place of their origin and a safe deflecting of flooding waters. For this purpose, there was established a service of torrent control in 1884 and this has been, in the Czech Lands, performed continuously till present.

10 Risk assessment

In the mountainous catchment areas, there are more frequently occurring local flooding situations repeated also in less than 10 years. Unfortunately, not only for the regional flooding situations, but also for the local flooding situations above mentioned, there has not been paid attention to the institutions ensuring flood-control protection of inhabitants and the territory. A result of this situation is that their owners recklessly situated recreational, but also housing facilities situated against the effects of flooding and erosion phenomena. On the contrary, after the disaster flooding situations, a non-professional public is negatively evaluating constructions built in the favour of public.

For a risk assessment of torrent activities, there was started a gradual elaboration of the plans of the areas endangered by the torrents. The plans include an occurrence, character, intensity, and scope of concrete dangerous states. The plans concern all catchment areas and thus also the land plots with accelerated erosion from which forest management of the catchment areas is endangered. The plans are handed over for the use by public administration and the appropriate state administration in the subject area.

11 Land use

A service body of the state for flood-control protection of the mountainous catchment areas of watercourses has been already for 120 years the service for torrent control. In these areas, the state is mostly the owner of forestland. But state influences by the direct relations of the forest management (in accordance with forest management documents – forest management plans), also the other forms of ownership. It is done, in particular, for the maintenance of quality of forests through the sustainable forest management and consequently also for the maintenance of water quality in the Czech Republic.

12 Main issues to be solved

Since the end of 40th of the last century, the torrent control service was frequently transformed with regard to their organization. There were cancelled purpose acts, the scope of measures was limited till the situation, that they were only fitfully

performed in the low parts of the catchment areas and in the built-up areas of municipalities. Prevention and measures in the upper parts of the catchment areas were not performed. In the year 1992, there was made a change and an organisational stabilisation – the activities of torrent control were included into the new Act on Forests in the year 1996, however, financing of these measures stayed completely dependent on the possibilities of the state. Prevention from damages and erosion, maintenance works for ensuring performed works functional is not sufficient yet.

The problems, i. e. organization stability and procurement of the torrent control service, a precise definition of its tasks and obligations, shared financing measures, are in the interest of the state when ensuring flood-control protection of citizens and territory. It is necessary to reach again the level, that was proved to be efficient in the past in the Czech Lands and that is currently performed in the Alpine lands. An inclusion of respective measures into the legal regulations, is an important topic as well.

Also improvement of awareness on general forestry issues, including forests important role in watershed management, and stressing the cross-sectoral responsibility for forests should be taken into account. Last but not the least, facing to the latest floods, it will be necessary again to take notice of the landscape and to respect nature laws and phenomenon, as flooding are part of it.[1] We have to understand the landscape as a «multifunctional space», both in rural areas and towns, with an important functions including ability to respond for intensive rainfalls. In the long-term perspective there is a need to defend the Earth against the climatic change. But more attention, political and particularly financial, is necessary to pay in mid-term horizon to the systematic and reasoned out measurements. It does not mean any new specific investments against floods and their effects but adaptation of all economic activities in the landscape respecting i. a. possible occurrence of floods.

Of course, a national debate on sustainable management in forestry has to include also a sustainable watershed management.

[1] Note to the just starting WSSD in Johannesburg: It seems that a sustainable life in the line with nature should be necessary to discuss, as sustainable development as such is a nonsense...

13.5 National Report France

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En France, les actions d'aménagement des bassins versants de montagne visant à lutter contre l'érosion et les risques naturels sont menés depuis plus d'un siècle dans le cadre de la Restauration des Terrains en Montagne (RTM).

Les actions publiques de prévention des risques naturels en montagne dépassent cependant largement le cadre strict de la RTM pour trois raisons:

- l'approche française d'aménagement des bassins versants est celle de la multi-fonctionnalité, dans une optique de gestion durable; la régulation des phénomènes naturels dans les territoires générateurs s'intègre donc aux autres fonctions, notamment en matière forestière,
- la prévention des risques naturels implique différents départements ministériels de l'Etat et les collectivités territoriales, dans un dispositif législatif et un contexte de décentralisation et de recherche de responsabilité qui ont beaucoup évolués au cours des quinze dernières années,
- la nécessité de conjuguer l'aménagement des hauts bassins avec des actions adaptées à la diversité des situations: dispositifs de protection rapprochée des enjeux existants situés à l'aval (habitations, voies de communication...), actions d'information préventive et de sensibilisation, prise en compte des risques dans l'urbanisme, dispositifs d'alerte et mesures de police, etc …

Le présent rapport présente les événements naturels marquants survenus dans la montagne française depuis la 22^{e} session du groupe de travail et l'évolution du dispositif institutionnel. Il aborde ensuite les actions menées dans le cadre de la RTM, domaine privilégié de la politique de prévention dans les bassins versants de montagne.

1 Les phénomènes naturels en 2000 et 2001

La montagne française n'a pas été touchée en 2000 et 2001 par des épisodes majeurs par leur ampleur et le nombre de victimes, comme cela avait été le cas en 1999 avant la 21ème session. Cela n'a pas été le cas de tous les pays.

Ce constat ne vaut que pour la montagne et la période citée, car on pourrait aussi citer les graves inondations du printemps 2001 dans le nord du pays (bassin de la Somme), les crues torrentielles des 8/9 septembre 2002 issues des montagnes cévenoles dans le sud (20 morts à ce jour), ou dans le domaine technologique l'explosion le 21/9/2001 d'une usine chimique à Toulouse (30 morts), près du lieu de notre précédente session.

Cette absence de catastrophes ne signifie pas que la montagne soit restée inactive, puisque plusieurs centaines d'événements aux conséquences notables, souvent localisés, ont été répertoriés par le service RTM en 2000 et 2001.

Nombre d'entre eux (une quarantaine par an) ont conduit à une déclaration de l'état de catastrophe naturelle permettant l'indemnisation des victimes.

Parmi ces événements, on relèvera par exemple:
- le débordement de nombreux cours d'eau et la réactivation ou l'apparition de glissements de terrain dans les Alpes du Sud au printemps et à l'automne 2000.
- une série de glissements de terrain (2 morts) et de chutes de blocs en Savoie et en Isère en fin d'hiver 2001,
- une crue devenue de référence dans la partie est des Hautes-Pyrénées, en juillet 2001 concernant 27 communes.

L'observation et la consignation des événements est importante pour les actions de prévention. En 2001, le Ministère chargé de l'Environnement a initié deux actions de rénovation de ces observations dans des bases de données nationales:
- l'enquête permanente des avalanches,
- les événements sur les risques montagne avec un objectif de dépouillement des sources diverses d'archives.

2 Aspects institutionnels

On ne développera pas ici les principales dispositions législatives servant de cadre à l'action publique: loi créant la Restauration des Terrains en Montagne (1882), loi sur l'indemnisation des victimes des catastrophes naturelles (1982), loi «montagne» (1985), loi sur la sécurité civile (1987), loi sur l'environnement (1995) instituant les Plans de Prévention des Risques naturels prévisibles (PPR, se substituant à des dispositions antérieures) et instaurant l'expropriation des biens menacés par un risque majeur imminent.

Une nouvelle loi sur l'aménagement et le développement du territoire a par ailleurs été adoptée (1999), favourisant une politique de massifs et de «pays» et instituant notamment un «schéma de services des espaces naturels et ruraux» où la dimension risque est prise en compte.

Toutes ces dispositions ont été reprises dans un «Code de l'Environnement» établi en 2000 comme l'avait été en son temps le «Code Forestier» et le «Code Rural», qui font l'objet de mises à jour régulières.

La préparation d'une loi d'orientation forestière, évoquée lors de la 22ème session du groupe de travail, s'est conclue par un vote à l'unanimité du parlement français le 9 juillet 2001. Elle introduit dans le cadre législatif la notion de «gestion durable» en accentuant le caractère d'intérêt général de la forêt, et harmonise différentes réglementations forestières et environnementales.

Pour ce qui concerne la prévention des risques naturels en montagne, deux nouveaux articles législatifs spécifiques traitent de la prise en compte des peuplements

forestiers dans l'élaboration des Plans de Prévention des Risques, et des aides aux collectivités pour les travaux de protection dans les bassins versants.

Plusieurs points, relatifs à la mise en œuvre de cette politique, peuvent être soulignés:

- la mise en œuvre de contrats de plans entre l'Etat et les Régions et de conventions interrégionales par massif de montagne, entre ces mêmes partenaires; ces documents définissent les actions et les moyens pour la période 2000–2007; ils s'accompagnent dans certaines Régions de programmes soutenus par l'Union Européenne
- la définition d'une stratégie forestière nationale qui s'est traduite par la signature entre l'Etat et l'Office National des Forêts d'un contrat pluriannuel fin 2001, et par une redéfinition des aides de l'Etat (les actions RTM en constituant un des aspects).
- le développement de la prise en compte des risques dans l'utilisation du territoire, sous l'impulsion du Ministère de l'Ecologie et du Développement Durable, et en raison de la prise de conscience croissante par les différents acteurs de leurs responsabilités face aux risques naturels.

3 La prévention des risques naturels par les actions de restauration des terrains en montagne (rtm)

Cette politique se concrétise dans trois domaines:

➢ **la connaissance des phénomènes et leur prise en compte dans l'aménagement de la montagne**

La connaissance des sites et des phénomènes, engagée de longue date, s'enrichit de l'observation permanente de ceux-ci. Elle permet toutes les expertises nécessaires à l'exercice des responsabilités publiques, et débouche sur les actions d'information préventive des populations et de cartographie réglementaire des risques spécifiques à la montagne.

Dans les départements de montagne des Alpes et des Pyrénées, le service RTM est un acteur déterminant de la politique d'affichage du risque de l'Etat; des Plans de Prévention des Risques sont par exemple entrés en vigueur dans 28 nouvelles communes de montagne en 2000 et 43 en 2001, ce qui traduit une montée en puissance par rapport à la période précédente (35 communes au total en 1998 et 1999).

➢ **la gestion patrimoniale des territoires de montagne**

La sécurité des personnes et des biens dépend en grande partie de la qualité d'entretien du milieu; c'est particulièrement le cas des forêts de montagne, dont 3 millions d'hectares sont publiques et gérées par l'Office National des Forêts.

Parmi ceux-ci, les terrains domaniaux RTM où le budget de l'Etat a consacré 9 M€ en 2000 et 12 M€ en 2001 pour des travaux spécialisés, principalement des ouvrages de correction (entretien et ouvrages nouveaux) et dont les 2/3 environ concernent les torrents; l'accent a été mis sur l'entretien des ouvrages existants, souvent très anciens.

A ce montant s'est ajouté 2,6 M€/an d'opérations d'entretien et de renouvellement des peuplements domaniaux jouant un rôle marqué de protection (190 000 ha), provenant du budget de l'O.N.F.

Malgré la difficile conjoncture financière, conséquence des tempêtes de décembre 1999 qui ont bouleversé l'économie forestière nationale (140 millions de m^3 de chablis), l'effort conjoint de l'Etat et de l'ONF pour les actions forestières de protection dans les Alpes et les Pyrénées, massifs pourtant épargnés par ces tempêtes, s'est accru.

- **les travaux de protection menés par les collectivités locales**

Qu'ils soient actifs (correction à la source) ou dans la majorité des cas passifs (protection rapprochée des enjeux sensibles), ces travaux spécialisés sont destinés à améliorer la sécurité des personnes et des biens à l'aval.

Dans le domaine de la RTM, les collectivités ont réalisé 13,6 M€ de travaux en 2000 et 13,8 M€ en 2001. Ils se répartissent en travaux torrentiels (64%), paravalanches (16%) et contre les instabilités de versant (26%); des aides financières aux communes maîtres d'ouvrages sont apportées par l'Etat (qui ont globalement représenté 15% du coût pendant la période), l'Union Européenne (3%), les Régions (15%) et des Départements (7%)

Les aides du Ministère chargé des forêts se sont recentrés sur les actions spécifiques à la gestion des bassins versants par régulation ou correction des phénomènes naturels (protection active), les autres partenaires financiers intervenant davantage sur les travaux de protection rapprochée.

13.6 National Report Norway

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1 Natural phenomena and catastrophes

There has not been a major catastrophe or natural disaster in any part of Norway since the flood of 1995.

2 Relevant legislation and policies in the management of mountain watersheds

A growing commitment to sustainable development is giving rise in many European countries to the review and reform of systems and policies of land use planning and use of resources. Norway is one of many countries engaged in reviewing and re-forming regional planning systems and policies in an effort to achieve sustainable development. Some of the steps which have been taken to incorporate sustainability into the use of land and water resources are the following:

2.1 The New Water Resources Act

The new Water Resources Act was brought into force on January 1, 2001 and replaced the old Watercourses Act from 1940.

The new law represents a major simplification of existing legislation from both a legal and linguistic standpoint. In addition, the new Water Resources Act has implied changes in 17 other laws and has emphasized the need to reduce bureaucracy. The new law is aimed at solving the problems of multi-use of water resources and emphasizes the need for biodiversity and sustainable development. It is also aimed at achieving a comprehensive view of the resources and at balancing development and recreational activity with environmental sustainability.

The law's main features include:
- Strengthening the public interest
- Revaluation of environmental interests
- Tougher sanctions for violations

2.2 Review and Revision of the Planning and Building Act

The committee charged with rewriting the Planning and Building Act was established by the government in 1998. It's mandate emphasizes environmentally friendly urban and rural development as pertains to such elements as adequate supply of housing, open-air activities, protection of cultural relics etc.

At the same time, the government intends to retain the present regulations which ensure local participation, the opportunity to register complains and above all a democratic, decentralized decision-making process.

2.3 Review and Revision of the Forest Act

The Forest Act provides the main legal basis for work carried out by forest owners and supervised by the local Forest Service. The Act aims to promote forest production, afforestation and forest protection. A basic principle is that the forest owner should be free to manage his forest without interference from the authorities as long as he observes the principle of sound forestry practice. The Act provides the Forest Service with authority to intervene in cases of poor management. Public involvement and co-operation in the planning and operation of forest activities is insignificant.

The ongoing reversion of the Forest Act does not seem to have affected the basic principle of freedom for forest owners to manage their forests responsibly.

Certification of forestry through the forest owners association constitutes the most important basis for forest activities today. For the forest owner this means that he has to be a member to be allowed to cut the forest and deliver timber. And he has to comply with the rules of certification, which means he must manage the forest in a sustainable and environmentally sound way. To enable him to do so, he has to make an environmental investigation of his forest and comply with it in future forestry activities.

As forestry and watershed management are interrelated businesses, Norway is endeavouring to get the relevant national sector authorities to improve their co-operation. An important reason for this is that forestry is a key commercial industry, which for a long time has been operating without much interference from others.

3 Public action and awareness raising

Increased growth of aquatic vegetation has taken place in several Norwegian watercourses regulated for hydropower. In certain rivers, mainly in the coastal areas of southern and western Norway there have been severe nuisance problems with the excessive growth of *Juncus supinus* Moench, leading to the formation of thick vegetation mats, clogging waterways and rendering them unsuitable for recreational activities such as boating, fishing and bathing. In additional such growth is unsightly, lowering the aesthetic value of the riverine landscape. Many of the affected rivers have suffered from acidification, but with extensive liming programs, fish including Atlantic salmon and sea trout have returned to many of the rivers. There are several factors that may explain the increase in *J. supinus*, including river regulation, liming and climate change. River regulation for hydropower, resulting in reduced discharge and a lower frequency or even absence of major floods, appears to be one of the main causes (Johansen *et al.*, 2000). However, the causal relationship is complicated and studies have been started to clarify the role of discharge regime. In addition, flushing trials have been undertaken. In such trials, undertaken during winter, discharge is severely reduced in order to expose the macrophytes to subzero temperatures. This is followed by a rapid increase in discharge to flush the

macrophyte growth out of the system. The program is funding such a trial in early 2002. Removal and harvesting of *J. supinus* has also been employed.

4 Research

4.1 Licensing of projects and instream flows

Allocation of instream flows is paramount in the licensing procedure of watercourse encroachments. The determination of instream flows is an area in which management has to make decisions on a daily basis with respect to new licenses, renewal of old licenses and in response to the Water Resources Act, brought into force 1 January 2001.

The European Union Water Framework Directive has been adopted by Norway. The Directive has clearly defined environmental standards and water quality must be defined according to ecological criteria. Discharge to a large extent determines the nature and development of the freshwater ecosystem and thus is of importance in the field of instream flows.

Traditionally the concept of minimum flows has been used as the flow below which the regulator is not allowed to go below. However, not least internationally, this concept has been shown to be inadequate. Environmentally based flexible instream flows are more in tune with modern sustainable watercourse management.

In order to meet the challenge of sustainable watercourse management and address the problem encountered in the licensing procedures, the Norwegian Water Resources and Energy Directorate (NVE) has initiated a five year R & D program on environmental instream flows. The objective of the program is to increase knowledge of the effects of strongly reduced discharge in order to form the basis for development of appropriate methods that will enable management to set ecologically sound instream flow

4.2 The Norwegian Environmental Flows Programme

There are several considerations that must be evaluated when setting environmental flows. These include energy production, pollution, ice problems, sediment transport and erosion, aesthetics and biology/ecology. At present there are certain areas where there is an urgent need for improving our practical knowledge of the consequences of reduced flows in regulated watercourses. These will form the focus of the Environmental Flows Programme. The program will involve extensive cooperation within NVE and between NVE and those involved in hydropower regulation, including other government agencies, power companies, research institutes and universities. The program started with limited funding in 2001 and has a preliminary 5-year time frame, although the complexity of the topic and the necessity for long-term studies, may necessitate an extension for a further 5 years.

13.7 National Report Poland

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1 Basic data

Territories located over 300–350 m above sea level are classified in Poland as mountainous areas. They are divided into foothills (300–500m) and mountains (over 500 m). Mountainous areas contribute 8.9% of the total land of Poland (Fig.1), and to 30% of the water resources, mainly rivers.

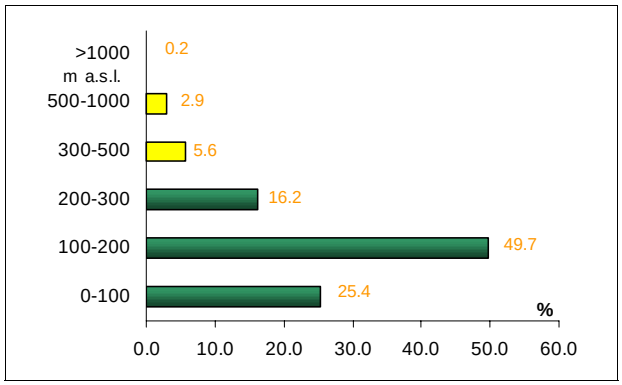


Figure 1:
Percentage participation of area with different altitude in Poland.

Mountains regions are located (Fig.2) in the Carpathians (20'000 km^2), Sudeten (5'000 km^2) and the Gory Swietokrzyskie mountains (2'800 km^2).



Figure 2:
Locality of Polish part of the Carpathians, the Sudeten, the Gory Swietokrzyskie Mnts and national parks.

Foothills extend in the Carpathians more than 60% of area, in the Sudeten 57% and in the Gory Swietokrzyskie Mts about 95%. These regions play also an important role for health and recreation of people, but in the past, this small area size, in spite of unusually significant functions for the whole country, was one of the reasons why the role of Polish mountains was underestimated. In the last years this situation changed due to enlargement of the protected area in Poland. Presently there are 23 national parks in Poland. and they cover about 1% of the country area (3144 km^2). Apart of national parks there are 109 landscape parks (21880 km^2), 392 areas of protected landscape (68210 km^2) and 1204 natural reservations -1300 km^2 (Fig.3).

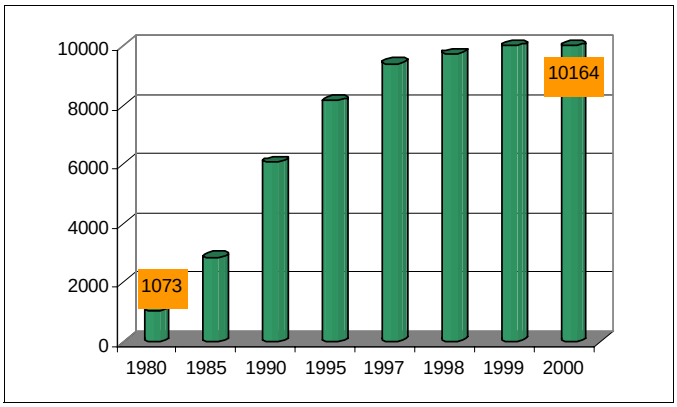


Figure 3:
Area under low protection in Poland [thousands of ha].

At present almost all mountain forests are under protection: from the passive protection in national parks and many nature reserves through the active protection to forests protecting soil, water and landscape. Nine of national parks have been established in Polish mountains. They cover about 102 000 ha and their forestage is estimated on 87%. Forestage of mountainous areas depends from altitude and range in the Carpathians from 26% at altitude 500 m to 74% above 1000 m, in the Sudeten from 22% to 97% above 800 m a.s.l. and it reaches 37% in the Gory Swietokrzyskie Mts.

Public forests in Poland take area of about 83% and the rest belongs to private owners. For all mountain forests these values are 79% and 21% respectively. The majority of Polish people accepts this proportion for better protection and keeping multifunctional character of forest areas, particularly in the mountain conditions. However in some areas private forests occupy much more, even up to 75% forest area and are of great importance to local societies. About 1.03 ha of private forest belongs to one owner on the average, and this is one of the lowest indices if compared with other European countries. In mountains forests this figure is still lower. It has negative influence on the degree of the owners interest in the proper management of forest economy in their own forest. The area of mountain forests that belong to different owners is shown in table 1.

Table 1: Property relations of mountain forests in Poland, (GUS 2001) [thousands of ha].

		Public forests				Private forests
		State treasury			Communal forests	
		State Forests	National Parks	Agency of Agriculture		
Poland		6953 79.0%	181 2.1%	66 0.7%	79 0.9%	1523 17.3%
Mountain forests	in Poland	650 9,3%	87 45,5%	-	20 27,8%	200 12,6%
	in mountains	66,9%	10,5%	-	2,0%	20,6%

Mountain forests in Poland are estimated to cover some 960 000 ha and this quantity depends on altitude criteria for lowlands and mountains. This area is growing gradually in connection with the execution of the National Program of Forest Cover Increase. Climate, soils, vegetation and socio-economic conditions made mountain forests a very diversified habitat. Composition of stands is largely modified from natural conditions. Nevertheless, some parts of Polish mountain forests are considered as primary. Stand volume about 250 m^3/ha is about 25% higher than the average at the national level.

2 Threats and harmful events in mountain forests

Three main factors decided about present condition of forests in the Polish mountains:

- Air pollution,
- Climate changes with anomalous weather conditions,
- Silviculture in the past.

Effects of atmospheric pollution, among others from neighboring countries, are heavy in consequences for the Polish forests and for mountain forests in particular. The situation in the Polish Carpathians is decisively more favourable than that in the Sudeten, especially because of the lower level of pollution and more fertile forest sites. The process of degradation of upper mountain spruce stands is stronger in the stands of artificial origin, which are not genetically adjusted to the conditions of the upper mountain zone. In recent years slight decrease in the value of mean indicator SO2 and dust in mountainous areas have been recorded.

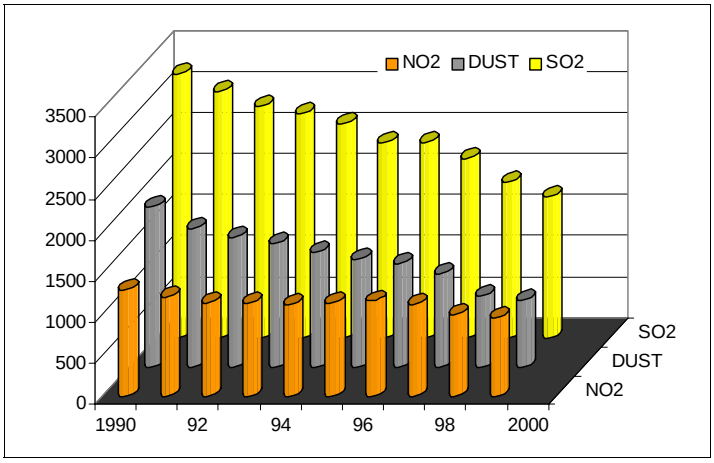


Figure 4:
Changes in air pollution in mountainous areas – thousands of tons (GUS 2001).

Air pollution was a main reason of the ecological disaster in Sudeten that started at the end of the seventies. An area of more then 160 sq. km was deforested. Afforestation of this area was a great success of the foresters. In the recent years the condition of trees, artificial and natural regenerations improved much, and it is undoubtedly due to limitation of pollution emission to the atmosphere.

The second reason of harmful events in mountain forests is severe and intense climatic conditions. Poland is located in the temperate zone with a climate characterized as quite variable in time and space. The climatic data from individual years demonstrate large deviation from the average long-term value, which contributes to occurrence of weather anomalies. Measurement results of temperature and rainfall on mountain meteorological station in Poland by last fifty years confirm that. The average temperatures increased by around one degree and precipitation decreased by some 100 mm in the last 50 years. In spite of the decrease in yearly sum of rainfall, extremely high rainfalls were noticed in summer months in a short period of few days, and that led to catastrophic floods.

The predicted climate changes will lead to further worsening of growth conditions of existing mountain spruce stands. In July 1997 due to a heavy rain a great flood occurred, that covered the whole Odra and the upper Vistula river watershed. The tide had a rainfall-overflooding character, disastrous, of all country reach. In 2001 flood waves occurred again, but in upper Vistula river watershed this time. Relatively small flood losses in upper Vistula watershed in 1997 and 2001 was due to new water reservoir in Czorsztyn (Fig. 5) with capacity of 235 mln m^3. Construction of this reservoir was finished just before flooding wave in 1997.



Figure 5:
Water reservoir in
Czorsztyn.

Another important for these region reservoir (Swinna Poreba – capacity 161 mln3) in Skawa watershed is still (since 1986) under construction.

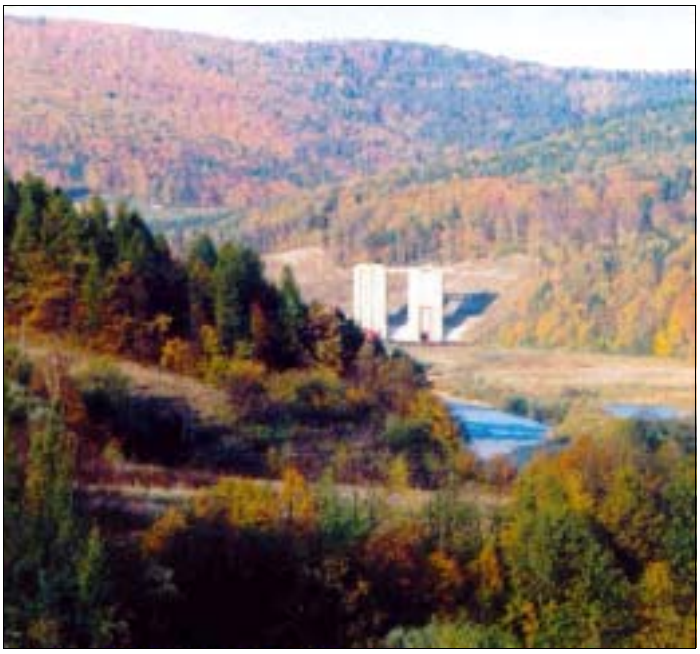




Figure 6: Water reservoir (Swinna Poreba – capacity 161 mln3) in Skawa watershed – since 1986 under construction.

The species composition of stands in Polish forests significantly differs from the primeval (natural) because of centuries of improper management (monoculture plantations, lack of natural tree regeneration, and the type of cutting system). In the Polish part of the Sudeten the coniferous sites occupy 46% of forest area but the current percentage of spruce stands area is about 78%. In the Polish part of the Carpathians the coniferous sites occupy only about 3% but the average percentage of coniferous stands reaches almost 64% of forest area.

Table 2: Deformation of species composition of mountain forests in Poland.

Sites and species	Sudeten (%)	Carpathians (%)
Coniferous sites	46	3
Rich sites	54	97
Coniferous species	78	64
Deciduous species	22	36

Deformation of species composition of mountain forests is much worse in higher altitudes, where slopes are steeper and where erosion processes are stronger. The lack of conformity of stands with forest sites has got a negative influence on vitality of trees, susceptibility to insects, fungi, wind, state of plants communities and consequently on water retention. Presently the main species of insect pests in mountain forests in Poland are: Ips typographus, Ips amitinus, Polygraphus poligraphus, Pityogenes chalcographus, Lymantria monacha, Pristiphora abietina, Zeiraphera diniana and Cephalcia sp. Heterobasidion annosus and Armillaria sp. are the most dangerous pathogens causing disease of the root system. The honey fungus disease is spreading and it has affected 50 000 ha of forests in the Polish part of the Carpathians. Damages caused by game are also important in mountain areas. Natural and artificial regenerations are in some cases affected up to 80%.

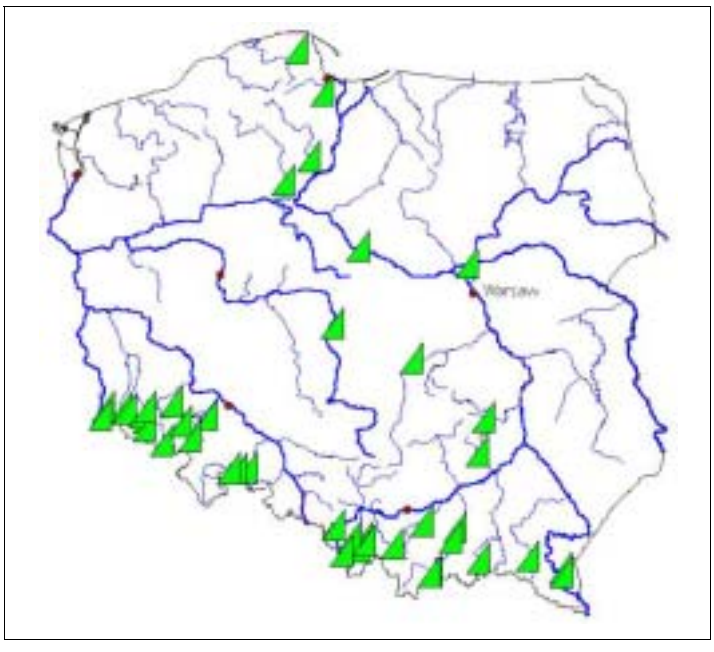


Figure 7:
Location of the biggest dams in Poland.

Summarizing, for better natural water retention and in order to limit erosion processes in mountain forest watersheds in Poland, the improvement of forest ecosystems quality is necessary. This can be achieved by optimization for mountain forests management in connection with consistent decreasing of air pollution and naturalization of forest ecosystems, first of all by acceleration of naturalization species composition of stands adapted to mountain forest sites and changing climatic conditions.

3 Legislation

During the last period many of important documents and acts connected with forest and water management were elaborated and adopted in Poland. Most of them was elaborated in the frame of the accession procedure of Poland to European Union. To the most important are:

- Programme of Conservation of Forest Gene Resources and Selection Breeding of Forest Trees (1993). That program defined the basis for conservation of forest gene resources, improvement of the seed base and selection of forest trees. The Bank of Genes in Kostrzyca (Sudeten) was established for all Polish forests in the frame of that program.
- «Guidelines on the improvement of forest management based on sustainability principles» (1995). The document recommends to introducing in Forest Promotional Complexes and furthering also in the rest of forest organizational units, the actions towards:
  - protection and reconstruction of water regimes, water and wetland biotopes and biocenoses, and co-operation with country planners in this respect;
  - development of enriched forest ecotones;
  - restriction of the size of clear-cuts;
  - enrichment of species, age, and spatial structure of forest stands;
  - preferences to natural methods of forest protection.
  - The Guidelines specify detailed principles regarding the protection of forest genetic resources, silviculture, forest protection and management.

3.1 National Programme for Expansion of Forest Cover (1995)

The country's forest cover increased from 20,8% in 1945 to 28,2% in 1995. According to mentioned document forest cover in Poland should increase to about 30% by the 2000 and 33% by 2050. An important area for an in forest cover is constituted by the Sudeten and Carpathian Natural Regions which are characterized by relief and structure unwanted to agriculture as by vitally important function of forestry in the protection of water and soils. In mountainous areas used agriculturally, the planting of trees should augment forests, above all in the prevention of surface runoff and the erosion of soils by water. In areas of the foothills with intensive agricultural utilization, such plantations will have to fully replace forests in the fulfilling of both the above functions and in the limitation of wind erosion. Particularly intensive planting of the landscape is called for in areas with the greatest air

pollution (such as the voiovodeships of Katowice, Kraków, Bielsko-Biala and Jelenia Góra).

3.2 National Policy on Forest (1997)

On April 1997 the Polish Government adopted the National Policy on Forests – the document, in which aims and trends of development of forestry for the XXI century had been included. According to this document the forest law respects strategy of sustainable development and importance of ecological, economic and social functions of forest. The methods of forestry management should take account of the specific natural, economic and social conditions in which they will be implemented and should be in harmony with the ecological and social functions of forests. Until 1992 a forest law referred separately to private property forests. According to it State Forests Organization Units were obliged to perform the entire range of activities connected with supervision, control and forest works in private forests. The main idea behind the new forest policy is that the subjects of the policy are forests under all forms of ownership and their functions. Other subjects of this policy are the aims and the principles of forest management and the links between forestry and society and other divisions of the national economy. Thus, according to a new forest law, each forest owner is obliged above all to manage forest strictly following principal rules, that is: sustainability, common forest protection and enlargement of forest resources. The law of course accepts and respects the ownership rights of owners to owned forest. According to the National Policy on Forests the safeguarding of the permanence of forests along with their multifunctionality, will be achieved by:

- increasing the country's forest resources,
- improving the state of forest resources and providing them with comprehensive
- protection,
- reorienting forest management away from the previous domination of the raw-material
- model towards a pro-ecological and economically balanced model of multifunctional
- forest management,
- participation of Poland in dialogue devoted to the formulation of global principles of sustainable forestry management.

Current activities of the Ministry of Environment concentrate on the supplementing the National Policy on Forest by Regional Operational Programmes.

3.3 Water Act (2001)

Since 1974 the new Water Act and the draft Act on Water Supply and Sewage Management shall ensure full adjustment to EU's water management and water protection requirements against pollution, including drainage system, monitoring of surface and underground waters, water and sewage analysis, water protection against agricultural nitrate, standards for drinking, household and fish keeping

water, standards for acceptable discharge of sewage in waters and sewage system, including unit raw material or product ratios, procedures for issuance of water permits and regulations concerning off-the-system sewage disposal on poorly populated areas.

4 Conclusions

1. The mountain forests in Poland are under permanent threat of:
   - air pollution, which stimulates acidification of soils and toxic action on organisms,
   - climate changes with anomalous weather conditions resulted between others in floods, soil erosion and landslides,
   - the occurrence of pests.
   - The biggest harmful events in polish mountains in the last period happened:
   - in the eighties in the Western Sudeten, when 160 km^2 was deforested,
   - in 1997 when the great flood, which covered the whole Odra and upper Vistula river watersheds,
   - in 2001 when a great flood occurred mainly in upper Vistula river watershed.

2. The hydrological research proved that due to deforestation the increase of annual sums of runoffs from Sudeten catchments reached 15- 35%. Changes in water cycle in Sudeten influenced on the size of great flood which happened in 1997 in whole Odra river watershed. Relatively small flood losses in upper Vistula watershed in 1997 and 2001 were caused between others by better condition of forests and new water reservoir in Czorsztyn with capacity of 235 mln m^3.

3. For better natural water retention and in order to limit floods and erosion processes in mountain forest watersheds in Poland, the improvement of quality of forest ecosystems is necessary. This can be achieved by further decreasing of air pollution and by elaborating long time climatic forecasts which can facilitate acceleration of naturalization species composition of stands adapted to mountain forest sites and changing climatic condition.

4. Sustainable development of mountain regions depends in great measure on technical infrastructure as well as on economic and social situation of particular provinces and villages. In mountainous villages, particularly in those situated relatively high, technical infrastructure is very poor, considerably poorer than in the rest of the country. The further development of mountain region is greatly conditioned by the changes in the infrastructure. It is one of basic direction for future management of mountain forest watersheds.

5. One of the most important priorities of the mountain forest watersheds management in Poland is the inclusion of private forests into ecologization process and afforestation part of post agriculture areas, predicted in the National Program of Forest Cover Increase.

6. In 1994 twelve Forest Promotional Complexes were established in order to pay particular attention to conservation of nature under conditions of realization of sustainable development policy. Two of such complexes are located in the Carpathians, but one more should be established in the Sudeten forests, and not only from the watershed management point of view.

7 The current Poland's policy for forests pays particular heed to provisions of the State Environmental Policy enacted by Parliament in 1991 and to their amendments in 2000. It is also in accordance with international acts that set out guidelines for sustainable forest management and ushered in the process of establishing criteria and indicators such as the Forestry Principles and Agenda 21, the European Declarations of Forestry Ministers on the Protection of Forests (Strasbourg 1990 and Helsinki 1993), and to the National Policy on Forests from 1997. The latter document is the synthesis of the above mentioned documents adopted to Polish conditions.

8. According to the National Policy on Forests the safeguarding of the permanence of forests along with their multifunctionality, will be achieved by:
   - increasing the country's forest resources,
   - improving the state of forest resources and providing them with comprehensive
   - protection,
   - reorienting forest management away from the previous domination of the raw-material
   - model towards a pro-ecological and economically balanced model of multifunctional
   - forest management that corresponds with criteria formulated for Europe by the
   - Helsinki process and takes account of the specifics of Polish forestry.

13.8 National Report Spain

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The orographic, climatic and lithologic conditions of the Spanish territory, added to some human activities over soil and vegetation cover, causes soil erosion processes in a great part of the land, as well as torrential phenomena all along the hydrographic network, which under climatic aridity become part of a larger desertification process. That is to say, natural resources general degradation in such conditions of ecological stress, makes its restoration a quite difficult task to achieve.

All those reasons involve high environmental, social and economic repercussions, like biological potential and soil productivity losses, spates and floods, earthing up reservoirs, water quality loss, and etcetera.

The forest-hydrologic restoration, erosion control and combating desertification actions, has been carried out in Spain organisedly and systematically since in 1901 the forest-hydrologic divisions were created, and up to nowadays. Today, most of those actions develop in the framework of the Central Administration and Autonomous Communities Agreement, with the support of the European co-finance. However, there has never been a national planning instrument to be the general framework for the aforementioned actions, a lack to be overcome with this Plan.

The necessity of planning correctly these actions, so as to carry out as best as it could theirs objectives (soil protection, hydrologic control and natural resources sustainable management) applying them to each project unit and giving priorities according to the difficulties and the real possibility of implementation, drove the Ministry of Environment to write the «National Plan of Priority Actions in Forest-Hydrologic Restoration, Erosion Control and Combating Desertification». The following characteristics are the most remarkable ones, and those who give the Plan especial importance within the Spanish forest planning framework:

- It has been worked out using an exhaustive field works database, each of them works involving the visit to every proposed action area.
- It has been carried out under the General Directorate on Nature Conservation (GDNC) co-ordination with the various Autonomous Communities collaboration, who have identified the different action areas by virtue of its territory deep knowledge and its experience in this kind of works implementation.
- When giving priority to each action, it was taken into account the real possibility of a short or long-dated implementation, due to the availability of the land, its technical definition and the existence or non existence of any kind of environmental, social, economic or technical obstacle.
- The Plan includes an economic estimation of them all proposed actions.
- It has been always taken into account the relation of this Plan with other national planning instruments, particularly the *National Action Programme to Combat Desertification*, the Spanish Forestry Strategy, the *National Hydrological and Forestry Restoration Plan* and the *Basins Hydrological Plans.* In addition to this, the Plan has been attached to the Spanish Forestry Plan as an enclosed document.

1 General information

1.1 Introduction

The 1415/2000 Royal Decree of 21st of July, by whom the organic basic structure of the Ministry of Environmental is developed, confers the General Directorate on Nature Conservation competencies in the making of planning and programs about hydrological and forestry restoration, afforestation, vegetation cover improvement and conservation and biodiversity management of the protecting forest ecosystems of the various Autonomous Communities shared basins, as well as all the actions they may involve.

Following the criteria established in the Plan, it must serve as an instrument to carry out the financed investments of the Ministry of Environmental over these restoration matters.

1.2 Objectives

The actions proposed for the hydrographic basins restoration and management included in the Plan, has been selected in order to carry out the following generic objectives:

- Erosion control
- Control and improvement of the hydrologic system and flows
- Protective vegetation cover improvement, conservation and restoration

Out from these generic objectives emerge a set of particular objectives, being the most remarkable ones as follows:

- Quality of the surface water protection and restoration
- Soil recovery and protection
- Vegetation and biodiversity restoration
- Recovery of the natural hydrological control facility
- Torrential strem bed plugging
- Improvement of the aquifers natural reloading
- Overflows protection supporting
- Protection of reservoirs and other hydraulic structure works

1.3 Criteria for the selection of the action areas

To be included in the National Plan of Priority Actions, the proposals must carry out the following terms:

- They must be contained in a certain geographical framework: one or more adjoining hidrographical sub-basins
- They must submit enough amount of actions within its geographical scope, so as to obtain an important improvement over the National Environment, as well as an important repercussion over the socio-economic circumstances of the generally poor regions.

- The objective must be the resolution of the fixed difficulties of national significance: soil erosion, torrential spates and floods, related problems with the water quality and its management, as well as other significant desertification processes, etc.
- There must be an agreement between the Public Administrations
- They must include actions as the following:
- Vegetation cover improvement, conservation and restoration
- Strem bed of the secondary natural drainage network plugging works
- Soil conservation practices
- Auxiliary actions (access dirt road, fire lane, etc)
- Actions intended to obtain the lands availability
- Projects writing and checking (technical assistance)
- They must include actions preferably set on the top of the watershed and /or on the river bank and strem bed of the secondary natural drainage network.
- They must have a clearly significant environmental and socio-economic consequence.

2 Methodology

The work **first phase** was about the *compilation* of the necessary national cartography and information: hydrographical division, erosive state maps, overflowing risk areas, land use, property regime, reservoirs, establishment of different zones due to its desertification risks (GDNC), the National Hydrological and Forestry Restoration Plan, 1st and 2nd phases (GDNC), *Basins Hydrologic Plans (Hydrographic Leagues), etc.*

With such information it was attempted a pre-selection of those sub-basin with a priority action, and it was sent to the Autonomous Communities and Hydrographical Leagues to be studied.

In order to qualify each sub-basin according to both characteristics, the following two index were calculated:
- soil loss priority basic index
- difficulties for overflowing damages index

Joining both criteria emerged the *Compound Priority Index (Cpi),* which established five priority levels: EXTREME, VERY HIGH, HIGH, MEDIUM AND LOW, finally making a pre-selection of those classified in the three upper levels.

The **second phase** of the work was about the contact making between the various Autonomous Communities in order to study each one of their specific proposals, so as to correct and/or enlarge the initial selection. Lately, it was attempted to obtain information about such proposals:
- Geographical delimitation: sub-basins
- Existing difficulties and main objectives
- Actions to be implemented

- Technical definition or previous planning of such actions.
- Actions economic valuation
- Lands availability
- Environmental and socio-economics consequences

The **third phase** was about the whole information synthesis and final proposal writing with the definition and valuation of each sub-basin actions. The data that were used come from either non implemented but written already existing projects or directly from the Autonomous Communities information or from an estimation of the critical areas surface (which were involved in serious erosion processes)

In the **fourth phase**, the field works, every proposed area was visited. The aim of such works was to check directly the theoretical difficulties obtained in the laboratory works in each of the selected sub-basins, so as to change if necessary the previous action proposal.

In the **last work phase** all the accepted proposals, each one with its field report, were all together examined, so as to establish a rank.

The criteria used in the assignment of the final priority to each sub-basin is the following:

- *Priority due to the difficulties:* is determined by the erosion level existing in the area; possible torrential spates and floods; water quality and its management as well as other significant desertification processes.
- *Priority due to maturity:* is determined by the technical definition existing stage, the availability of lands, technology and the necessary resources, and the possible legal, social, economic, environmental and administrative existing obstacles.

Bearing in mind both criteria, a *global final priority has been assigned to every sub-basin.* The result is a five levels ranking of priorities, from the first to the fifth, fitting the number one priority with those basins with more difficulties and a more urgent needed action.

2.1 Proposed actions

- **Vegetation cover improvement, conservation and restoration**
  - Reforestation.
  - Non arboreal vegetation cover improvement or introduction
  - Timber silvicultural treatments
  - River banks restoration.
- **Agrarian lands afforestation**
  Agricultural land afforestation (fallows, ligneous crops in steep slopes, barrens, etc.). These actions are well-favoured by subsidies established for its implementation and maintenance, as well as extra payments in return of possible incomes losses.

- **Agrarian soils conservation practices**
  The main actions in order to correct the consequences are: terraces, drainage, contourning, alive fences, etc.

- **Slope stabilization**
  Including works like soil retaining walls, drainage in order to remove the water excess that overload the slopes, fasine, vegetation covering, etc.

- **Torrential strem bed plugging**
  Transverse works:
  - Sill barriers
  - Check dam
  - Small barriers at incipient gullies and ravines

  Longitudinal works:
  - Side erosion defence works
  - Retaining slope soil creeping works
  - Floods defence works

- **Auxiliary actions to those previous mentioned in order to facilitate its implementation and/or its following maintenance.**
  - Roading improvement in those action priority areas.
  - Fire defence actions.

- **Actions designed to obtain the availability of those lands not directly managed by the Administration**

- **Technical assistance**

3 The results: basins selection and priorities setting

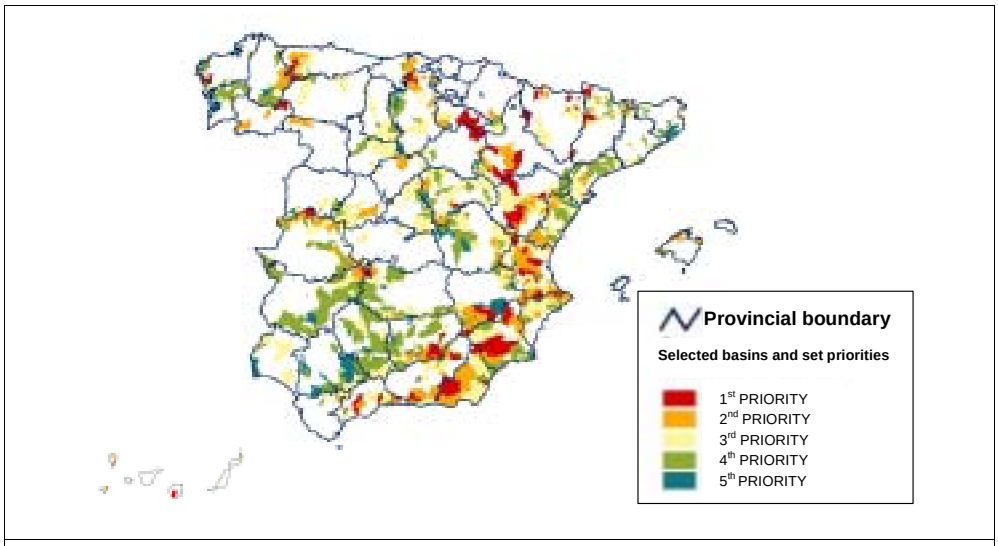


Figure 1:
Selected basins and set priorities.

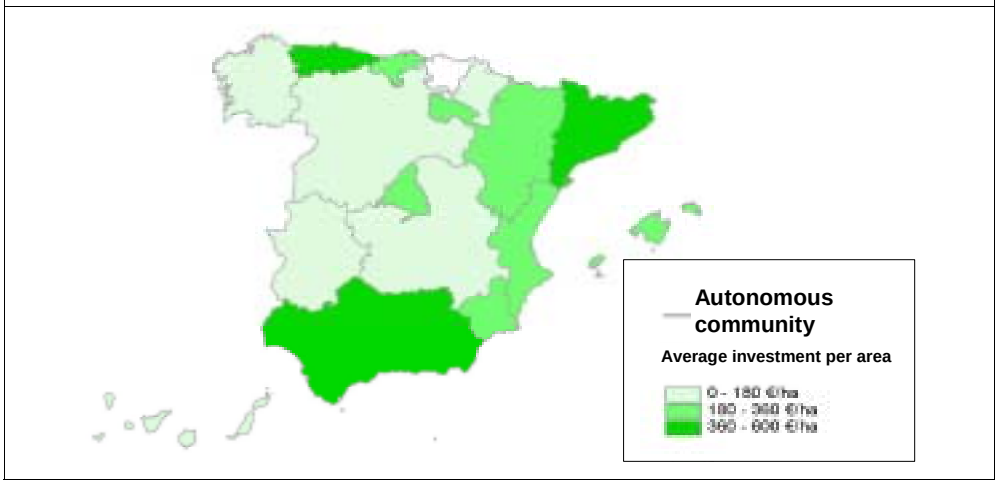


Figure 2:
Average investment per area.

4 Financing and investment program.

The investments proposed for this Plan rises up to 11.736.821 thousands of €.

According to the Ministry of Environmental foresights investments over these matters, and according to the Spanish Forestry Plan, those short-dated urgent actions, considered of possible implementation, has been programmed for the 2002–2008 period, which involves 711.005 thousands of €, being the average investment rate of 101.572 thousand € per year. Alternately specific works classified with a 2nd, or even 3rd Priority, would also be implemented.

The financing of this first 2002–2008 interval is included in the EU Structural Funds financial period. The rest of the long-dated investment has not been programmed, among other causes, because of the Plan periodical revisions, which might change the initial foresights.

13.9 National Report Switzerland

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1 Storm damage in Switzerland

1.1 Storm damage in 2000

Storm events in Switzerland in the year 2000 were mainly dominated by the floods in the cantons of Valais and Ticino of 14/15 October.(1) Representing around CHF 670 million or 92% of the total damage costs of between CHF 725 and CHF 730 million and claiming 16 of the total of 20 fatalities claimed by natural hazards that year, this event was by far the most serious. Figure 1 provides an overview of the damage caused by the floods of 14/15 October. With 16 fatalities and CHF 479 million of material damage, the canton of Valais was the area most severely affected by this event. The locations within the canton where the damage was concentrated were Gondo, Baltschieder and Stalden-Neubrück. The canton of Ticino was also affected by this storm. The water in the Lago Maggiore reached its highest level recorded since 1868. The cost of the material damage in Ticino totalled around CHF 170 million. Bordering areas in the cantons of Vaud and Bern were also affected.

Like the first map, Figure 2 shows the storm damage for all of the year 2000. Along with the October floods, the main events in that year included a few summer storms and two extended periods of precipitation in August and November.

From the point of view of storm damage, the year 2000 was an eventful year. It was in fact the third most eventful year since 1972, exceeded in severity only by the years 1987 and 1993, and followed closely by the years 1999 and 1978. The scale of financial damage in the year 2000 can thus be classified as rare but not exceptional. The average annual cost of storm damage in the monitoring period of 1970–2000 (without taking inflation into account) was approximately CHF 215 million.

The year 2000 was also exceptional on account of the high number of fatalities; a total of 20 lives were lost. Excluding 1999 when 21 of a total of 25 fatalities arose in canyoning accidents, we have to go back as far as the early 20th century to find a year in which there was a similarly high number of fatalities.

The following tables provide information about the causes (Table 1) and nature (Table 2) of the damage suffered.

Table 1: Causes of damage in the 40 storm events in the year 2000.

	Number of Events			
	minor	average	major	total
Storms and torrential rain	15	5	2	22
Extended periods of rain	1	2	3	6
Snow melt and rain	3	-	-	3
Unknown cause and other reasons	9	-	-	9
Total	28	7	5	40

Table 2: Types of damage caused in the 40 storm events in the year 2000.

	Number of Events			
	minor	average	major	total
Damage caused by water	11	3	1	15
Damage caused by loose material	14	-	-	14
Damage caused by water and loose material	3	4	4	11
Total	28	7	5	40

1.2 Storm damage in 2001

Despite a few major individual events, as a whole 2001 can be classified as year in which there was relatively little damage.(2) The level of damage in 2001 is similar to that which arose in 1983, 1992 and 1995. The total damage costs of around CHF 77 million, however, is significantly higher than the average annual value. The average cost of damage arising from storms for the monitoring period of 1972–2001 (without taking inflation into account) is approximately CHF 210 million.

Storm activity in 2001 mainly involved a number of floods in March, four heavy storms in the summer months and a debris flow incident in Täsch in the canton of Valais. These events account for around 85% of the cost of material damage for the year. The very wet storm in March caused a number of flooding incidents which affected French-speaking Switzerland, Seeland and Upper Aargau in particular. Along with the material damage caused in 2001, there was one fatality arising from the bad weather events: a car passenger was killed by rockfall near Samnaun in the canton of Grisons.

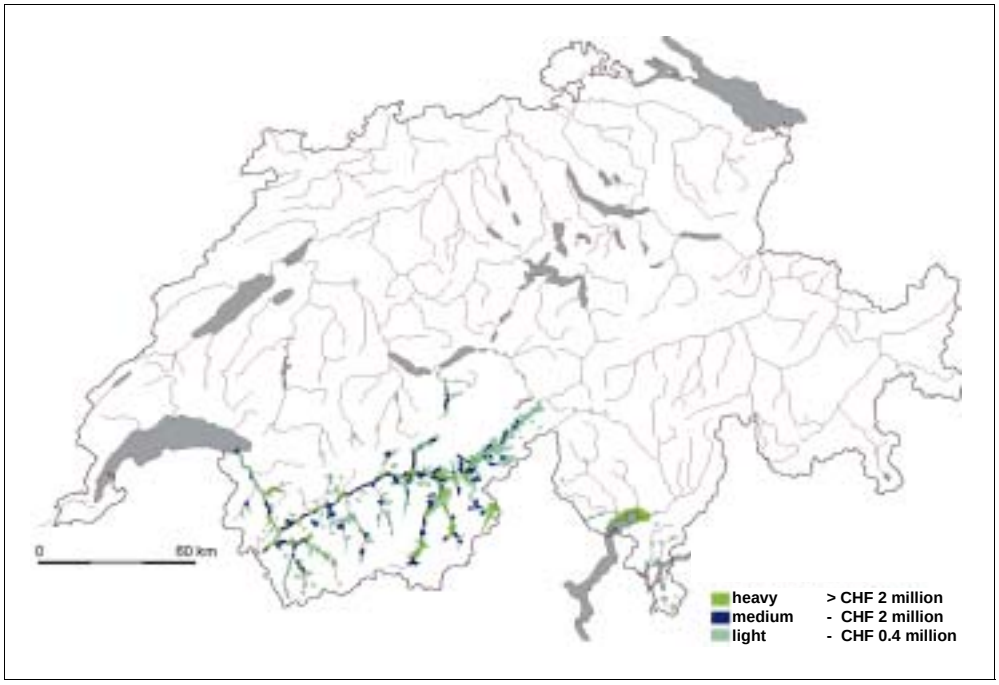


Figure 1:
Location and intensity of storm damage in October 2000.

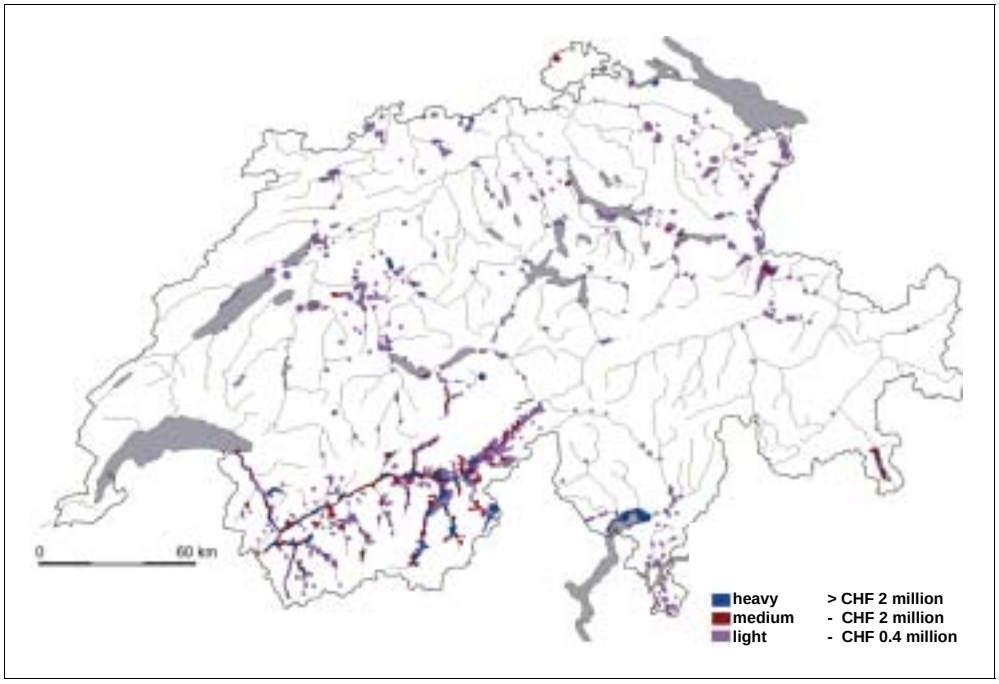


Figure 2:
Location and intensity of storm damage in 2000.

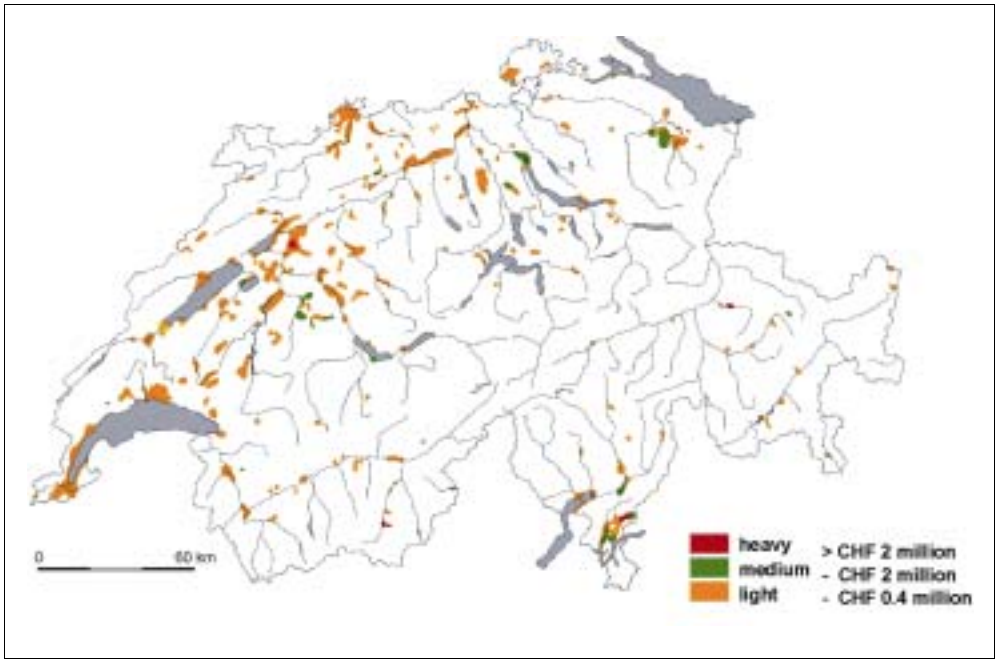


Figure 3:
Location and intensity of storm damage in 2001.

The following tables provide information about the causes (Table 3) and nature (Table 4) of the damage suffered in 2001.

Table 3: Causes of damage in the 41 storm events in 2001.

	Number of Events				Material Damage	
	minor	average	major	total	[Million CHF]	[%]
Storms and torrential rain	13	-	4	17	39.9	52
Extended periods of rain	7	4	1	12	17.2	22
Snow melt and rain	3	-	1	4	18.4	24
Unknown cause and other reasons	8	-	-	8	1.8	2
Total	31	4	6	41	77.3	100

Table 4: Types of damage in the 41 storm events in 2001.

	Number of Events				Material Damage	
	minor	average	major	total	[Million CHF]	[%]
Damage caused by water	10	-	2	12	27.2	35
Damage caused by loose material	10	1	-	11	1.7	2
Damage caused by water and Loose material	11	3	4	18	48.4	63
Total	31	4	6	41	77.3	100

1.3 Important insights derived from the storm events in 2000 and 2001

The storm events that gave rise to debris flows, landslides and floods, which in turn caused fatalities and material damage, prompted the insights summarized below:[3]

- The early recognition of the possible risks to human life and material assets posed by natural hazards (avalanches, floods, debris flows and landslides) and the strict observation of these risks in land use need to be supported and promoted. Given the high price of building land in various parts of the Alpine region and the limited scope with respect to land use in these areas due, not least, to natural hazards, high quality and practicable risk assessment is essential. There is a backlog here in the area of natural hazard processes such as debris flows, landslides and flooding which needs to be given top priority.
- Integrated risk management which exploits and co-ordinates the existing potential with respect to possible measures needs to be supported and promoted. These measures include preventive measures, disaster management measures (intervention) and/or repair measures as well as the establishment of a risk dialogue that is tailored to the needs of society. It is the job of the state to bear the sole responsibility for the risks posed by natural hazards, their possible effects and their reduction while business and private individuals benefit from the situation without accepting responsibility for the eventual consequences of such risks.
- The development of a modern electronic register system as a basis for the implementation of periodic developmental analyses should also be supported as part of the efforts to protect human life and material assets. Priority should be given to registers containing information about hazards and protected structures.
- Opportunities for communication need to be improved so as to promote the exchange of information and experience at both national and international level. Possible examples of this include the increased use of internet technology and the staging of events for the periodic comparison of the status of integrated risk management in individual Alpine countries.
- Sustainable development needs to be promoted in a targeted and consistent way so as to ensure the reduction of anthropogenic impacts on the environment and support the careful management of non-renewable and scarce raw materials.

2 Prevention Policy for Protection against Natural Hazards: An Analysis of the Trends

2.1 The vision of the Platform for Natural Hazards (PLANAT)

In the course of the 2000/2002 report period, the Platform for Natural Hazards (PLANAT), which was set up by the Swiss Federal Council (i.e. government), developed and published its vision for the future safety strategy in the context of protection against natural hazards.[4]

The PLANAT vision includes the following key elements:[4]

Natural hazards – a social challenge

Rising settlement density, appreciation of property values, increasing traffic and wide-ranging employment and leisure requirements all contribute to the increase in the risk posed by natural hazards. The reduction of this risk to a tolerable level is a critical task facing our society.

Defining protection objectives

The main aim with respect to overcoming the threat posed by natural hazards is the protection of human health and life. All inhabitants and visitors throughout Switzerland have a right to the same acceptable level of safety.

Integrated risk management

Protection against natural hazards presupposes the equal validity of all protection measures, i.e. prevention, intervention and recovery/restoration, and the measures that need to be implemented to accomplish them.

Absolute safety does not exist

What is needed is a risk culture which allows the transparent presentation and assessment of risks and their changes and the necessary protection measures.

Joint action and optimum use of resources

Protection against natural hazards is achieved through the joint efforts of public and private instances.

2.2 Forest legislation

Following the introduction of the new forest legislation ten years ago, a Swiss National Forest Programme is now being developed which will also take international obligations in this area into account. The ongoing process will reveal the extent to which the adaptation of the law is required.

In the context of protection against natural hazards, the conservation of the protection forest and its protective services is crucial for the viability of the mountain regions. The second National Forest Inventory[8] indicates that Switzerland's protection forests have suffered more extensive damage than the other forests and that the tendency in their development is towards greater instability (see Figure 4).

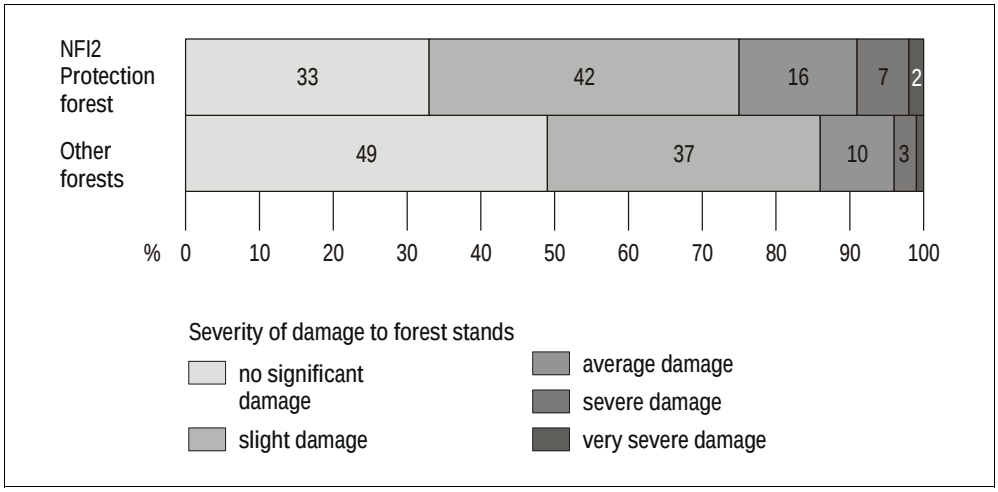


Figure 4:
Status of rock-fall and avalanche-protection forests.

Switzerland's already elevated timber reserves (see Figure 5) continue to increase in the Alpine region. This means that older heavier trees are becoming more vulnerable to the effects of storms. The neglect of protection forest maintenance, in particular in the watersheds of mountain streams and along their banks, will, therefore, lead to an acceleration in erosion processes in the Alpine region. Thus, the risk of the blocking of these streams and the damage arising from this is already foreseeable. The objectives of the Swiss National Forest Programme include reducing the backlog that exists with respect to the regeneration of old stands and reducing the pressure arising from the damage caused to trees by game in search of food which prevents the natural regeneration of the protection forest in a way that is suited to the location. Another key objective is to ensure the minimum but sustainable maintenance of protection forest as an important component of the management of natural hazards.

With the help of financial incentives it should be possible to facilitate new forms of organization and co-operation that promote and support the integrated use and maintenance of watershed areas in mountain regions while also taking ecological, economic, safety-technology (natural hazards) and social imperatives into account. Based on this approach, protection forest maintenance should be organized more efficiently and effectively as part of an integrated watershed management approach. If this strategy is implemented, based on their joint interests in providing both protection against natural hazards and conserving nature and the landscape, a «*rapprochement*» can be expected between agriculture and forestry in the context of the use and maintenance of watershed areas. Such a development would ensure the viability of a mountain region that is worth living in.

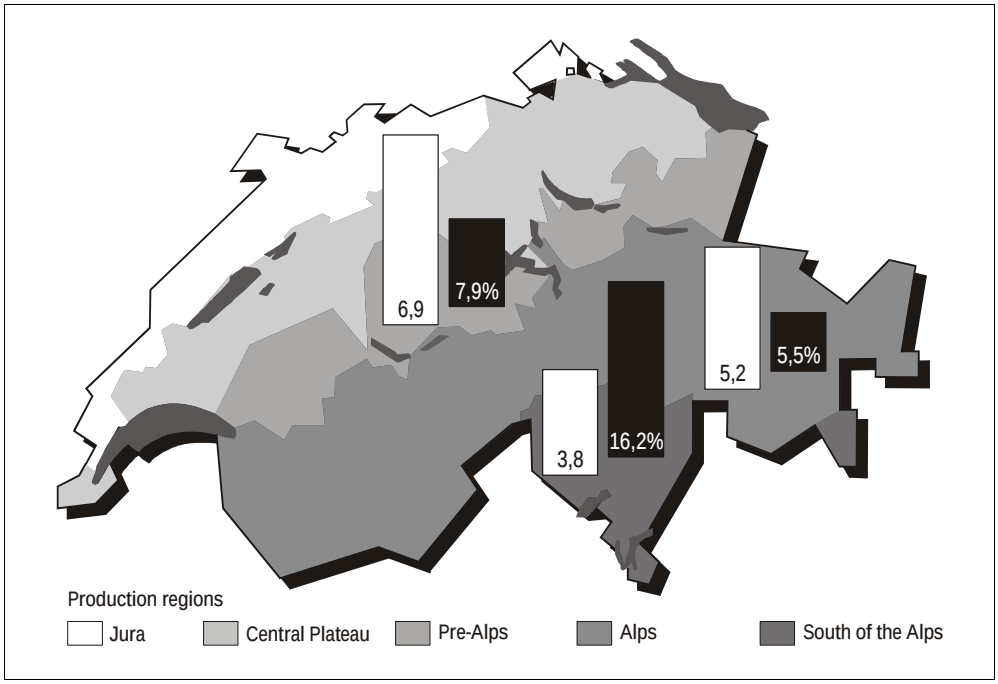


Figure 5:
Increase in timber reserves in the mountain region.

2.3 Growing trend in natural hazards and potential for damage

In using the Alpine region, human civilization has been struggling with the forces of nature since time immemorial. The extreme weather conditions combined with the steepness of the land and its propensity to erosion contribute to the more or less typical dynamics of the natural processes. The potential for damage changed dramatically over the course of the last century. Around 1900 the threat in many locations mainly resided in the extensive over-use of mountain forests. As a result, settlements and transport axes were insufficiently protected against avalanches, rockfalls, landslides, floods and debris flows. Today, the potential for damage is still increasing in Switzerland, mainly as a result of the increasingly intensive use of the areas at risk and the associated increase in the material assets located in these areas.

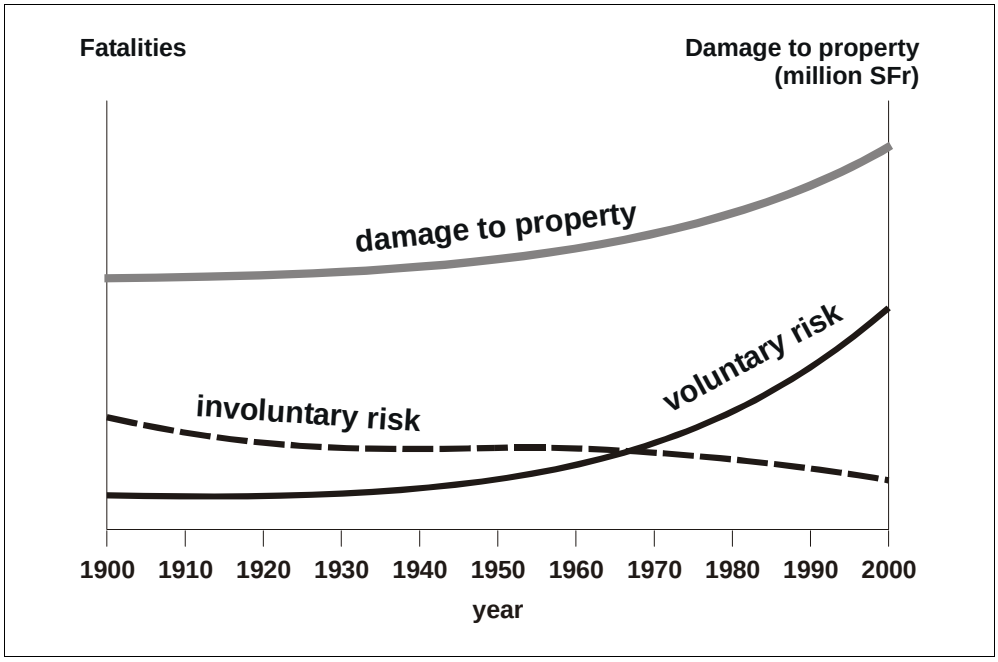


Figure 6:
Decreasing trend in fatalities during extreme weather events as compared with the increase in fatalities arising from risks assumed on a voluntary basis and the risk of material damage (risk acceptance).[9]

While in the past avalanches and debris flows in the mountain region only represented a threat to the Alpine farm buildings, pastures and cultivated lands which were used on a seasonal basis, today, the region has residential buildings, important transport and transit axis and tourist infrastructure that is used all year round. The local authority area of Brienz in the Bernese Oberland is an example[9] of how settlement expanded in areas at risk from debris flows and overbank sedimentation between 1870 and 1993 (see Figure 7).

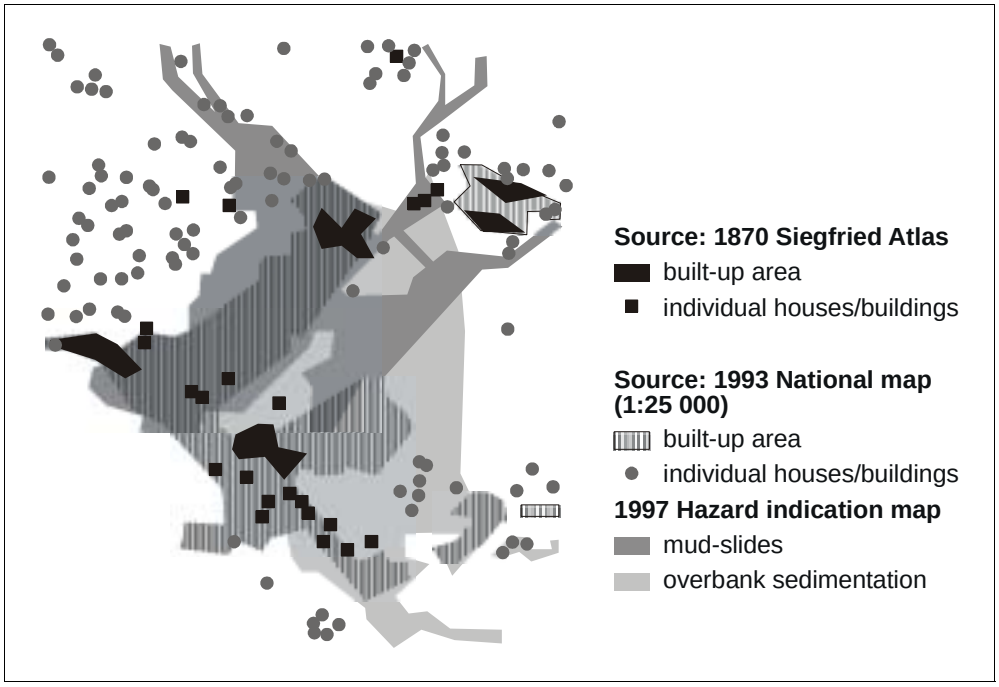


Figure 7:
Risk situation in the local authority area of Brienz (Bernese Oberland) – Comparison between 1870 and 1993.

Today, a new threat has emerged that is adding to the potential for risk, i.e. climate change. Although there is still no definitive scientific proof, the current understanding of climatic processes would suggest that the proven phenomenon of global warming is causing extreme wind speeds and increased intensity of precipitation, at least on the southern slopes of the Alps. In addition, more intense flooding can be expected in winter and transition periods. However, it is unlikely that in the near future extreme events at regional level will provide conclusive proof of a change in climate-based risk.

2.4 Increasing safety requirements in a society dominated by leisure, communication and mobility

With the ongoing development of the legislation governing forests and hydraulic engineering – last revised in 1991 – and the emergence of the insurance sector over the past century, the task of providing protection against natural hazards and the management of natural disasters falls to the state, insurance sector and voluntary organizations. Similarly, nowadays the fire brigade and civil defense units have been trained and equipped to respond to natural disasters with rescue and clearing operations so as to limit the damage and ensure the rapid restitution of the damaged area. This kind of response necessitates detailed emergency planning.

This improvement in public services in the context of protection against natural hazards is related to the increasing demand for safety *vis à vis* natural hazards. This demand is furthermore intensified by the fact that people generally place greater emphasis on the safety aspects than the risk aspects.

On the other hand, due to modern leisure requirements and the fact that in many cases people's homes and places of work are no longer in the same place, traffic levels have increased significantly. This also applies in the mountain region and the likelihood of accidents arising as a consequence of natural events along transport axes in the Alpine regions is also increasing as a result. This leads to greater demand for additional safety measures, such as protective structures and early-warning systems, and the improvement of communications systems. And this in turn prompts increasing requests for the installation of rockfall protection systems along vulnerable stretches of road which were not previously a major cause for concern.

The example of the Gotthard railway line demonstrates the evolution of safety requirements in the course of the past century, which reflects the increasing potential for damage and as a result the risk posed by natural hazards (see Figure 8.).



Figure 8: «The Evolution of Safety Requirements on the Gotthard Railway Line between 1900 and 2000».

2.5 Safety 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 a rich industrialized country like

Switzerland with its access to state-of-the-art safety technology cannot guarantee absolute protection against natural hazards.

Thus, for example, in a typical Alpine canton like Graubünden 450 known natural hazard spots 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 these risks using construction measures or to protect the actual transport links.

Meanwhile the general public is becoming increasingly less aware of the limits of technology. People, including the inhabitants of the mountain cantons, want roads that can be used day and night, irrespective of climatic and topographical conditions. The availability of such services is now seen as an automatic right.

There is an increased focus on individual freedom and self-interest while individual responsibility takes a back seat. The prevailing attitude is that nature must subject itself to the requirements of man.

This attitudinal trend is also evidenced in people's increasing willingness to voluntarily confront the risks posed by natural hazards like avalanches by participating in the endless new adventure sports such as canyoning, off-piste snowboarding etc. Thus, the number of fatalities for which the victims themselves bear responsibility is growing.

2.6 The possibilities and limits of land use

In a country full of lakes, mountains and forests like Switzerland, despite the extensive requirements, the scope for land use is limited. This is one of the reasons why the value of the material assets under threat has grown so significantly. As a result we must now address not only issue of risk reduction, but also the question of the reasonable acceptance of risks associated with natural hazards.

Questions such as «what can happen?», «what is acceptable?» and «where is it acceptable?» are all part of a risk dialogue that must take place between the «protectors» and the «protected».

An approximate comparison of the scale of the damage caused by the avalanches in the winters of 1951 and 1999 prompts the conclusion that consistent and integrated natural hazard management is worth the effort. The experience gained over the past 50 years in dealing with the threat of avalanches and the taking into account of this factor in the context of land use is encouraging. For example, thanks to the use of hazard maps as specified in the 1984 «Instructions for the taking into account of the threat of avalanche in the course of spatial planning activities», there has been a notable decline in damage to buildings (from 1,300 to 720). The closure of roads and rail links and evacuation of buildings in yellow and blue zones also proved effective.

Because the pressure from settlements and traffic has increased significantly since the introduction of the above-mentioned instructions in 1984, similar recommendations concerning the risks associated with flooding and landslides were published by the relevant federal authorities in 1997 and 1998. Needless to say, the authorities hope that these will be as effective as the avalanche instructions.

2.7 The possibilities and limits of technology

Thanks to the development of construction and anchorage techniques many protective measures are now possible that were previously inconceivable. However, despite this progress, there is still room for improvement. It must also be kept in mind that the construction of protective structures will always give rise to maintenance costs, and this task must be taken seriously if the structure in question is function properly on a permanent basis. The estimated total value of protective structures in Switzerland is CHF 50 billion. They must all be maintained and replaced occasionally. In view of diminishing financial resources and the fact that the protective structures do not provide complete protection, all proposed investments in this area must be subject to a serious risk and cost-benefit analyses. On no account can we afford to neglect the existing structures.

2.8 Modern society is a risk society – Are we learning how to manage these risks?

«*Only man can speak of catastrophes – assuming he survives them.*
For nature there is no such thing as catastrophe»

This quote from the Swiss author Max Frisch draws attention to the fact that the reaction to natural hazards is defined exclusively from the perspective of humans. These extreme events threaten human life, interfere with human infrastructure and disturb production processes. The increased vulnerability of man and his material assets to the consequences of catastrophic events is indelibly linked with technical progress.

Modern society's requirements in terms of safety are characterized by a variety of risk groups and their requirements. This applies to the health sector, for example, as much as it does to protection against natural hazards. The diversity of the risk groups shows that protection against natural hazards is merely one part of sustainable risk management.

The possibilities for reducing these risks come up against the limits of technology and increasingly also ecological and economic limits. This also applies to the risks posed to man, animals and material assets by natural hazards. Neither the state nor the private sector can indefinitely bear the costs associated with the reduction of residual risks and adaptations of a social or medical nature or those involving transport – even if this is deemed desirable from an individual perspective. Insurance companies are now facing the same problem and they will be even more

exposed to it if the damage caused by natural disasters continues to increase as in recent years.

Abrupt processes like avalanches, rockfalls or debris flows rapidly endanger human life and are instantly perceived as unacceptable risks. This explains why protection against these hazards is dominated by the necessity to «avoid» or «prohibit».

As opposed to this, in the case of slower processes such as flooding, the threat to human life is usually less significant, although the potential for material damage is extensive. Since time immemorial man has been attracted to rivers, streams and lakes as attractive settlement locations and for the practical advantages offered by their banks and shorelines and, more recently, the services offered by hydro-electric power. The disadvantages of periodic flooding were accepted and the necessary adjustments made. Thus, despite regular flooding, settlements near lakes and along rivers continued to expand. The benefits accrued during flood-free periods outweighed the losses incurred during the floods. Previously, damage was limited with the help of suitable measures such as the restricted use of basements, the construction of footbridges etc. Today, there is a decline in people's awareness of and involvement in such exceptional situations. The sense of individual responsibility is declining and people expect complete protection.

The evolution in the value system and expectations of a modern society that must live with a wide variety of risks necessitates dialogue on the subject of risk between the different groups involved.

In future, the debate will focus on two specific questions: «How important is safety to us?» and «How much are we willing to pay for it»?. These questions will need to be explored not only from the point of view of the increasing scarcity of resources, but also in view of the ecological and social limits. It will also be necessary to differentiate between collective and individual risk and risks that are accepted voluntarily and involuntarily.

2.9 The dilemma facing our consumer and leisure society: do we protect nature against man or man against nature?

The report submitted to the Standing Committee of the Alpine Convention on the topic of the serious damage caused by avalanches in the winter of 1999 indicates that the fragile Alpine ecosystem has reached its limits in terms of its capacity to cope with environmental impacts. According to the report, the same applies to the feasibility of reasonable safety standards in various tourist locations in the Alps. Thus, the report concludes that the time has come to place greater emphasis on the sustainable development of these mountain regions.

When a winter like 1999 with avalanches throughout the Alpine region:[5]

- claims the lives of 60 victims who were not responsible for their deaths,
- causes direct material damage involving a total cost of almost CHF 1 billion,
- causes over CHF 500 million in indirect damage, such as losses to tourism,

- gives rise to supply problems,
- causes traffic chaos on the transit axes
- and triggers psychological problems among tourists trapped in tourist resorts

the time has undoubtedly come to consider whether the limits of feasibility have not been reached many places and whether it would not make more sense in the long term to adopt aims which correspond to the sustainability criteria. While acknowledging that the future management of the Alpine region is not a simple task, it is ultimately a question of preserving the mountain regions as viable locations that are worth living in. This means maintaining an intact landscape, on the one hand, and, on the other hand, working to establish uses that are tailored to the existing risks and suited to the locations in question while also doing everything possible to conserve nature and the landscape.

3 Technological Development

3.1 Protection forest maintenance

On 15 August 1997 a heavy storm broke over the region of Sachseln in central Switzerland. In just two hours, up to 150 litres of water fell per m^2 of land. Over 400 landslides from the steep mountain slopes were set in motion, many of them took the form of mud slides in the stream courses. This material mixed with the raging floods and vast volumes of water and mud destroyed the village of Sachseln, blocked roads, rail links and infrastructure supply lines and buried extensive areas of fertile cultivated land. The total cost of the damage incurred was in excess of CHF 100 million. So as to reach a better understanding of the links between forest vegetation and the landslides, the Swiss Research Institute for Forest, Snow and Landscape (WSL) was commissioned to carry out studies on the limits of the influence of forest in such circumstances(6). The following conclusions were reached in these studies:

- The state of the forest plays an important role: in the forested part of the study area, there were ten times more landslides in locations with poor quality forest (see Figure 9)
- Under otherwise comparative conditions, there were significantly fewer – one third fewer – landslides in the forested areas than in the unforested areas (see Figure 10)

Stable forest stands comprising mosaics of trees of different species, ages and heights offer the best protection.

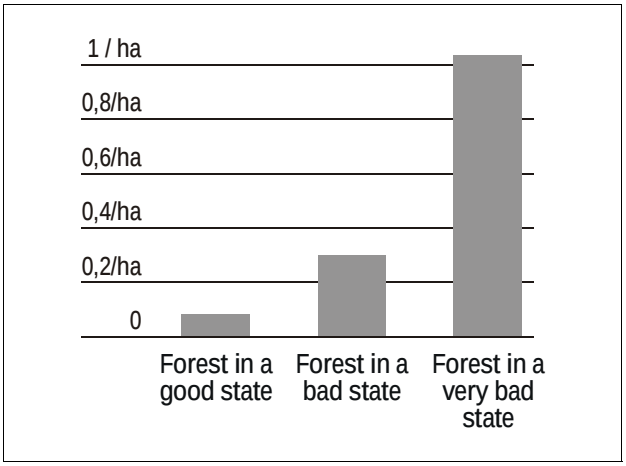


Figure 9:
The influence of the state of forests on the number of landslides. Forests with a stable stand structure and suitable species distribution reduce the risk of landslides.

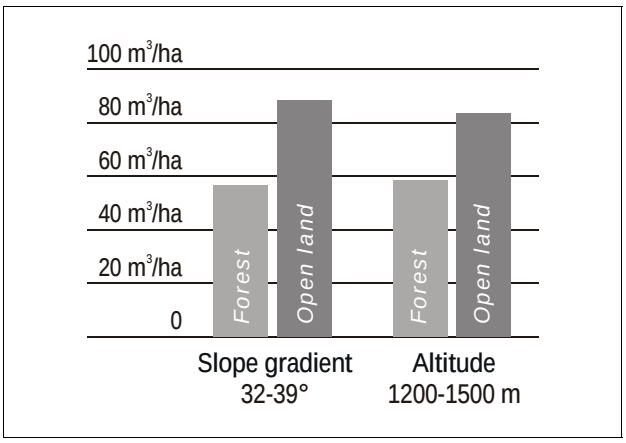


Figure 10:
The influence of forest vegetation on the size of landslides. Thanks to its extensive root networks, forest cover reduces the size of landslides and thus makes an important contribution to the bedload balance in the watershed area.

3.2 The concept of minimum protection forest maintenance – success monitoring of representative control areas

Good forest quality can only be achieved on a permanent basis through constant maintenance and regeneration. Intervention should be carried out in a targeted way in areas where such maintenance is necessary and sustainable in its effects with the help of instructions for minimum protection forest maintenance.

The following decision aid is intended for use by forestry services in their efforts to ensure minimum protection forest maintenance. A systematic success monitoring system is also being developed which will be implemented by foresters at selected representative control points. The aim of this success monitoring is to manage the natural development of the forest in a way that guarantees the uninterrupted provision of protection services while reducing the work involved to a minimum.

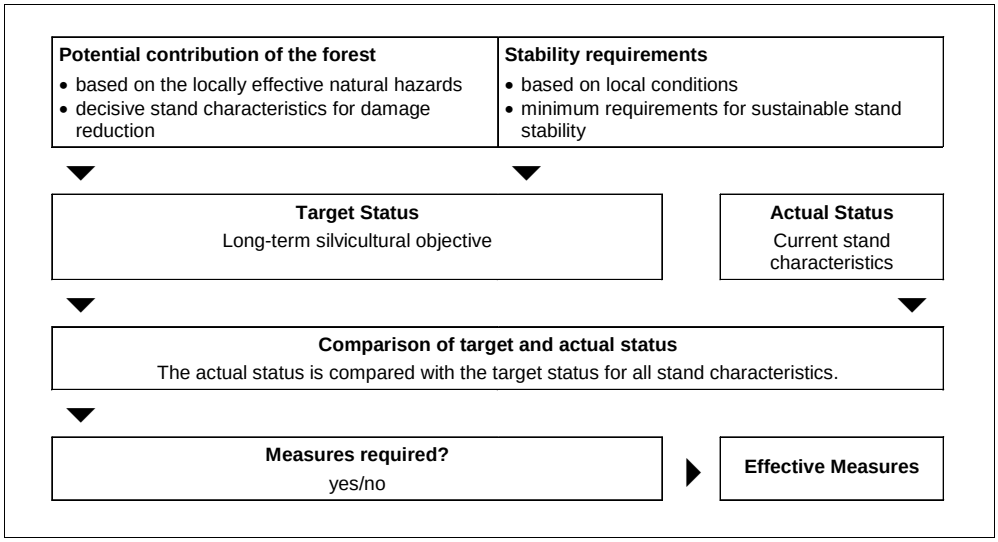


Figure 11:
Decision aid for implementation of minimum protection-forest-maintenance measures.

3.3 A pragmatic approach to risk analysis

Due to the complexity of the processing of the necessary information, the estimation of the risks associated with natural hazards poses a difficult task. Thus, a comparable overview of the risks facing larger areas is not expected to be available in the foreseeable future. For this reason an attempt was made to find a simple practicable approach which uses the available knowledge in a targeted and comprehensible way to obtain a rapid overview of risks and the action required to minimize them.

- Firstly, the natural hazards in a selected area are identified and the impact zones defined. When available, event registers, hazard indication maps and hazard maps are used as decision aids.
- Secondly, any existing protection measures, such as early warning systems, zone plans, protection forests etc., are recorded and assessed with regard to their efficacy.
- Thirdly, data is collected on the potential for damage within each defined area. This concerns the persons present in the area, on the one hand, and material assets such as buildings etc., on the other.
- Fourthly, people with in-depth local knowledge and experts estimate the damage to be expected for each source of danger. This assessment is based on nine scenarios (see. Figure 12.).

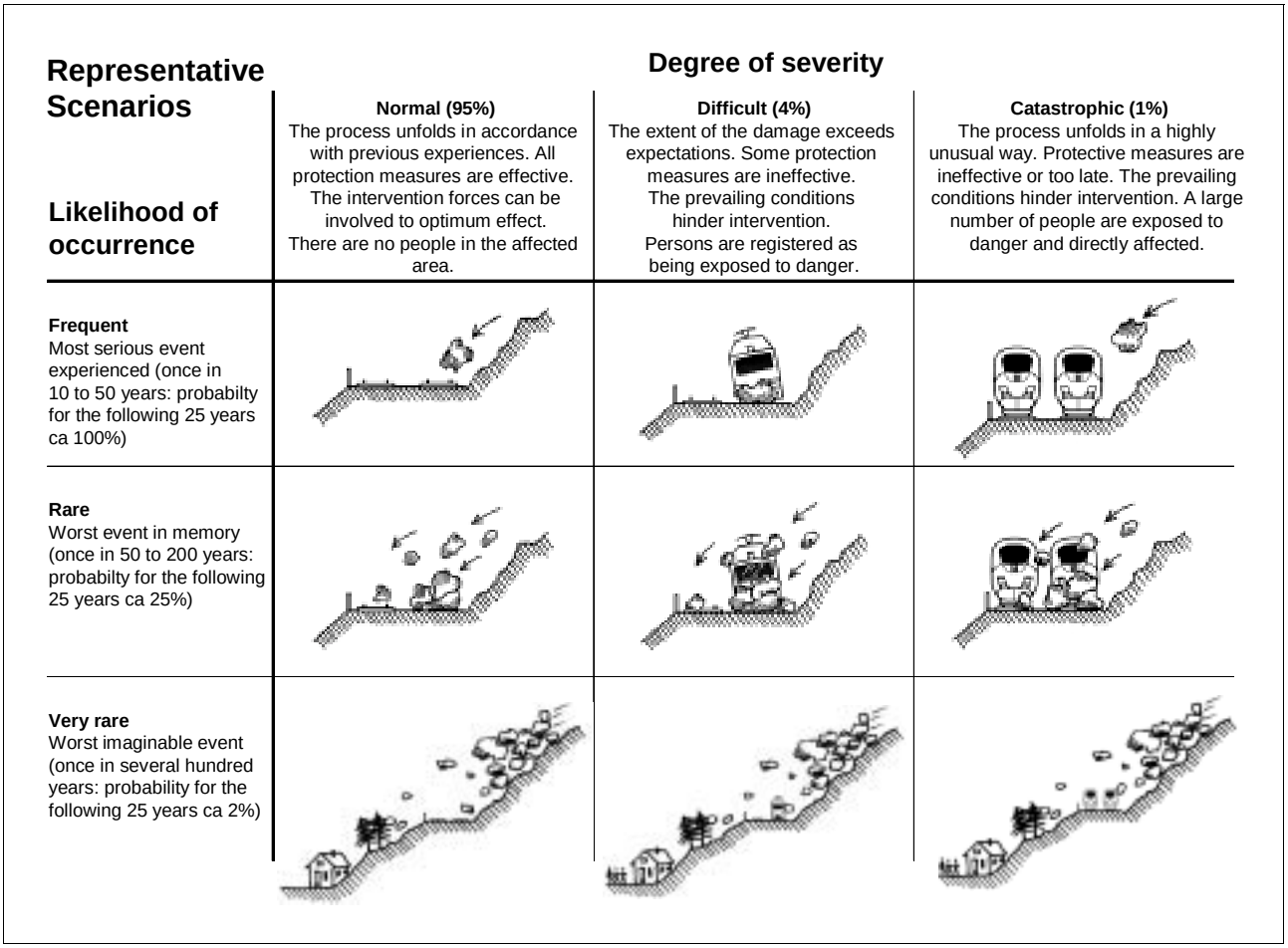


Figure 12: Representative Scenarios.

Finally, using a computer, the risks are calculated on the basis of the documented assessments and presented in comparative form. (Figure 13.)

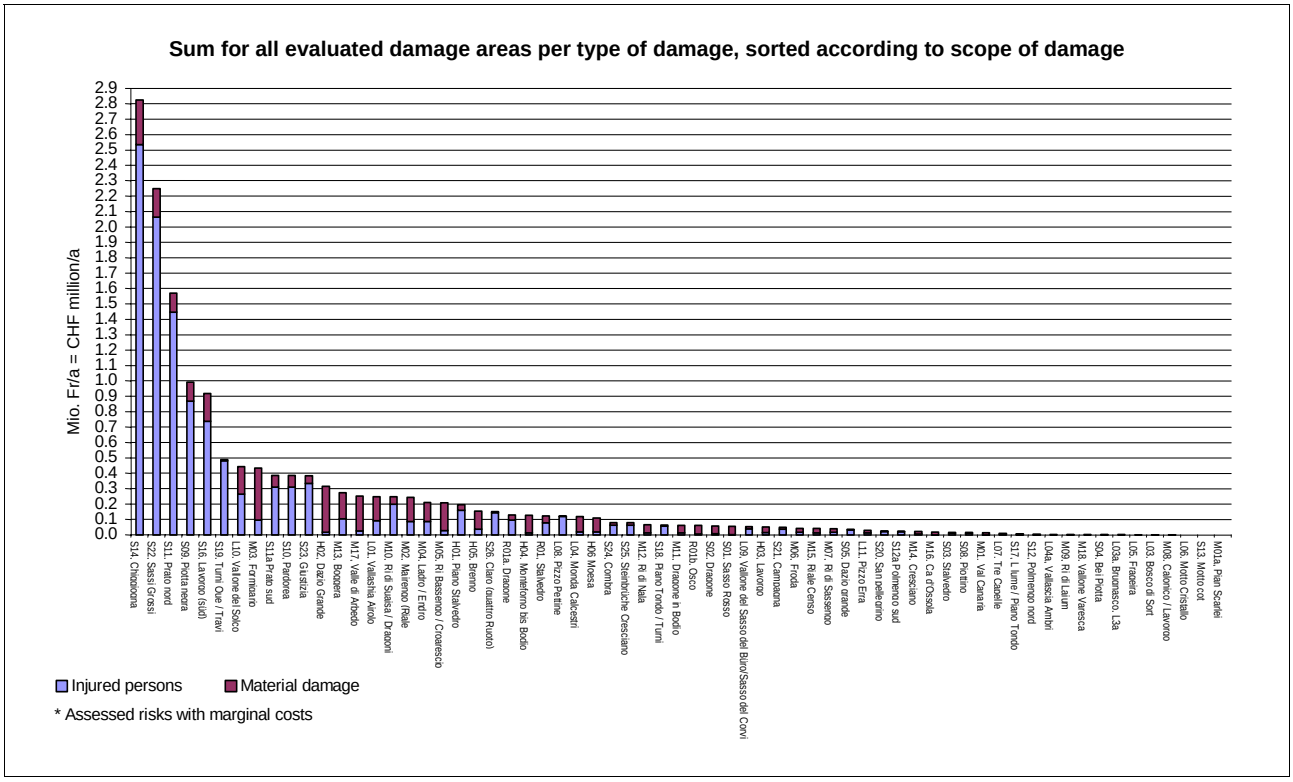


Figure 13: Sum for all evaluated damage areas per type of damage sorted.

This pragmatic approach can now be used to produce a global and risk-based safety plan in a fast and targeted way that can be applied with the involvement of all of the concerned and interested parties. Such plans can be used to:

- support the risk dialogue if the opinions of potential victims and those responsible differ strongly;
- as a preparatory instrument for more detailed analyses;
- as a planning instrument for an initial and approximate prioritization of the measures required, if the resources and time are not available for a more detailed analysis.

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13.10 National Report United Kingdom

D. Henderson
Chief Conservator
Forestry Commission
United Kingdom

Within the UK, the mountain area is 3 million hectares and the mountain forest area is 400,000 hectares. Many of these mountain areas are located in Scotland – and particularly in the Highlands of Scotland.

At the 1st Ministerial Conference on the Protection of Forests in Europe in Strasbourg in 1990, the UK was not convinced of the applicability of the Resolution S4 on «Adapting the Management of Mountain Forests to New Environmental Conditions» within the UK. Having reviewed the resolution in this International Year of the Mountains and taking into account developments since Strasbourg, we now believe that there is much that is relevant to the mountain and hills of Scotland and the rest of the UK. In the circumstances the UK Government will arrange to sign this Resolution at the fourth Ministerial Conference on the Protection of Forests in Europe in Vienna next year.

1 Protective work in the past

1.1 Protection of human beings, settlements and traffic from natural hazards (avalanches, rock-falls, land-slides, flooding, erosion etc)

Problems arising from natural hazards of this sort are often local, but serious for those directly affected. The UK is committed to securing good environmental practice in forestry; what this means in practice is set out in the UK Forestry Standard (published in 1999) and associated technical guidance. Of particular relevance to mountain watersheds is the technical guidance entitled «Forests and Water Guidelines». These guidelines are aimed at ensuring that the role of forests is beneficial and harmful effects (resulting, for example, from cultivation) are avoided. They recognize that good management maintains and develops the natural protective functions of forests to the benefit of the whole aquatic ecosystem. The beneficial effects of well managed forestry, include the enhancement of riparian habitats through bankside protection and the provision of shade and shelter, protecting water quality, reducing soil erosion, and increasing the infiltration and storage of rainfall with possible (although limited) benefits for reducing flood flows.

Examples of practical protective work include:-

- provision of cross drains to control run-off in cultivation channels;
- keeping drain ends back from the riparian zone, using silt traps if there is a moderate or high erosion risk;
- good practice in road construction and maintenance;
- encouraging the development of appropriate riparian vegetation, including riparian woodlands in flood plains.

Protective work of this sort reduces erosion and sedimentation. An important benefit is the protection and improvement in habitats for salmonid fish, which are of economic significance in mountain areas.

The «Forests and Water Guidelines» have been prepared with the assistance of a wide range of organizations, including water and environmental authorities. They are currently in their third edition, with consultation taking place on a fourth edition to reflect increased understanding of issues and latest research findings.

1.2 Management of catchment areas to protect them from erosion or flooding and to conserve drinking water catchment areas and their quality

The «Forests and Water Guidelines» provide guidance on managing catchment areas to protect them in these ways. The Guidelines are used in the development of forest plans and explain how to address potential issues such as water yield, base flows, peak flows, sedimentation, turbidity water and nutrient enrichment.

In addition to detailed operational guidance of this sort, the Guidelines provide a context for preparation by local authorities, of Indicative Forestry Strategies. The Indicative Forestry Strategies identify areas that are preferred for new planting and also explain where there are sensitivities, which may include sensitivities relating to water catchment areas, river systems, lakes and water quality. In drawing up these Strategies, local authorities take advice from environmental authorities as well as forestry interests. These Strategies may also recognize the value of flood plain woodlands as a tool for helping to manage floods, where this is seen as being valuable.

1.3 Important research results that contribute to the improvement of mountain watershed management

Studies have recently been completed of the impact of afforestation (ploughing, drainage and aerial application of rock phosphate fertilizer), road construction and harvesting on public water supply catchments in the West Highlands of Scotland. Another study, of the effect of afforestation on water quality and the salmonid fishery in the upper catchment of a river in north Scotland, is on-going.

Ten forested and two moorland acid-sensitive catchment streams were selected in upland Wales in 1991 to monitor the long-term effects of forestry on surface water acidification.

Catchment-based critical loads assessments are routinely carried out in Scotland.

A study of the effect of forest drainage on the generation of extreme flows is being carried out in the hills of northern England.

A number of long-term catchment studies investigating the effects of forestry on water quality and/or quantity are maintained throughout upland Britain by a partnership of organizations.

Monitoring is also being undertaken to assess the effectiveness of the «Forestry and Water Guidelines».

(Further details of this work can be viewed on www.forestry.gov.uk.)

1.4 New basic documents (modifications to legislation, guidelines etc)

Legislation is being developed to translate the requirements of the EC Water Framework Directive into domestic law within the countries of the UK. As this legislation is implemented, the «Forests and Water Guidelines» are likely to be used as a reference work for consequential regulatory activity.

2 Harmful events at the regional scale

While many of the impacts discussed in Section 1 often have an impact at a fairly local level, acidification can have an impact at a regional scale.

2.1 Site of damage

Acidification of fresh waters occurs where the inputs of acidic sulphur and nitrogen compounds derived from the combustion of fossil fuels exceed the buffering (neutralizing) capacity of the soils and the underlying rocks through which water passes before entering streams, rivers and still water. The buffering capacity of these receiving waters is also an important factor. The most acidified areas in the UK are in the uplands where catchments with base-poor, slow weathering soils and rocks coincide with high pollutant inputs in the form of large volumes of moderately polluted rainfall. Although most pollutant inputs are now declining due to emission control, surface water acidification remains a particular problem in parts of central and south-west Scotland, part of upland England (Cumbria and the Pennines) and Wales.

2.2 Amount of damage

Before the industrial revolution, waters in upland areas were generally unpolluted, with good stocks of salmonids and other fish. Today, where surface water acidification has occurred, fish populations have declined or, in some instances, been lost completely. Other wildlife has also been seriously affected, with reduced numbers of some birds, and an impoverished diversity of aquatic invertebrates.

In many upland areas, surface waters are also sources of supply for domestic use. Increased acidity and consequent increased solubility of aluminium and manganese have implications for public and private water supplies, influencing compliance with water quality standards and potentially increasing the cost of water treatment.

The quantity of sulphur and nitrogen pollutants deposited at a given site is strongly influenced by the nature of the vegetation layer. Forest canopies can significantly increase the capture of some of these pollutants in the atmosphere. This increased capture, often termed scavenging, is a function of the stand structure which creates turbulent air mixing. The effect therefore becomes more important as trees grow and the height of the stand increases. The enhanced capture of mist, which can contain large concentrations of sulphur and nitrogen, is greatest at high altitude because of the increased duration of cloud cover and high wind speeds.

Long-term studies continue in order to determine the magnitude of this scavenging effect and its role in acidification, and also to validate models of deposition.

2.3 Cause of damage

As indicated above, the primary cause of acidification is the deposition of acidifying sulphur and nitrogen compounds derived in part from the combustion of fossil fuels.

Reduction in the emission of acid pollutants is the only way of solving the general problem of surface water acidification. In the UK there has been a marked reduction in sulphur (S) emissions, and hence deposition, since the late 1960s and a slow response to this has been detected in some surface waters since the early 1980s. UK nitrogen (N) emissions have stabilized since the late 1980s, but future trends in nitrate concentrations of surface waters remain uncertain. The European Union has agreed to further S and N pollutant reductions by 2010, but these will not result in the recovery of all acidified waters or remove the risk of continued acidification in all currently susceptible areas. Investigations continue to assess the effectiveness of emission reductions in reducing pollutant inputs, and to identify the rates and extent of recovery in terrestrial and aquatic ecosystems.

3 Harmful events – consequences from the point of view of the state

3.1 Early diagnosis

In order to protect the freshwater environment, the forestry authorities take the scavenging effect into account when considering new planting or restocking plans. To this end it is necessary for both the forestry authority and applicants to identify which areas are most at risk. The critical load approach is well fitted for this purpose. A critical load is defined as the maximum load of a pollutant that a given ecosystem can tolerate without suffering adverse change. For fresh waters, critical loads can be calculated which, provided they are not exceeded, should ensure the maintenance of water chemistry suitable for the protection of populations of fish and other freshwater organisms.

3.2 Hazard assessment

Maps are used to indicate where critical loads for total acidity for fresh waters are exceeded and to indicate where additional scavenging by trees could lead to further freshwater acidification.

3.3 Land use

Forestry in the UK is a devolved subject and the devolved administrations have developed Forestry Strategies. The Scottish Forestry Strategy has identified as one of its priorities for action the need to «aid recovery for acidified rivers and lochs

and improve riparian habitat». Anticipated benefits include aiding restoration of ecological diversity of rivers and lochs. Specific actions include the consideration of selective deforestation in some catchments (this would need to be justified through formal Environmental Impact Assessment) and the establishment and management of riparian woodlands. In addition, water catchment issues are identified as being likely to require detailed attention in local Indicative Forestry Strategies.

4 Main problems that must be solved

Current research programs are:-

- testing the effectiveness of best management practices in protecting the environment and developing guidance;
- maintaining long-term studies of the effect of forestry on surface water acidification;
- carrying out catchment-based critical loads assessments in support of forestry expansion proposals;
- investigate the impact of forest felling and replanting and of emission abatements on critical loads exceedance;
- contributing to a Europe-wide study of the impact of forests and silvicultural practices on the extreme flows of rivers.
- contributing to the effective planning and management of catchment studies.

Other challenges include:-

- implementing the requirements of the EC Water Framework Directive;
- extending the area of woodland which benefits water catchments, for example through appropriate woodland management and expansion in the riparian zone;
- assessing the likely impact and implications of climate change;
- ensuring that forestry contributes to sustainable rural economics in mountain areas of the UK.

Appendix

Final Resolution of Davos 2002

Mountainous areas provide the basis of life for millions of people in Europe. For example, in the EU 15 countries 54 million people live in mountains and mountainous areas account for 38.8% of the total EU 15 land area. Some 14 million persons live in 5.800 municipalities in the Alpine Arc that is 1.200 km long and 200 km wide and stretches from Vienna to Nice; and there are also important mountain areas in other parts of Europe.

Mountainous areas provide employment, transit zones, water reservoirs, landscape, wilderness, natural parks and reserves, recreational and sport areas, open spaces or simply nature.

But mountainous areas are also vulnerable to natural catastrophes and hazards as well as to global change.

Our generation has the responsibility to ensure that our mountain heritage is passed along to future generations in such a way that it will provide the basis for their livelihoods, while maintaining its specific characteristics.

The 23rd session of the Working Party on the Management of Mountain Watersheds considers that the concept and practice of integrated watershed management are necessary for sustainable development in the mountain areas of Europe. The following measures are important for maintaining intact mountain areas to meet social, ecological and economic needs in the future:

- Land use in mountainous areas should be adapted to local natural conditions in order to minimise danger to human life. Areas highly threatened by erosion and natural hazards such as avalanches, debris-flow, rockfalls, landslides and floods are not appropriate for human settlements and infrastructure.
- To ensure sustainable development in mountainous areas it is essential to pay simultaneous consideration to agriculture, forestry, land-use planning, transport, trade, tourism, conservation of nature, landscape and cultural heritage, water management, and protection from and prevention of natural hazards. Cross-sectoral approaches are required, and therefore, land use planning should be integrated rather than sector-based.
- Mountain ecosystems are fragile and particularly vulnerable. They suffer from the adverse impacts of soil erosion, forest fires, air pollution and other phenomenon, as well as the impact of globalization, including climate change. Governments have a responsibility to fulfill their international obligations, in particular in the difficult area of air pollution control and climate change and to implement the United Nations Framework Convention on Climate Change and the Kyoto Protocol.
- All preventive efforts to ensure the protection against natural hazards in catchment areas should be coordinated in such a way that the residual risk for human beings, infrastructure and property is minimized for all types of natural hazard.
- Mountain forests provide a wide range of goods and services and are necessary for human settlements in many areas. Employment linked to all these activities is important, not only for the regional economy, but also to prevent out-

migration from mountain areas. Therefore, sound management and protection of mountain forests is of vital importance to the sustainable development of many mountain areas and the services that mountain forests provide to the public should be fairly compensated through appropriate financial mechanisms at regional and international levels.

- A greater effort should be made to extend the knowledge generated in the mountains of Europe to other watersheds in the rest of the world. The need to exchange at the international level experience and progress in knowledge on mountainous areas is greater than ever.
- Education, capacity-building, training and research can make important contributions to sustainable development in mountain areas. Specific issues on mountainous areas must be studied critically in greater depth when making plans for the future. Better use of information technology tools should be made, particularly in the teaching area.
- Continuous, longterm monitoring of ecological and hydrological phenomena is necessary for basic understanding of watershed processes.

Close co-operation and shared responsibility in watershed management between local, regional and national authorities, at appropriately decentralised levels, is necessary.

The participants
of the 23th international meeting
of the Working Party
on Mountain Watershed Management

Workshop Program

Date	*Activities*	*Responsable Person*	*Remarks*
Sunday, 15th Sept.	Arrival of Participants	Tourist Office	
Monday, 16th Sept.			
0815	Registration		
0830–0915	Welcome Adress WP - IUFRO – FAO Hostcountry FAO/EFC IUFRO	Mrs M. von Ballmoos J. Krecec W. Schärer M. Tage A. Goettle	Gov. of Davos Chairmen WP Swiss Forest Agency FAO, Rom President of S8
0915–1045	**Session A:** «Catchment Area» – «Watershed» Management **Modern Watershedmanage-ment a contribution for the future sustainable develop-ment of mountain areas**	Chairmen: D. McGuire	
0915–0945	from a politcal point of view	RR S. Engler	Member of the cantonal Govern.
0945–1045	from a scientific point of view	H. Schreier	University of British Columbia
1045–1115	**Coffeebreak**		
Monday, 16th Sept.			
1115–1230	**Session B:** **Lessons we learnd from the past a base for a Future Management of Mountain Watersheds**	Chairmen: Doug. McGuire	FAO; Rom
1115–1140	The tricky question of equilibrium; lessons from the rivers	D. Vischer	ETH-Zürich
1140–1205	Our lessons we learned from the past natural catastrophes	Ch. Pfister	University of Bern
1205–1345	**Lunchbreak**		
1345–1600	**Session C:** **Riskmanagement in Catchment areas**	Chairmen: A. Hurand	RTM Pyrénees
1345–1410	Riskmanagement a decision tool which has to consider ecological, economical and social aspects	H. R. Heinimann	ETH-Zürich
1410–1435	The influence of different land uses in a catchment area on natural hazards	Ch. Hegg	Federal research-station (Forest, Snow and Land-scape, WSL)
1435–1500	Mapping and Characterisation of mountain watersheds using GIS and remote Sensing	Maria Luisa Parachini	European Commission JRC / IES

Date	*Activities*	*Responsable Person*	*Remarks*
1500 - 1900	**Session D:** **Profit of watershed management for lowland areas**	Chairmen: J. Krecek	Technical University of Prag
1500–1525	Experiences made by FAO	M. Tage	FAO, Rom
1525–1600	Coffeebreak		
1600–1625	Experiences made in Bavaria	A. Goettle	Bavarian State Office for Water Manag.; Munich
1625–1650	How does the future look like	G. Fiebiger	Austrian Forest Technical Service
1650–1720	Future requirements of the management of mountain watershedss and benefits for lowland aeras	Discussion	
1900	**FAO – Reception – Celebration of the 50th Anniversary**	Hosted by FAO	Kongresshotel
Tuesday, 17th Sept.	**Progress in Watershed Management and Sustainable Mountain Development**		
0815–0830	Adoption of the agenda	Chairman: J. Krecek	CharlesUniversity of Prag
0830–0855	**Session E:** **Climate change and its impact on the Management of Mountain Watersheds**	Chairman: J. Krecek	CharlesUniversity of Prag
0855–0920	The Social and Institutional Dimensions of Mountain Watersheds	A. Hocevar	University of Ljubliana
0920–0945	The story of the Beaver Brook Watershed Colorado	Bruce van Havern	Dep. Of the Interior Colorado/USA
0945–1730	**Session F:** **Country reports**		
0920 - 1000	Short presentation of the written national reports (max. 10‘) **Discussion after 3 presentations (max. 10‘)**	Representants of the countries	
1000–1030	Coffeebreak		
1030–1245	Short presentation of the written national reports (max. 10‘) Discussion after 3 presentations (max. 10‘)	Chairmen A. Hurand Representants of the countries	RTM Pyrénees
1245–1400	Lunchbreak		
1400–1600	Short presentation of the written na +observers reports (max. 10‘) Discussion after 3 presentations (max. 10‘)	Chairmen Doug. McGuire Representants of the observer organisations	FAO; Rom P. Zingari; B. Van Haveren; M. Prachalova

Date	*Activities*	*Responsable Person*	*Remarks*
1525–1545	Success of Resolution S4	P. Zingari	European Obersvatory of Mountain Forests
1545–1615	Coffeebreak		
1615–1730	Discussion: Needs for a future sustainable Management of Mountain Watersheds Information from the Megève Workshop Passing a **resolution** to EFC, FAO and the governements of the present countries	Chairmen: P. Greminger P. Zingari	Swiss forest Agency European Obersvatory of Mountain Forests
1915	Host country reception	Swiss forest Agency	
Wednesday, 18th Sept.	**Working Party Business/Excursion**		
0845–0945	**Programme of the Working Party – defining intersessional activities** What benefits do you expect from the WP? How could this WP serve to meet the needs of your country managing the watershed in an integral way? How do we show the success of an integrated watershed management?	Chairmen: J. Krecek	Technical University of Prag
0945–1015	Coffeebreak		
1030–1230	Working Party Business Election of officers of the Working Party Date and place of the 24th session Other matters Control of success 23.rd WP Adoption of the report Excursions	Chairmen: J. Krecek	Technical University of Prag
1230	**Closing of the 23 rd Session of the Working Party**		
1230–1330	Lunchbreak		

Date	*Activities*	*Responsable Person*	*Remarks*
1330–1900	Excursion Riskmanagement in the local area of Davos Example of Debris flow measures Avalanche Risk Management Management of protective forests Visit Swiss Federal Institute for Snow and Avalanche Research	Different speakers (see special programm)	
Thursday, 19th Sept. **(all day ending in Zurich)**	Study Tour - Special Program Examples of Avalanche and Torrentcontrol in Switzerland Davos – Oberalp – Gotthard-Luzern – Zürich	Different speakers (see special programm)	