SWISS NATIONAL RESEARCH PROGRAMME 31 (NRP 31) : « CLIMATE CHANGES AND NATURAL DISASTERS »

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ABSTRACT

The objective of the NRP 31 is the detailed study of the mechanisms and consequences of future climate changes in the Swiss environment, and the resulting interactions between climate, the water cycle, natural hazards, ecosystems and society.
This programme should help improve our understanding of the response of the environment to abrupt short-term climatic events and to long-term climate changes, and provide answers to economic and political decision making. The emphasis of research will be on processes acting on the regional scale, especially in the Swiss Alps. A particular attention will be given to interdisciplinary studies. There is an attempt to bring together specific projects in especially sensitive geographical test-zones, as representative as possible of Swiss conditions. Numerous applications of the research supported by NRP 31 are envisaged, results will be continuously subject to detailed and realistic assessment.
As an example of this approach, the flood events which affected the town of Brig in the Swiss Alps the 24 September 1993, will be presented and discussed in detail.

INTRODUCTION

Our environment is a dynamic system which operates both in the short term (for example extreme weather events) or in the long term (climate processes). While natural catastrophes are often caused by unpredictable extreme perturbations, causing destructive effects on local or regional scales, climate changes operate on far larger spatial scales and impact upon the natural environment and also, in the long term, on socio-economic systems.
The general public, the media, as well the national and international policy-makers are becoming increasingly concerned by such problems, as exemplified by the United Nations Conference on Environnment and Development in Rio de Janeiro in June 1992. As a conclusion, the potential impacts of abrupt climate changes are sufficiently important to justify immediate negotiations, even if many uncertainties remain as to the nature and amplitude of climate changes in decades to come.
In this context, the Swiss Federal Council approved in June 1990, the NRP 31 Programme on «*Climate Change and Natural Disasters*», which is financed by the Swiss National Science Foundation. This programme represents a Swiss contribution to international research efforts on this theme, and is coordinated for example with the UN International Decade on Natural Disasters Reduction (IDNDR). NRP 31 brings together fundamental research, interdisciplinary studies, and policy response strategies in order to provide a scientific framework for economic and political decision making on the national level.

DESCRIPTION OF THE SWISS NATIONAL RESEARCH PROGRAMME 31

Context and Objectives

The principal objective of the NRP 31 is the basic study of climate processes in the alpine region - both in present-day climate and in a changed global climate - and the detailed examination of the consequences of possible futures climate changes. This programme should help improve our understanding of the response of the environment to sudden short-term climatic events as well as to long-term climate changes, and then to test how society and politicians react to these events in Switzerland (NRP31 1992).

Climate changes represent one of the major environmental preoccupations of this decade. Conclusions of the IPCC - Intergovernmental Panel on Climate Change - (Houghton *et al.* 1990, 1992) predict an alarming increase of the atmospheric temperature on the earth. The ground-level atmospheric temperature has increased globally by 0.3 to 0.6 °C since the middle of the last century, although there is yet no clear indication from observations of a direct link between emissions of greenhouse-gases from industry and agriculture and this global warming trend. Nevertheless, if this trend is confirmed, predictions for the future are pessimistic : a rise of 1 °C by the year 2025 and about 3 °C by 2100 (0,3 °C per decade) with the IPCC scenario A: «*Business as usual*» (Houghton 1990, 1992). This is a rate of change 10-100 times greater then natural climate variability.

Specific model calculations for future climates in 2030 for the Southern Europe, based on a doubling atmospheric CO_2-concentration scenario (IPCC-A), reveal trends of increasing mean temperatures, especially in summer (+ 2 to + 3 ° C), and increasing precipitation sums in winter (+ 5 %) but a marked precipitation decrease in summer (- 5 to - 15 %). These trends are consistent with present-day hypotheses concerning greenhouse-gas forcing of the climate system.

Conclusions of the IPCC on the global scale will have also effects on the regional alpine scale, which will also be sensitive to climate changes. If the expected global warming is confirmed for the next century, we can forecast for example a spectacular retreat of the glaciers (up to three quarters of the present surface area), an upward migration of the permafrost boundary (200 to 700 m) and of the snowfall level (150 to 300 m), a change in the precipitation régime, an acceleration of the water cycle (water discharge), an increase in frequency and size of storms, a loss of biodiversity, etc. Under climate changes, the risks of natural disasters may grow in frequency and intensity for the next decades : storms, heavy rainfalls, floods, mudflows, landslides, rockfalls, avalanches, glacial damage and forest fires (resulting from greater aridity). On the other hand, natural disasters are also caused by a combination of different unfavorable factors linked to human development (settlements or change in land-use). These disasters will have more serious effects and increasingly affect areas that have so far remained untouched by such phenomena. From an economic point of view, costs due to more frequent natural disasters may be enormous, for example one can mention investments for protection infrastructures or impacts on mountain economies (changes in ecosystems, agriculture, forestry, land-use and tourism, especially winter skiing).

The problem of climate change on the regional scale and its resulting interactions between climate, ecosystems, natural hazards and society is the main thrust of NRP 31 activities. Numerous applications of the research supported by NRP 31 are envisaged. The emphasis of research will be on processes acting on the regional scale, in which the Alps and their interaction with their surroundings will be a major focal point. The completion of the programme is scheduled for 1997. To date, 50 research groups are taking part in the NRP 31, coming from Swiss higher educational institutes (Universities and Federal Institutes of Technology), administration, private research firms. A particular emphasis will be given to interdisciplinary studies. In order to encourage cooperation between researchers and facilitate the collation of results and their applications, five project groups have been formed. The Fig. 1 summarizes the main themes examined in each group (NRP31 1992).

Consequently, it will be attempted to bring together specific projects in especially sensitive geographical test-zones, as representative as possible of Swiss conditions. Three regions in the Swiss Alps have been designated for this purpose, characterized by a concentration of research projects (areas situated in both French and German parts of Switzerland). Throughout this period, research results will be continuously subject to detailed and realistic assessment of the risk potential under changed climatic conditions, and a sound assessment of the policy response strategies.

NRP 31 investigations are now in progress and will completed by the end of 1996. We propose here to discuss rapidly two aspects concerning climate changes, especially warming, derived from the first available results. In the next two chapters, we will first focus on features of observed climate in Switzerland since 1901, then we will discuss a practical example of crisis management, taken from the flood disaster which affected the town of Brig in the Swiss Alps in September 1993.

Figure 1 : Summary of the main themes examined in the research groups of the NRP 31.

NRP 31 Groups	*Themes*
CLIMATE	Historical climate data, post-ice age climate history reconstruction (in lacustrine sediments and ice cores), simulation of present and future alpine climate, regional scale climate data (downscaling methods).
WATER CYCLE	Flow discharges, water régime in ground and snow cover, karst and ground-water reservoirs behaviour, dimensionning of hydraulic works, heavy rainfalls, hail, monitoring with radar technology, dynamic of storms.
NATURAL HAZARDS	Processes of ice and snow melting, glacier fluctuations, icefalls, avalanches, permafrost evolution, drainage processes in torrents, floods, mudflows, climate influence on landslides, rockfalls and rockslides.
ECOSYSTEMS	Impacts on soils and roots, modification of vegetation types, reactions to a rise of atmospheric CO_2-concentration, simulation of changes in ecosystems, impacts of storms, forest fires.
SOCIETY	Social, economical, political, and administrative aspects, land-use planning, risk and disaster management, impacts on tourism and agriculture, damage statistics, risk perception of population and decision-makers.

First Results : Lack of Snow and Retreat of Glaciers

For the first time in over 300 years, 7 successive years with little or no snow were recorded on the Swiss Middlelands between 1988 and 1993. Is this an indication that winters in Switzerland are subject to warming which exceeds the mean climatic variations of the past? Written historical records since the late 15th century, and data from the climatological network of the Swiss Meteorological Institute, provide the longest information on snow statistics in the world *(NRP 31 Project Pfister: "Space-time reconstruction of weather anomalies").* These data confirm that winters in the late Middle Ages were colder and had more snow than today. During the Little Ice Age, which ended around 1880 - 1890, the duration of snow cover on the Swiss Middlelands averaged about 60 days per year. During the 20th Century, average snow duration has been about 46 days, and only 20 days in the past seven years. However, it should be emphasized that the increasing tendency for snow-free winters observed since 1988 should be put into the perspective of other periods of lack of snow which have occured in the past, as will be seen in the next section.

Another effect of global warming is associated with the retreat of mountain glaciers. The morphology of Swiss alpine glaciers has undergone profound modifications since 1850, and this will continue to be the case under expected climate change conditions. Warming has pushed upwards the average level of snowfall by about 100 m, and has resulted in a spectacular retreat of glaciers in which over 35% of their surface area has been lost since 1850. If this tendency were to persist, then the retreat of glaciers would accelerate, leading to the disappearance of many glaciers, in particular the smaller ice fields; an increase in mean temperature of 1.8 °C would be sufficient to reduce the number of existing Swiss glaciers by 80% and total surface area by 70% with respect to today's situation. It is estimated that in the next 25 years, the surface area of glaciers in Central Switzerland (Gotthard and Grisons) will diminish by about one-quarter. In these regions, one glacier out of eight will have disappeared by the year 2020, and by the end of the 21st Century, only one-fifth will remain *(NRP 31 Project Maisch: "Impacts of climate changes on glacier surfaces: Scenarios of the retreat of glaciers).*

However, this situation, as in the case of snow statistics, is not exceptional. In the last 10,000 years, similar or even stronger glacier retreats have occured. Nevertheless, the evolution of climate and its influence on snow and ice, plays an essential role in the present socio-economic context in terms of mountain tourism and the ski industry, where considerable investments have taken place in recent decades. Climate change will result in a reduction in the ski season (from January to March) and in an increase in skiing on glaciers or on snow fields at higher altitudes above 1500 m *(NRP 31 Project Elsasser: "Effects of climate change on tourism").*

CLIMATIC ASPECTS IN SWITZERLAND

What are the consequences of the IPCC conclusions on the Alpine scale ? Unfortunately, current prediction tools (General Circulation Models) have an insufficient spatial resolution to be applied directly on a local scale, for example to a mountainous region as the Alps. Several approaches are being tested, as part of the NRP 31, to establish a link between global and regional atmospheric scales («Downscaling» procedures; Beniston 1994). Final results will be available by the end of this year. We prefer to present here features of the observed climate in Switzerland, from the climate data available for the last hundred years (1901-1992; Beniston *et al.* 1994a, 1994b; *NRP 31 Project Roten : "Spatial resolution of climatic modifications in the Alpine domain"*). In this country, climate data have a space and time distribution which gives a relatively precise idea of the climatological evolution on a regional scale since the beginning of the 20th century (1901), or even earlier for certain stations (since 1864). The Swiss Climate Data Base of the Swiss Meteorological Institute comprises one of the densest climatological networks in the world with over 150 stations over the Swiss territory (approx. 41'000 km^2).
The complexity of Alpine climates in terms of macro-scale features is brought by the competing influence of Mediterranean, continental, Atlantic and Polar régimes. Any response to global climate change will result in the altered frequencies of these principal régimes, possibly leading to an amplification of the regional response of climatological variables (temperature, precipitations, sunshine duration, snow depth, pressure).

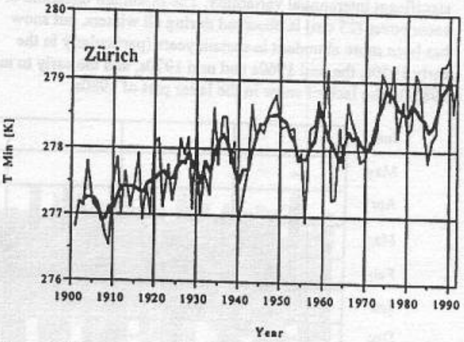

Figure 2 : Average annual daily minimum temperature trends in Zürich, 1901-1992, the bold line represents a 5-year filter function to remove high-frequency fluctuations from the data.

Fig. 2 provides a graphical representation of the evolution of daily minimum temperatures at the station of Zürich from 1901 to 1992; a five-year running mean has been applied in order to filter out high-frequency fluctuations from the data (Beniston *et al.* 1994a, 1994b). At this station, minimum temperatures have increased continuously by about 2 degrees during this period, especially in the early fall and in the winter. Maximum temperatures remain essentially unchanged and exhibit even a light decreasing trend especially between 1940 and 1980 (- 1 °C). As a result of these observations, the diurnal range of temperature has tended to decrease on an annual average basis from 9 °C at the beginning of the century to about 7.5 °C today. This fact has been reported in other analysis studies for the Northern Hemisphere, and is also consistent with model studies of greenhous-gas induced warming (Beniston *et al.* 1994a, 1994b). Since the mid 1980s, the annual trends of increasing temperature in Switzerland are therefore in accord with the global warming tendencies, but the rate of warming far exceeds that of the global tendencies. Nevertheless, the Swiss data indicates that the 1940s were the warmest decade of the century (1.5 °C/decade rate of warming), more so than the 1980s (1 °C/decade), when the 1960s and 1970s revert to cooling (- 1 °C/decade). When all the records are combined together, the net effect over the century is a warming, which is also consistent with the IPCC projections.

The data for precipitation show no significant trend over this century in Zürich and in other Swiss stations, while sunshine duration shows a general tendency of decreasing through the century until the early 1980s. However, these two variables exhibit very noisy time-series, reflecting strong interannual variability in the Alpine region.

Fig. 3 gives an overview of the occurrence of snow cover in the Alpine village of Davos (1590 m) during the period from 1931-1992, for three thresholds of total snow depth (25, 50 and 70 cm respectively). The main comment concerning the snow depth is that, even in a high-altitude resort as Davos, there is a significant interannual variability. The minimum threshold of snow cover (25 cm) is observed during all winters, but snow has been more abundant in certain years (particularly in the early 1950s, the mid 1960s and mid 1970s, and the early to mid 1980s). The lack of snow in the latter part of 1980s, culminating in the winter 1989-1990, which raised considerable media interest and led to financial difficulties for low-altitude resorts (under 1500 m), was not in itself an exception. There have been other periods in which snow has been lacking in terms of snow duration and abundance (for exemple 1978-1979).

During the most part of the century, the annual average pressure mesured in Zürich, representative of the large-scale pressure field over Switzerland, has fluctuated within a range of 949-951 hPa. Since the beginning of the 1980s, however, the surface pressure has increased continuously to reach values beyond 952 hPa. Persistent patterns of high pressure episodes and extended periods of blocking highs can be also identified in the records toward the 1990s. This pronounced increase of pressure since the decade of the 1980s seems to be related to a greater frequency of blocking high episodes in the Alpine region, especially during the winter season, which may be indicative of a shift in the relative occurences of typical weather régimes over the Alps in recent years (Beniston *et al.* 1994a, 1994b). On the other hand, the behavior of pressure in Switzerland seems closely associated with periods of blocking episodes related to North Atlantic Oscillation Index (NAO is a measure of the strength of the Westerlies over the North Atlantic), confirming the link between the global and the regional scale.

The periods of persistent high pressures, especially towards the end of the 1980s, were accompanied by low snow depth. This reflects the fact that snow precipitation during episodes of blocking high pressures was insufficient to allow snow to accumulate to the depths generally attained in other years of greater snow abundancy.

Figure 3 : Time-frequency diagram of snow depths in Davos for 25, 50 and 75 cm thresholds. The vertical extent of the bars corresponds to the duration of the events.

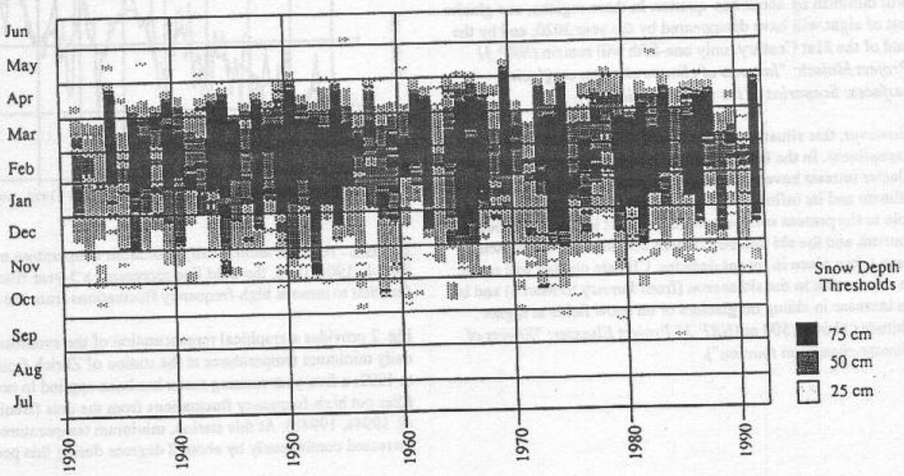

Fig. 4 shows that the beginning of the snow season in the Alpine village of Davos (for the 25 cm threshold) underwent a change from the 1930s to the early 1970s, when the snow appeared as much as one month earlier in the 1970s. In the last 20 years, however, the beginning of the snow season has reverted to its values of the 1930s. The duration of snow cover in excess of 25 cm has an inverse relationship : there was a marked increase in the duration of the snow season from 1930s to 1970s (130 days to 160 days with continuous snow cover), then a return to the 1930s values in the 1980s. The winter 1989/90 was the period of least snow duration of the recorded data (98 days). It should be noted that geographical aspects (slope orientation and exposure) are quite important for the distribution of snow in time, which is often a regional feature.

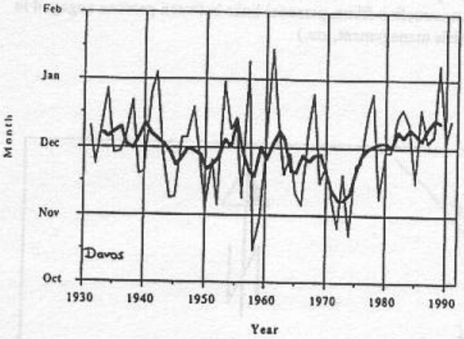

Figure 4 : Evolution of the beginning of the snow season in Davos, 1930-1992, the bold line represents a 5-year filter function to remove high-frequency signals from the data.

In conclusion, for all climatological parameters, it appears that the amplitudes on the regional scale are much larger than on the global scale, but it has been established that there is indeed a regional response or a regional sensitivity to global changes, especially in the 1980s (high pressures in fall and winter). All variables, especially the snow depth, exhibit strong interannual variability with decadal-scale fluctuations. On the other hand, sunshine duration, precipitation and to a lesser extent temperature, anomalies are particularly well correlated with the pressure anomalies for the North of the Alps. There is thus some evidence that climate trends in Switzerland are consistent with global warming tendencies.

Correlations between high-elevations stations are quite good and serve to support the hypothesis that the same climatic change is leading to the same kind of response within the Alps. This gives the possibility to cluster Alpine climate stations into groups of similar climates on a regional scale. One significant difference concerns the South of the Alps which exhibits a different climatic régime dominated by Mediterranean-type climate (precipitations and temperature), the Alps acting as a significant barrier to the westerly and northerly airflows.

CASE STUDY : FLOOD DISASTER IN BRIG/ WALLIS - SWITZERLAND (SEPTEMBER 1993)

General Context (Kunz 1993)

On September 24, 1993, the town of Brig and the region of Upper Wallis in the Swiss Alps were struck by catastrophic floods. These events were linked to a meteorological situation characterized by a warm and moist depression moving in from the Western Mediterranean. This perturbation was blocked by the southern slopes of the Alps and resulted in intense and continuous precipitation for 5 days (approx. 400 mm total rainfall). Because of the high level of the 0 °C isotherm (3,000 m), precipitation was not retained at high elevations as snow. As the soils had exceeded their saturation limits, surface runoff resulted in an intense erosion of the river basins and a rise in the river levels leading to severe flooding; the return period of such events is estimated at between 30 and 70 years. In the town of Brig, the discharge of the Saltina river rose excessively, as well as the sediment load whose volume was estimated at 250,000 m^3.

In meteorological terms, the intensity of precipitation recorded during this event was not in itself exceptional. The catastrophic flooding in Brig was more the result of construction (under-dimensioned bridge) and urbanization with excessive building in sensitive zones. 20,000 people were affected by these floods, but only two people lost their lives. Estimates of damage costs are in the range of 500 million Swiss Francs (US$ 380 million).

The Brig Flood Event (September 24, 1993)

Following three days of continuous rainfall, the Saltina river which originates in the Simplon Pass area, began to threaten the town of Brig through which it flows. On September 24, 1993, around noon, the level of the river was very high beneath the "Saltinabrücke", a bridge 70 m large. At 2 PM, the police and fire brigades were on full alert. Around 4 PM, the river and its load of gravel and rocks, had more and more difficulty in flowing beneath the Saltinabrücke. The excessive sediment load began to block itself beneath the upstream edge of the bridge, thus immediately forming an obstacle to the flow. At this stage, the Saltina flowed out of its bed. This is located on an alluvial cone, so that the flood waters followed the line of maximum slope, thereby flooding neighboring settlements and in particular the town of Brig, where the main streets were invated by thousands of cubic meters of sediments (Fig.5).

During the alarm phase, the population was requested to leave the buildings, in particular the ground level and cellars. However, these recommendations were only partially followed, and most people were surprised by the swift arrival of the flood waters. The first reactions were to place sand-bags on the Saltinabrücke and to use bulldozers to dig out the river bed; it was soon obvious that these measures were of little use.

The Brig fire brigade managed to set up a minimum coordination infrastructure within the first hours of the disaster, rounding up 60 local firemen. In parallel, other organizations such as the Civil Defense and the Swiss Lifeguard Society came into action, followed by spontaneous actions on the part of small firemen's groups. These latter contributions are difficult to evaluate, but confirm the capability of the various firemen's divisions to organize themselves rapidly and spontaneously in an independent manner.

From the moment that a crisis unit was set up, a major coordination effort of all brigades was attempted. One of the first effective measures to reduce the flooding was to build a wood and gravel dam on either side of the river. The work to tame the Saltina was carried out by a local construction firm and lasted all night. The river bed was slowly cleaned and emptied, after three and a half days of uninterrupted work.

Local Crisis Management (Zimmermann and Müller 1994)

Even though there had been crisis management exercises, the executive authorities of the town of Brig had no first-hand experience of how to manage such a catastrophe. The chief of staff of the crisis unit was the president (mayor) of the town of Brig. The first meeting of the unit took place on September 24 at 5 PM, at a time when the tasks and representativity of the persons present was not yet clearly defined. The first meetings of this crisis unit were poorly structured and the decisions taken were vague; much improvisation was required in view of the unusual situation. However, it became clear that one of the main tasks of this unit was to avoid panic in the population. In order to remain efficient and to face up to complex problems, an optimal use of existing structures was encouraged (construction frims, personal links between persons engaged in crisis management, etc.)

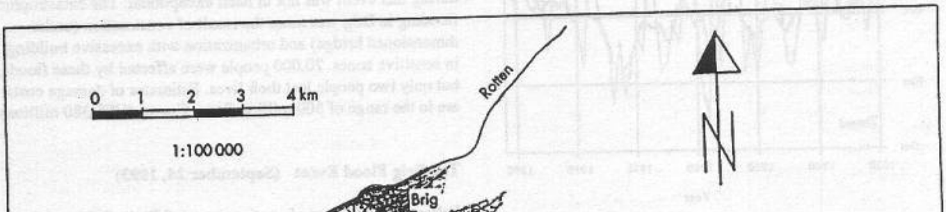

Figure 5 : Location of the Swiss town of Brig in its surroundings with the drainage basin of the river Saltina.

From the start of the events, the local radio station (Radio Rottu) played a leading role in the broadcasting of information at a time when other means of communication were cut. The search for missing persons also took place with the help of the station. At a later time, official communications for the press, the radio, and television were the responsibility of the chief of staff of the crisis unit, who had to take into account difficulties related to verification of information. Caution was required to counter the tendency of the media to look for "spectacular" information only. A "communications triangle" was thus established, each with its own problems: the crisis unit (credibility), the media (competition) and the population (insecurity); the latter two tended put to pressure on the crisis unit to take immediate action.

24 hours after the event, the crisis unit needed to be restructured, because the management of the catastrophe now required more professional management, organizational and technical expertise. At this stage of the organization, it became obvious that the crisis unit, and in particular its chief of staff, required full powers while at the same time retaining a unified decision basis. This type of managemenent may appear somewhat totalitarian but is in fact well embedded in the Swiss social traditions. The crisis management thereby higlighted the central role played by the chief of staff, i.e., the president of the town of Brig. His knowledge of the area, his popularity at the local and regional level, his political capacity, his military experience, and generally his natural authority made him a principal actor, also with respect to the cantonal and federal authorities. The president of Brig was later an essential figure during the phase of financial compensation for flood damage by private insurance companies and by the Swiss Confederation.

The crisis unit divided itself at that time into several sections, each responsible for a particular activity: construction and safety, coordination, finance, supply, insurance and compensation, etc. The coordination section was aimed at overseeing the three aid organizations: the fire brigades, the civil defence, and the army, all incorporated into a civil and military structure. Essential tasks needed to be carried out according to a set of priorities; safety, search for missing persons, cleaning up, reconstruction, and definition of the needs of the population. The re-establishment of infrastructure was related particularly to electricity (fully re-established at the beginning of October), telephone links, fresh water supply (the ground water table had been polluted by hydrocarbon spills), sewer control, domestic heating, and control of food supplies. The reconstruction phase lasted between 4 and 12 months.

Overview and Consequences (Zimmermann and Müller 1994)

After a week of coordination, the activities of the fire brigades were significantly reduced and were replaced by the military. Fire brigades are typically operational for short periods of time only. The army was instrumental in coordinating work, as opposed to the civil defense where the hierarchy was poorly defined and whose equipment was rudimentary and insufficient. The army was thus perceived as one of the most competent partner in the crisis division. Following the catastrophe, the army remained active for 30 days with aver 1,500 troops engaged. The image of the army within the ranks of the population was boosted during the cleaning up operations. However, the inhabitants of Brig were more reluctant to see the security measures and ID checks established by the military in conjunction with the local police to avoid acts of plunder and vandalism.

After 10 days, the crisis unit reduced its activities, following the cleaning up of rock and mud deposits in the streets and the stepping down of part of the military troops. The members of the unit were partially relieved of their responsibilities when reconstruction work began to be coordinated by specialists of aid organizations.

The crisis management of this catastrophe highlighted the essential role of the Brig authorities, as well as that of the police and local fire brigades, and later that of the army. These key players were first to be on the site during the acute crisis phase, in the first 6 - 36 hours, and then were operational for the immediate management of the catastrophe. Throughout this crisis, the cantonal and federal authorities were not present in the first hours following the catastrophe, even though they had been alerted of the imminent danger in Brig (reconnaissance by helicopter, telephone calls, etc.). It took more than 24 hours to set up an information unit at the cantonal level.
Following this catastrophe, emergency exercises have been conducted by the local authorities. Additionally, technical measures to avoid future flooding by the Saltina have been suggested by ETH-Zurich, involving protective dikes, cleaning-up of the river bed, and predicting zones of alluvial depositing. The previous flooding episode took place in 1927. However, in September 1994, exactly one year after the catastrophe, a small flood by the Saltina threatened Brig once again as a result of a similar meteorological situation. The fears of the town's inhabitants concerning their future seemed justified.

CONCLUSIONS

On the basis of the final report of the NRP 31, which will published in 1997, recommendations for pratical applications, strategies and action plans, will be made for both state institutions and private individuals. Follow-on projects will also be formulated. Although we cannot act to control climate phenomena directly, we do have the possibility of reducing the consequences of natural disasters through appropriate preventive measures. In future, we shall increasingly be faced with problems of catastrophic impacts on natural and socio-economic systems, especially if an increase in frequency and intensity of meteorological «trigger» events, such as those that have affected the town of Brig, are to be expected as a result of global warming. The recurrence of such disasters (when and where the next one will occur ?) and the ability of policy makers to react, represent one significant goal of the research in the NRP 31.

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