


VADEMECUM

HAZARD MAPS

AND RELATED INSTRUMENTS

THE SWISS SYSTEM AND

ITS APPLICATION ABROAD

CAPITALISATION OF EXPERIENCE

DEZA DIREKTION FÜR ENTWICKLUNG UND ZUSAMMENARBEIT
DDC DIRECTION DU DÉVELOPPEMENT ET DE LA COOPÉRATION
DSC DIREZIONE DELLO SVILUPPO E DELLA COOPERAZIONE
SDC SWISS AGENCY FOR DEVELOPMENT AND COOPERATION
COSUDE AGENCIA SUIZA PARA EL DESARROLLO Y LA COOPERACIÓN

Foreword

Risks from natural hazards play an increasingly important role in developing as well as developed countries. Switzerland is not an exception. Mountainous terrain is at the origin of various types of hazards. Major disasters in the past decades were a wake-up call for authorities, insurance companies and the public at large. A review of the risk and disaster management system became evident. The assessment of the prevailing hazards, vulnerabilities and risks was recognized as an important task and the representation of the information on maps necessary for many reasons. The answer to the question "what is likely to happen" is the key to protecting oneself in a sustainable way. Therefore, hazard maps and related instruments have been developed on a federal level and applied in many cantons and municipalities over the past 10 years. The Swiss system and its integrated risk management, taking into account the three aspects of prevention, intervention and reconstruction in a balanced way was also exported to some foreign countries.

The present vademecum is an up-to-date working aid for persons who deal with the management of risks from natural hazards. PLANAT, the Swiss national Platform Natural Hazards (www.natural-hazards.ch), promotes a sound assessment of hazards and risks as a first step in the whole disaster risk reduction process. A specific task force of the platform is dealing with relevant and current international aspects in the field of natural risk management, as a contribution to the Swiss cooperation and know-how exchanges with foreign countries.

Hazard maps and related instruments are necessary tools to represent and visualize the conditions found on the ground. The booklet shows the major concerns when developing and producing hazard maps, provides a critical view on the Swiss system, and it points to obstacles when implementing the information on the map.

PLANAT encourages readers of the vademecum to use the information provided and to apply it accordingly.

Andreas Goetz
President of PLANAT

PLANAT
Nationale Plattform Naturgefahren
Plate-forme nationale «Dangers naturels»
Piattaforma nazionale «Pericoli naturali»
National Platform for Natural Hazards
www.natural-hazards.ch

Impressum

Authors

Markus Zimmermann	NDR Consulting Zimmermann, 3600 Thun
Andrea Pozzi	Niederer + Pozzi Umwelt AG, 8730 Uznach
Franz Stoessel	SDC, 3003 Bern

Contributors

Pedro Basabe	UN ISDR, 1211 Geneva
John Beck	EPFL, 1015 Lausanne
René Graf	Forest Service, Canton Luzern, 6002 Luzern
Svetlana Jumaeva	SDC, COOF Dushanbe, Tajikistan
Roberto Loat	FOWG, 2501 Biel
Ali Neumann	SDC, COOF Managua, Nicaragua
Zora Papankova	SDC/SVP, Bratislava, Slovakia
Monika Supekova	SDC/SVP, Bratislava, Slovakia
Philipp Teysseire	Teysseire & Candolfi AG, 3930 Visp
Daniel Zimmermann	Niederer + Pozzi Umwelt AG, 8730 Uznach

Bern, May 2005

Abbreviations

DFID	Department for International Development, UK
FOWG	Federal Office for Water and Geology
PLANAT	Swiss National Platform Natural Hazards
SAEFL	Swiss Agency for the Environment, Forests and Landscape
SLF	Swiss Federal Institute for Snow and Avalanche Research
WSL	Swiss Federal Institute for Forest, Snow and Landscape Research
SDC	Swiss Agency for Development and Cooperation
UNDP	United Nations Development Programme
UN ISDR	United Nations International Strategy for Disaster Reduction
DTM	Digital Terrain Model
GIS	Geographical Information System
VCA	Vulnerability and Capacity Assessment

Content

1 Why this vademecum?

In recent years the Swiss Agency for Development and Cooperation (SDC) has been working in a number of countries in the field of natural disaster reduction. In many cases hazard maps were produced and implemented. The Swiss policy in general as well as the Swiss methodology to assess hazards and to mitigate risks in particular served as a conceptual basis. The experience gathered during these activities was taken as an opportunity to review the application of the Swiss methodology in a foreign setting.

This vademecum deals with various aspects of hazard and danger maps and their related products. It is directed to SDC staff (in the field or at headquarters) who manage disaster reduction projects or who are involved in development projects in hazard-prone areas. It will:

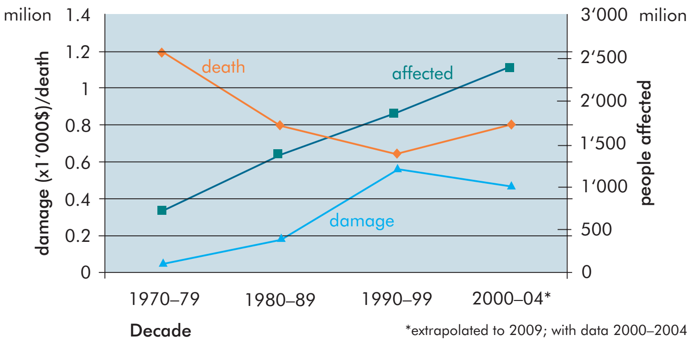
1. provide a methodological framework for hazard and risk maps (chapters 2 and 3);
2. highlight the Swiss approach (chapter 4);
3. describe the application of the Swiss system abroad (chapter 5), and finally;
4. point to issues related to the practical use of such instruments (chapter 6).
5. In chapter 7 some recommendations are summarized.

The instruments presented and discussed in this report focus on water-related hazards and risks, i.e. flooding, flash floods, debris flows, landslides. Specific instruments used for other natural hazards, particularly earthquake zoning, are presented but not further commented.

2 The need for hazard maps

Natural disasters constitute an increasing threat and burden for many countries, not only in the developing world. While the annual death toll due to floods, earthquakes or droughts decreased by two thirds to about 60’000 persons during the last three decades, the economic damage worldwide increased tenfold in the same period (www.em-dat.net). Several years of development can be wiped out by one individual disaster, as was the case for Hurricane Mitch in Central America (1998). Therefore, disasters have to be seen essentially as a development failure and their reduction is not only a topic in and of itself but increasingly an issue for all development activities. The 2004 report by the UNDP “Reducing Disaster Risk: A Challenge for Development” (http://www.undp.org/bcpr/disred/rdr.htm) or the DIFD publication: “Disaster risk reduction: a development concern” strongly highlights this necessity.
(www.dfid.gov.uk/pubs/files/disaster-risk-reduction.pdf).

Disaster impact



*extrapolated to 2009; with data 2000–2004

Evolution of disaster impact (death, affected, damage) per decade. Information for last decade extrapolated from data 2000–2004.

Source: Data from CRED database (www.em-dat.net).

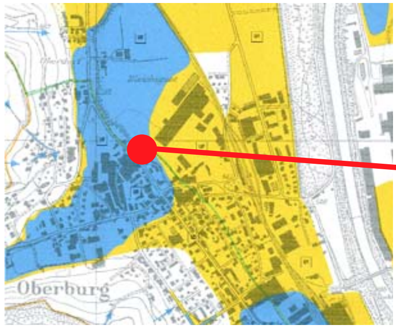
A thorough assessment of the prevailing hazards and risks in a specific region is imperative for any kind of development activity that has a spatial impact. This is particularly important in disaster-prone areas, like large floodplains, narrow valleys with landslides and rock fall, or areas of high seismicity. Today, a number of tools and instruments are available to analyse, visualise and evaluate major hazards and risks.

The most well-known and established tools in Switzerland are different types of hazard maps. Here, the term “hazard map” is used as a generic term for maps showing any kind of hazard information (e.g. occurrence of past events, landslide areas, floodplains, etc.); where as a danger map clearly represents the degree of danger in a particular location (cf. paragraph 4.2.3). There are other tools that serve as a basis for or are inferred from hazard or danger maps. The most important are:

Type of instrument	Content	Purpose
Event map **Event register**	Record of past events: – Type of process (flood, slide, etc.) – Extent of affected area – Date of occurrence	Provides a first overview of the hazard and disaster conditions in a particular area if many cases are recorded. Basis for other hazard maps.
Hazard indication map (hazard index map)	Representation of the: – Type of hazard – Spatial extent of process (areas possibly affected by an extreme event)	Provides an overview of the hazard situation (where a hazardous process such as flooding or landslide might occur. Priority setting for land-use management (overall basis) or planning of measures Monitoring of sites
Danger map	Representation of the: – Type of Hazard – Spatial extent – Degree of danger, i.e. ■ magnitude of process ■ frequency of process – Additional information (as required)	Management tool for – land-use planning (municipal level) – structural and non-structural measures, – emergency planning – site monitoring. Basis for risk assessment
Vulnerability map	Various aspects of vulnerability, e.g. population density, overall living condition (poverty, income, employment, health, education, etc), water and sanitation, condition of structures. In Switzerland the map of damage potential is used as a vulnerability map.	Tool for emergency management. Management tool for priority setting (structural and non-structural measures) and land-use planning Basis for risk assessment.
Risk map	Areas of comparable risk. Very often a qualitative classification (e.g. low to high), or in some cases a quantitative scale (damage per ha per year; number of deaths per ha per year	Most appropriate tool for decision making (planning of structural and non-structural measures).

When working with these tools and instruments three questions have to be answered:

- What is the content of the instruments, what do they show?
- How are these instruments produced and later on used?
- What are generally the problems when producing or applying these instruments?



The flood danger map of Oberburg (Switzerland) represents the danger of this particular situation.

Flood event in Oberburg, 1 July 1987.

In the past few years, Switzerland developed a number of such instruments. These serve as an indispensable basis for an integrated disaster reduction approach, which is not only being discussed presently in Switzerland, but equally at the international level. The methodology fulfils many of the demands but also gives rise to a number of problems and disadvantages, particularly when used abroad. This refers to the production of the instruments as well as the implementation and transformation of the hazard information into practical use.

3 What exactly is risk?

The hazard – risk – disaster context

The terms hazard and risk are used in many occasions, whether people are talking of natural phenomena or of any other threat, e.g. technological risks. Unfortunately, there exists a widespread confusion about the use of these terms and their description, and therefore, of the various instruments and products as well. Very often people talk about risks and address hazards only. In other instances they mix vulnerable elements and hazards. The use of well-established definitions prevents misunderstandings. Among many glossaries, the ISDR Glossary for natural risks is today widely accepted (www.unisdr.org). These ISDR definitions on the following pages are given in quotation marks with some additional information.

Hazard

"A potentially damaging physical event, phenomenon or human activity that may cause the loss of life or injury, property damage, social and economic disruption or environmental degradation". Hazards can include conditions that may represent future threats and can have different origins: natural (geological, hydrometeorological and biological) or induced by human processes (environmental degradation and technological hazards). Hazards can be single, sequential or combined in their origin and effects. Each hazard is characterised by its location, intensity, and probability.

Superficial landslide, originating in a dense forest, sliding and flowing downhill (Emmental, Switzerland, 2002)

Vulnerability

"The conditions determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of a community to the impact of hazards", i.e. the possibility of an element at risk (a person, a village, livelihood) to be damaged or destroyed by a hazard. The vulnerability is determined by the exposure, the value and the susceptibility to be damaged (a concrete building suffers less damage than an adobe house when flooded). The coping mechanisms (trained rescue personnel, enforced building codes, etc.) can considerably reduce the vulnerability of a society and add to their resilience.

Houses on stilts within a floodplain: the vulnerability of these structures to floods is considerably reduced; however, they are more vulnerable to strong winds (Philippines, 1995).

Risk

"The probability of harmful consequences, or expected losses (deaths, injuries, property, livelihoods, economic activity disrupted or environment damaged) resulting from interactions between natural or human-induced hazards and vulnerable conditions. Conventionally risk is expressed by the notation Risk = Hazards x Vulnerability." Risk can be expressed as probable loss calculated as an average annual value or for a particular scenario.

The village under the large landslide complex is at high risk (Sörenberg, Switzerland, 2002)

Disaster / loss

"A serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources." If a hazardous process occurs, it is called an event. Only if the process affects elements at risk is it called a disaster. The resulting loss (number of deaths, direct and indirect economic loss, loss of social structures etc.) is controlled by the vulnerability of the elements at risk and the magnitude of the process.

A flood brought mud and debris to the city centre. Damage: CHF 0.5 B, two people killed (Brig, Switzerland, 1993).

Disaster risk management "The systematic process of using administrative decisions, organization, operational skills and capacities to implement policies, strategies and coping capacities of the society and communities to lessen the impacts of natural hazards and related environmental and technological disasters. This comprises all forms of activities, including structural and non-structural measures to avoid (prevention) or to limit (mitigation and preparedness) adverse effects of hazards."

Risk assessment "A methodology to determine the nature and extent of risk by analysing potential hazards and evaluating existing conditions of vulnerability that could pose a potential threat or harm to people, property, livelihoods and the environment on which they depend." Risk assessment is the basis of decision-making for every type of involvement in disaster risk management (or disaster reduction). For this purpose tools and instruments exist. Some of them were developed in Switzerland. They are currently being applied in a number of cases abroad.

Instruments The instruments discussed hereafter (chapters 4 to 6) are products to analyse, visualise and evaluate the major hazard and risks in a particular area. According to the problems to be addressed and the area to be considered, a particular type of instrument can be chosen and adapted.

Stakeholders Disaster risk management is a multi-stakeholder issue (the stakeholders, among others, are natural and social scientists, land use planners, insurance companies, politicians and, very importantly, the directly affected population). Instruments have to be produced in a manner that a great number of end-users can apply them and implement the respective information (cf. chapters 5 and 7).

4 The Swiss Approach

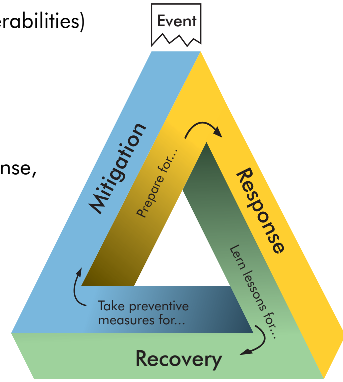
4.1 Policy

Natural disaster reduction has a long tradition in Switzerland. As early as the mid 19th century, people started to propose and implement remedial measures for hazards. For instance, large-scale reforestation during the second half of the century was implemented to reduce the then prevailing floods and mountain torrent activity. Two federal laws (forest law, water management law), enacted in 1876 and 1877, respectively, provided the basis for a major financial support by the federal government for protection works implemented by cantons and municipalities.
In the 1970s, the first hazard maps were produced (avalanche hazards) and a prototype danger map developed for Grindelwald (Kienholz 1977). The new federal law on land-use management of 1979 demanded the consideration of natural hazards for land-use planning. However, only the 1987 flood disasters initiated discussions to rethink the whole hazard reduction approach. On the federal level, new water management and forest laws (1991) and their respective decrees (1994) were established. These laws demand the cantonal authorities, among others, to perform hazard assessments and to establish the respective maps.
In recent years, with the discussions during the IDNDR (United Nations International

Decade for Natural Disaster Reduction, 1990–1999), a new Swiss policy for natural disaster reduction has been outlined. The "Platform Natural Hazards" or PLANAT (a Federal Government advisory body) acts as a coordinating platform to establish this policy and to promote its implementation (www.planat.ch). The new policy envisages a paradigm change from solely preventing hazards to a risk culture.

This new policy is based on the risk concept:

1 Risk assessment (including analysis of all prevailing hazards and vulnerabilities) according to harmonized procedures (similar for all hazards).
2 Risk evaluation and definition of protection goals.
3 Planning of measures, applying an integrated approach (according to the risk management cycle):
   - Equally balanced coping mechanisms (Prevention/mitigation, Response, Recovery) using landuse planning, non-structural, structural and biological measures as well as emergency management planning.
   - Planning of measures according to sustainability principles: Measures have to be economically effective, socially acceptable and environmentally friendly.
   - Partnership with all actors (including international cooperation). It invites all interested parties, levels and sectors into a risk dialogue. The private sector and the affected population play an important part.



4.2 Instruments

An integrated approach for the reduction of hazards and risks demands well-established hazard and risk assessments. Switzerland developed a chain of instruments to analyse, visualise and evaluate those hazards and risks.

The primary goal of all these instruments is to find answers to the following questions:

1 **What** can happen (avalanche, flood, rockfall) and **where** will it happen (which geographical locations can be affected)? *(identification of hazards)*
2 How **often** and how **intense** will it happen, how big is the expected **damage**? *(analysis of hazards and vulnerabilities and risk)*
3 What are the most **efficient ways** to **protect** people and assets? *(planning of measures)*

Operational and legally binding instruments to implement the Swiss policy are the hazard indication map (para. 4.2.2) and the danger map (para. 4.2.3). Other instruments discussed in this chapter are used as complements. Danger maps are produced in a systematic way since 1995. Until 2004 about 250 municipalities have established danger maps.
In Switzerland the instruments (hazard and danger maps, risk maps) are directly used for:

- land use planning, zoning, building codes
- emergency management
- determination of cost efficiency of structural and non-structural measures

4.2.1 Event maps and event registers

There are different types of event registers. Basically, it is a collection of information about known events, reported by the media, found in municipal archives or chronicles (including photos and/or drawings) or reported by witnesses.

Type and scale	– Written database (list) – Map with individual events; scale: 1:10’000 to 1:50’000.
Content	Event registers record date, location, effect, extent, and possible cause of events occurred in the past, including data that might have triggered the event (e.g. rainfall and discharge data). They distinguish between the various hazards like floods, landslides, avalanches, etc.
Purpose	Event registers provide a first overview of the hazard and disaster conditions in a particular area if many cases are recorded. The information may be used to verify and validate computer models and conventional hazard assessments. Event registers strongly help people to remember.
Way of production	Collection of data and information in – Existing databases (mainly national level), written reports, newspapers – National and local archives – Interviews with local people (mainly elderly persons) – Mapping (recent or known past events) Further sophistication may require digital data management (database, GIS).
Costs	An event register is a cheap instrument. A rough overview of a particular area is possible within few days, detailed information within a few months.
Obstacles and difficulties	Depending on the sources, the information is more or less detailed. Data collection may suffer from major information gaps.
Legal requirements	None

In the last few years a coherent register of events including special data forms for each phenomenon has been established in Switzerland as a digital database (“StorMe”) at the Swiss Acency for Environment, Forests and Landscape (SAEFL).

http://www.umwelt-schweiz.ch/buwal/de/fachgebiete/fg_natgef/vollzug_wag/erhebungen/

Schäden

Mensch / Tiere — Schäden ja nein

	[Anzahl] Tote	[Anzahl] Verletzte	[Anzahl] Evakuierte
Personen			
Tiere			

Sachwerte — Schäden ja nein

	[Anzahl] zerstört	[Anzahl] beschädigt	[Anzahl] betroffen
Wohnhäuser			
Industrie, Gewerbe			
Landwirtschaftl. Ökonomiegebäude			
Öffentliche Gebäude und Infrastruktur			
Schutzbauten			
Andere (Beschreibung in Memo)			

Verbindungen / Infrastruktur — Schäden ja nein

	zerstört [m']	beschädigt [m']	verschüttet [m']	Unterbruch [Std]
Nationalstrassen				
Hauptstrassen				
Übrige Strassen				
Bahnlinien				
Transportanlagen, Masten				
Leitungen				

Wald / Landwirtschaft — Schäden ja nein

	betroff. Fläche [ha]	Schadholzkub. [m³]
Wald		
Landwirts. Nutzfläche		

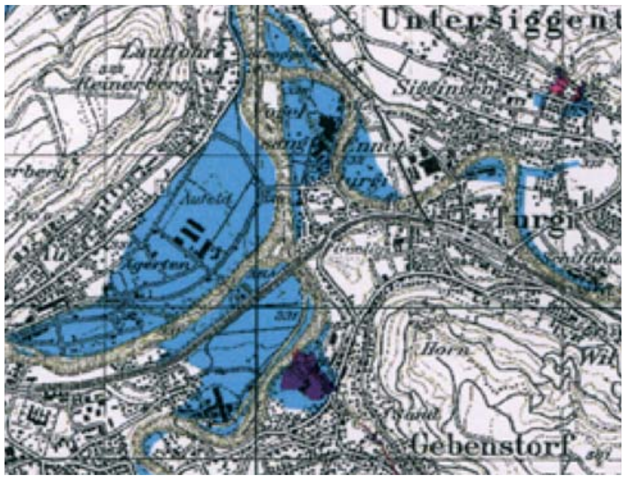
Kantonsinterne Nummer: Ereigniskatasternummer:

Grunddaten 1/4

4.2.2 Hazard indication map (hazard index map)

Hazard indication maps exist for almost all cantons in Switzerland. The maps have the following characteristics:

Type and scale	Map; scale of 1:25’000 to 1:100’000
Content	Hazards are distinguished according to the type of hazard (flood, debris flow, avalanche, rockfall, landslide), source area, flow path and impact area. Different types of hazards are outlined using signs or hatching.
Purpose	Shows where a hazardous process (such as flooding, landslide) can occur. Regional planners use the information for future planning of land use, particularly for infrastructure planning. Combined with land use information, it indicates the areas where a more explicit hazard assessment is needed (priority setting).
Way of production	Based on the interpretation of topographical, geological and hydrological data. Critical locations in the systems need to be specifically evaluated. In recent years, non-sophisticated computer models have been developed to perform mapping. Such computer models usually require Digital Terrain Models. Nowadays, GIS-based models are standard.
Costs	In Switzerland the average cost for a multi-hazard map is of the order of CHF 500 per km², i.e. CHF 250’000 for an average-sized canton.
Obstacles and difficulties	Over-interpretation by local people (at the municipal level).
Legal requirements	Binding for activities of cantonal authorities (cantonal land-use plans), non-binding for private land tenures.



Legend:
- extreme floods possible
- debris flow possible

Source:
Detail of the flood hazard indication map of the Canton Aargau, Departement of Water Courses, Aarau

Scale established: 1:25’000
Scale published: 1:50’000

Hazard indication map of the Canton Aargau, Switzerland

4.2.3 Danger map

The danger map is the most established and used product in Switzerland. If the Swiss system is mentioned, mainly this map, its way of production and its implementation are referred to.

Type and scale	Map; scale of 1:5'000 to 1:10'000
Content	– Type of process (flood, landslide, rockfall, avalanche, etc.) – Intensity of the process (e.g. water depth, flow velocity, rockfall energy) – Probability of the process with four probability classes: return period 0–30, 30–100, 100–300 years, extreme event. The degree of danger is represented by three colours (see below).
Purpose	– Primary management tool for land-use planning and regulation at the municipal level (adaptation of the land use plans according to the degree of danger to prevent an increase in risk and to control present land-use). – Justification for structural protection measures. – Basis for site monitoring and emergency planning. – Basis for risk assessments.
Way of production	The technical basis for the danger maps is a set of intensity maps (see para. 4.2.7) produced for particular probability classes and then overlaid to determine the critical danger situation. Recommendations by the federal government regulate the criteria, which have to be applied when producing danger maps (for reference see para 8.1). In general, the production of a danger map is an interdisciplinary work.
Costs	Danger maps according to the recommendations require about 5 working days per km². To establish a map for a municipality requires about 1 year.
Obstacles	The danger maps have to consider land plots (high level of accuracy). For some hazards (e.g. debris flows) there is a range of interpretation in the delineation of the various danger classes. Without regular updates, the map might loose its value (due to major topographical changes or construction activity)
Legal requirements	Binding for land tenures.

In recent years, the application of geographical information systems (GIS) and computer models (disposition models, 1d- and 2d process models) have been applied for the simulation of natural hazards (mainly flooding, debris flow, rockfall, avalanche, slope failure). Disposition models simulate the susceptibility of a particular area to release hazardous processes. In most cases they are composed of various layers (e.g. slope angle, geological conditions, watershed size etc.), which can be overlaid using GIS procedures. The process models calculate the areas affected as well as the intensity of the process in a particular location. A detailed digital elevation model is a prerequisite. However, even with sophisticated models, a thorough calibration and a field check to verify the results remain indispensable.

A number of models are in use in Switzerland and are also appropriate for an application in a foreign context. The following list contains the most frequently used modelling software working on PC's using Windows. These simulation programmes are available on the market (or will be soon available):

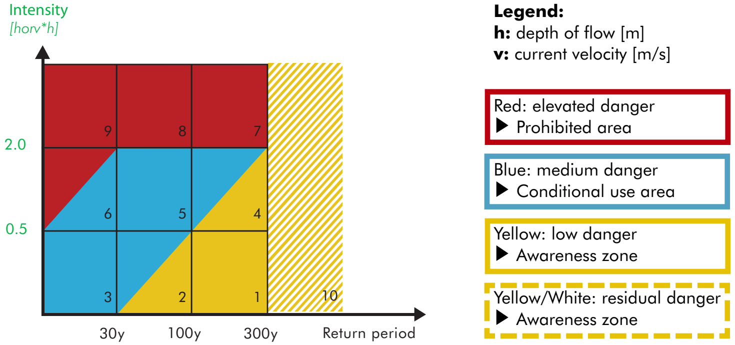
Simulation programmes for various natural hazards:

Model	Name	Requirements	Costs
1d and 2d flood	**HEC-RAS:** water surface profile model. Steady and unsteady flow modelling capabilities, including floodplain encroachments, bridges, culverts, channel modifications, split flow, sub-critical & supercritical flow, and more http://www.bossintl.com/	Easy to learn and use, allowing the user to quickly define a river model to be analysed. Data input is performed through interactive graphics and easy-to-use dialog boxes.	CHF 150
	Telemac 2d: Powerful integrated modelling tool for use in the field of free-surface flows. The various simulation modules use high-capacity algorithms based on the finiteelement method. http://www.telemacsystem.com/	Sophisticated software package, very user friendly although high skills in hydraulics are required. Pre- and post-processing tools are needed to integrate topographic & GIS data.	CHF 40'000
Debris flow	**DBF-1d** is a new one-dimensional, two-phase debris flow model for predicting flow velocities, flow heights, runout distances and impact pressures. http://www.wsl.ch/slf/dbf-1d/	DBF-1D was created for practitioners performing debris flow hazard mapping, analysis and mitigation design in steep mountain torrents.	Betaversion
	FLO-2D is a dynamic flood routing model that simulates channel flow, unconfined overland flow and street flow. It can be used for flood flow, hyperconcentrated flow and debris flow. http://www.flo-2d.com/homepage.htm	Sophisticate software, using a detailed digital terrain model and hydrological data.	$ 995
2d and 3d rock fall	**CRSP:** The Colorado Rockfall Simulation Program (CRSP) was developed for the purpose of modelling rockfall behaviour and to provide a statistical analysis of probable rockfall events at any given site. The software can be used as a tool to study the behaviour of rockfall, determine the need for rockfall mitigation, and as an aid in the design of rockfall mitigation. http://www.dot.state.co.us/geotech/crsp.cfm	This easy to use program provides a site-specific analysis of rockfall with output of velocity and bounce height statistics at various locations on the slope. The model is a two-dimensional representation of the most probable rockfall path as determined by the field investigator.	Price on demand (ca. $1'500)
Avalanche	**AVAL 1D** is a one-dimensional avalanche dynamics program that predicts runout distances, flow velocities and impact pressures of both flowing and powder snow avalanches. http://www.slf.ch/aval-1d/aval1d-start-en.htm	Emphasis was given on an easy-to-use graphical user interface for both flowing and powder snow avalanches. The software has now reached a level of development where it can easily be introduced to practitioners.	CHF 4'000

The core of the Swiss danger mapping system are the three colours (red, blue and yellow), which indicate the degree of danger. In addition, there is a special yellow-white signature for endangered areas with a very rare probability of occurrence exceeding typical design levels.

This three-colour system is used in Switzerland for all types of hazards, i.e. flooding, riverbank erosion, debris flows, landslides (deep-seated, shallow), rockfall, and snow avalanches. The criteria to classify the intensity for the individual hazards are given in paragraph 4.2.7 (intensity map). The return period (or probability of occurrence) is the same for all hazards.

Matrix for the determination of the danger level (in this case for a flood hazard):



The implementation of this system for a practical case is presented in the figure below (Danger Map for Sörenberg, Central Switzerland).

Danger map for Sörenberg, Switzerland

Legend:

- elevated danger
- medium danger
- low danger
- residual danger

Source:
Sörenberg
(Flühli Municipality),
Canton Lucerne

Original scale:
1:5'000

The level of danger for all types of hazards (flood, rockfall, snow avalanche, landslide, debris flow) is determined in a similar way: it's a combination of the magnitude (or intensity) of the process in a particular location and its probability of occurrence (or return period) in that location. The narrative description of the three (four) colours considers the *degree* by which people, animals, and assets of considerable material value are endangered. That is: in the red zone people are *endangered* inside houses (assuming buildings may collapse through the impact of the process), whereas in the blue zone people should be safe inside a building. Here an important prerequisite, therefore, is the assumption that safety of human life is usually much higher inside buildings than outside. This is true for most cases in Switzerland; however, in another context this might be a wrong assumption.

For a particular location, all types of hazards are assessed (e.g. flood, debris flow, snow avalanche etc.). The levels of danger are determined separately for each type of hazard. In case several types of hazard threaten the same location – for example flooding and debris flow – this condition is shown in suitable form on the hazard map. The highest level of danger is decisive in each case.

The practical implementation of the corresponding hazard information into local land-use planning follows recommendations provided by the federal authorities:

Red zone	The construction of new buildings is prohibited. Existing buildings can be maintained, however, it is prohibited to substantially increase the value or increase the number of people (e.g. to add an additional story on a house).
Blue zone	The construction of new buildings is possible under certain conditions (mainly proofing of the building against the impact of a natural process). The specifications can be outlined in the municipal building code.
Yellow zone	Sensitive (life support) infrastructure or buildings with a high concentration of people (e.g. school) need to consider the prevailing hazards; however, there are no restrictions for private construction activities. The last point is a major drawback in these recommendations, since major damage to assets is possible within the yellow zone. Some cantons, therefore, recommend that municipalities setup restrictions for the yellow zone in their building codes as well (mutual recommendations by the authorities, but no regulation by law).
Yellow-white	No land-use restrictions. Efforts should be made to ensure that critical facilities such as hazardous materials production, storage and waste facilities, water and wastewater plants, and essential services like hospitals, schools, etc. are hazard-proof and preparedness measures are foreseen in an emergency plan.

In Switzerland, some cantons are following these recommendations strictly; others have a slightly different interpretation, adapted to their local context.

4.2.4 Vulnerability map (map of potential damage)

Vulnerability maps are not yet well developed in Switzerland. In recent years, maps of potential damage (possible economic loss from buildings) were established.

Type and scale	– Map; scale of 1:5’000 to 1:10’000 – Geocoded list of elements
Content	Economic assets (in most cases insurance value of buildings are represented because insurance is compulsory for almost all buildings in Switzerland), either as an average value per unit area or as cluster values (groups of houses) or information for each individual house.
Purpose	Tool for emergency management (not common in Switzerland). Management tool for priority setting (structural and non-structural measures) and land-use planning (not common in Switzerland). Basis for the production of risk maps.
Way of production	– Mapping of endangered elements – Assignment of values to the endangered elements where appropriate (e.g. data provided by insurance companies) – Estimation of vulnerability (according to criteria established by the FOWG or by the SAEFL; for reference see para. 8.1) GIS-based or manual drawing.
Costs	Relatively cheap to establish when data are available.
Obstacles	Availability of data (when provided, often confidential e.g. by insurance company). Detailed analysis requires very good data about vulnerability of individual buildings.
Legal requirements	So far none. No clear regulations.

Map of potential damage of the municipality of Weesen, Switzerland

Legend:
High damage potential in
- Industrial area
- Mixed use
- Residential area

Source:
Municipality of Weesen,
Canton St. Gallen

Original scale:
1:5’000

4.2.5 Risk map

In Switzerland less importance has been given to the development of risk maps, as risk is a continually changing issue due to the continuous intensification of land use on the one hand and a result of protection works on the other hand. Only few examples exist. They have the following characteristics:

Type and scale	Map; scale of 1:5’000 to 1:25’000
Content	The risk map shows either – an average loss (e.g. CHF/ha) per event or per year – a number of deaths per event or per year – qualitative classification of risk (e.g. low to high)
Purpose	A risk map is the basis for the chronological and financial prioritisation of protection measures. It is the most appropriate tool for decision making about structural and non-structural measures.
Way of production	In a risk map, areas and objects are classified by their risk values. The risk values are defined as a product of the potential damage (determined for each object category) and the probability of the event (from the actual hazard assessment).
Costs	No data exists. However, if danger maps (particularly intensity maps) are present and the value at risk is defined, the production of a risk map is considerably cheap.
Obstacles	No experience with this instrument Such maps need to be updated regularly
Legal requirements	No regulations

Risk map for Sörenberg, Switzerland

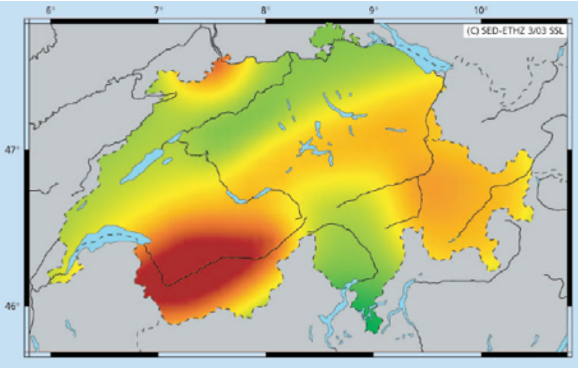
Legend:
- elevated risk
- high risk
- medium risk
- low risk

Source:
Sörenberg
(Flühli Municipality),
Canton Lucerne

Original scale:
1:5’000

4.2.6 Earthquake maps

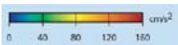
The earthquake risk has been neglected in Switzerland in the past decades. Only at the end of the 1990s did it become an issue for the federal administration. In recent years a number of recommendations and guidelines were developed to consider earthquake risks for construction. In many other countries, however, the earthquake risk is of high relevance and many more tools have been developed.



Macro zoning of the earthquake hazards in Switzerland

Content:
Probabilistic earthquake hazard in Switzerland. The map shows the spatial distribution of the peak ground acceleration in subsoil of Class A (according to Building Code SIA 261) within a period of 500 years (SED, 2003).

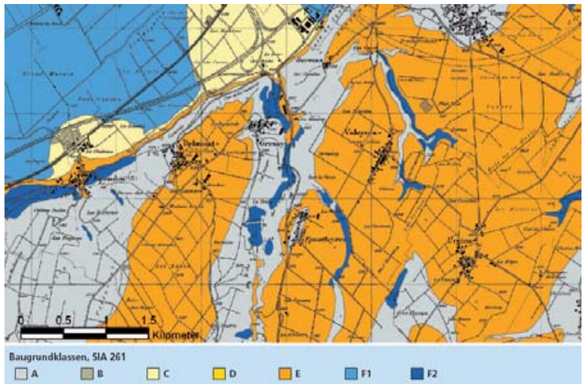
Source:
National Alert Centre, Federal office for the protection of the population, May 2004.



The same type of information (macro zoning) is available for the Mediterranean area (SESAME) and on a global scale:
(www.gfz-potsdam.de/pb5/pb53/projects/en/sesame/menue_sesame_e.html and www.seismo.ethz.ch/GSHAP/)

In Switzerland new regulations for micro zoning have been published in early 2005 (see appendix). An important tool is the map of soil properties in building areas according to Building Code SIA 261. This is relatively cheap and easy way to establish the map.

Soil properties in building areas according to Building Code SIA 261.
Map of Yverdon-les-Bains, scale 1: 25'000.



Legend:
- A Hard and soft rock
- B Accumulation of consolidated and cemented sand and gravel.
- C Accumulation of consolidated and non-zemented sand and gravel.
- D Accumulation of non-consolidated fine sand, silt and clay.
- E Alluvial top soil.
- F1 Organic accumulations
- F2 Active or dormant landslides

Source: Verfahren zur Erstellung und Verwendung von Mikrozonierungsstudien in der Schweiz. FOWG, Biel, 2005

4.2.7 Intensity map

An intensity map is a basic product to establish instruments, which are directly inferred from them (danger map, risk map, etc.). In some countries the so-called "hazard maps" are in fact intensity maps (e.g. Japan uses flood intensity maps [water depth] as hazard maps).

Type and scale	Map; scale of 1:5'000 to 1:10'000
Content	Provides the spatial extent and the corresponding intensities of a natural event (e.g. water depth, impact force of snow avalanches) having a specific return period or probability.
Purpose	Serves as a basis for the: – danger map – estimation of potential damage – protection deficit map – risk map
Way of production	The following methods are used – Interpretation of the event register – Field investigations (source, impact areas of processes) – Computer models
Costs	Intensity maps are not produced as individual instruments. They appear in the costs for danger maps (see para 4.2.3 Danger Map).
Obstacles and difficulties	Requires appropriate basic data.
Legal requirements	So far none. Recommendations by the federal government regulate the criteria, which have to be applied when classifying intensity or magnitude (for reference see para. 8.1).

Intensities are classified into 3 classes. The classes for the various natural processes have the following thresholds (given in the recommendations by FOWG, SAEFL and SLF; see paragraph 8.1):

Intensity class	Flooding	Debris flow	Snow avalanche	Rock fall (boulders)	Landslide
High	h > 2 m or h * v > 2 m²/s	h > 1 m and v > 1 m/s	P > 30 kPa	E > 300 kJ	D > 1 m/event or 0.1 m/day
Moderate	0.5 > h > 2 m or 0.5 > h * v > 2 m²/s	h < 1 m or v < 1 m/s	3 < P < 30 kPa	30<E<300 kJ	D of the order of some dm/y
Low	h < 0.5 m or h * v < 0.5 m²/s	No low-intensity class for debris flows	1<P<3 kPa, for powder snow avalanche only	E < 30 kJ	D < 2 cm/y

h = flow depth or water depth; v = velocity of the flow; E = Energy; D = Displacement, P: Pressure

4.2.8 Further instruments in use

In Switzerland a number of additional instruments are in use. Most of them serve as basis for the production of danger maps.

Type of instrument	Content	Purpose	Scales found and *recommended*
Map of phenomena	Representation of phenomena, which indicate a particular hazard (e.g. deposits of rock slide, flood marks etc.).	Basis for the danger map or hazard indication map	1:5'000 to 1:25'000 *smaller scale possible*
Map or register of protection works	Location and actual condition of protection works	Basis for maintenance works and definition of scenarios.	1:5'000 Register
Map of protection goals	Degree of safety to be achieved for surface, line and point elements.	Basis for evaluation and planning of protection measures and land-use regulation.	1:5'000 to 1:10'000
Map of protection deficit (safety deficit)	Shows surface, line and point elements where the protection goals are not met.	Basis for evaluation and planning of protection measures and land-use regulation.	1:5'000 to 1:10'000
Risk profile	Written description of the hazard, vulnerability and risk conditions within a region, country or smaller political entity. Emphasis on coping capacities.	Instrument used for decision-making. Priority setting for activities (programming)	–

4.3 Validation

The Swiss hazard mapping system is rather young. The experience gathered can be summarized as follows:

Positive aspects

- The Swiss system is transparent, comprehensible and easy to understand. There is a chain of instruments, which are used for the management of natural risks.
- The Swiss system is based on a number of manuals (guidelines and recommendations), which are supported nationwide. The most important are listed in 8.1.
- The existing tools are practice-oriented although they still allow a certain range of misjudgement within the personnel reviews of the different topics. Skill and experience in the interpretation of data are indispensable.
- In Switzerland a legal framework exists to implement danger and risk maps (land-use plans and building codes at the municipal level where hazard-related topics can be included).
- Event registers are important for map production and have a long tradition in Switzerland.

Questionable aspects

- The inclusion of residual risks, such as an extreme event, is very important for emergency planning. It is, however, very difficult to explain to laypersons, why such considerations have been incorporated in the process.
- The system including event maps, hazard indication maps and danger maps is rather complex, expensive and time consuming. It requires much experience on both sides: editor as well as the user. For this reason also, the regular updating of the maps is costly, and therefore, often neglected.
- For the same reason, complexity, local authorities should be included in the process of elaborating hazard maps (to get familiar with the methodology and to take part in the decisions about the relevant scenarios). However, this is sometimes difficult to undertake.
- The definition of the return period or probability of occurrence is merely impossible for some natural processes such as landslides or debris flows. It is even more difficult to explain these terms to local authorities.
- In the Swiss system the vulnerability and risk context is still weak, and therefore, the production of maps is still hazard-orientated.
- The Swiss danger maps and their implementation into a legally binding land-use plan have direct implications for land tenures (restriction for particular land-use). At the municipal level, the solving of conflicts between landowners and legally based land-use restrictions are not yet solved properly (e.g. compensation of land in a high danger zone).
- There is an on-going discussion about the use of danger maps or risk maps for particular areas. The following pros and cons are listed here:

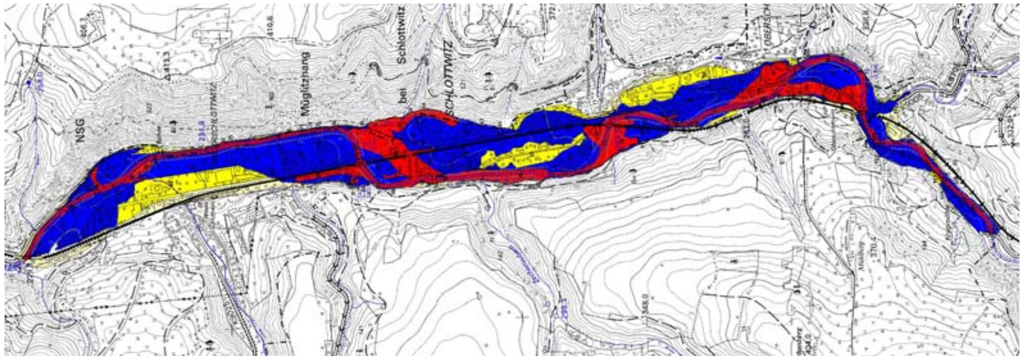
	Risk map	Danger map
Advantages	■ tool for a global analysis allowing the development of strategies and concepts ■ possible to establish without complex economic damage calculations ■ shows changes in the risk situation much better than the hazard map ■ tool to validate disaster reduction measures	■ very useful for land-use planning: Usually one of the first questions asked is "can I build here?" (prevention of future loss) ■ studying hazards is the basis for risk analysis (it is an intermediary step at a lower cost)
Disadvantages	■ vulnerability- and land-use data are not easily available ■ people are not aware of and use to dealing with risks ■ the term "risk" is still understood very individually	■ more difficult to understand than a water depth map at a defined return period (the value "intensity x probability" is more difficult to understand) ■ most countries study the 100-year return period; additional probabilities, such as the 30 or 300 year event or the extreme event as used in Switzerland, are not considered

5 The Swiss system abroad

In recent years the Swiss Agency for Development and Cooperation (SDC) implemented disaster reduction programmes and projects in a number of countries. Where danger maps and related products were involved, the Swiss methodology was used, transferred and applied. The following countries serve as examples:

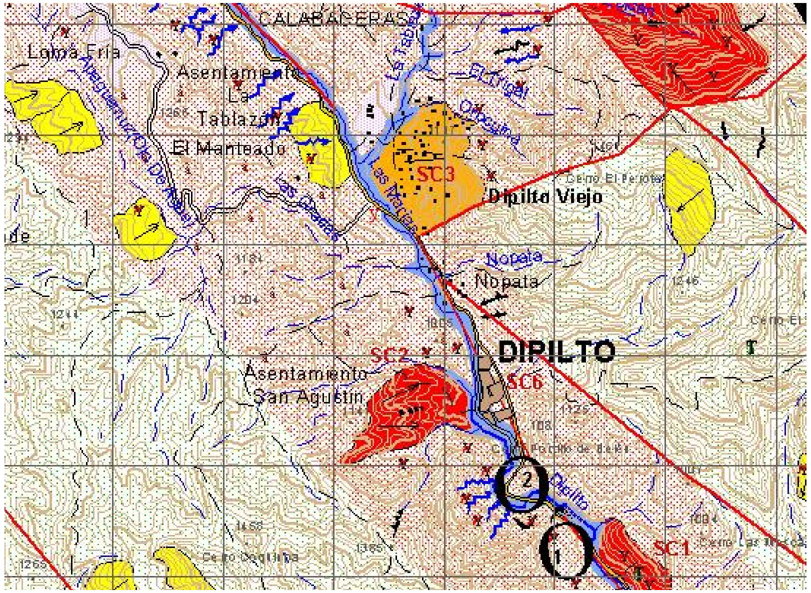
5.1 Examples where the Swiss system is applied

5.1.1 Germany / Saxony



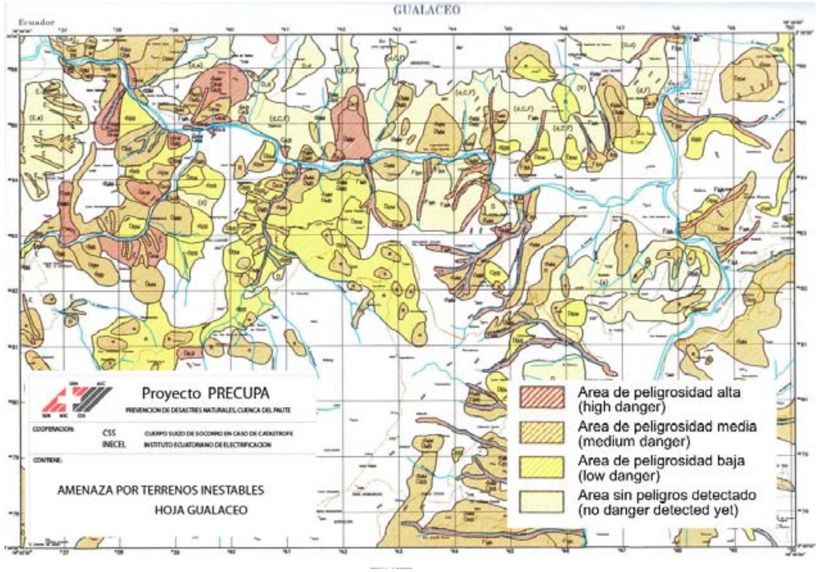
Title Danger map of Schlottwitz, Germany
Type Danger map with focus on floods caused by a tributary of Elbe River
Content Danger in 4 categories as shown in the diagram in chapter 4.2.3
Scale Original scale: 1:5’000
Comment *Experience while producing the map:* A large number of danger maps where produced in a short time after the floods in August 2002. The System was new for Saxony and some ideas to simplify the map were integrated.
Experience while implementing the gained information: Until now the danger maps with the differentiation in the 30, 100, and 300 year return period are not yet considered in the German laws and therefore only the 100 year return period is taken into account for legislation.
Review of the Swiss system: The most important statement given by the local authorities was, that the making of these maps was very time consuming due to the lack of experience and therefore very expensive. On the other hand, the aerial photos made during the 2002 floods have proved to be one of the most important assets in producing the maps.
Source Municipality of Schlottwitz (Saxony, Germany).
Landestalsperrenverwaltung des Freistaates Sachsen, Talsperrenmeisterei Gottleuba/Weißeritz: Hochwasser 2002, Studie Hochwasserschutzkonzept im Schadengebiet der Fliessgewässer (2003).

5.1.2 Nicaragua



Title Mapa indicativo de peligros y propuesta de zonificación territorial.
Type Hazard indication map with focus on landslides and flooding.
Content Landslide hazards (3 activity classes: red, orange, yellow), inundation areas (blue), debris flow trajectories (blue), and geological fault lines (red). Risks are marked with special numbered symbols (SC).
Combination of different information, e.g. danger classes, risk sites and land-use proposals (in the dotted raster).
Scale Original scale: 1:50’000
Comment *Experience while producing the map:* The Swiss guidelines are oriented towards practical land-use recommendations and therefore easy to adopt. The approach for the definition of intensity and probability was easy to explain, although scale and available data allowed only one hazard class for floods.
Experience while implementing the gained information: The legal framework for implementation is still under development, but as a starter, good experience was gained at the local level.
Review of the Swiss system: a very important part lacking in the Swiss system is the possibility to integrate vulnerability assessment in terms of social, environmental and physical tasks.
The blue colour in danger maps (medium danger) is often referred to as flooding. A good combination of colours in danger maps would be the range red – orange – yellow. Multi-hazard maps are preferred by poorly qualified users.
Source República de Nicaragua, Municipio de Dipilto. SDC’s disaster reduction programme for Central America, Managua, 2003

5.1.3 Ecuador



Title Landslide-prone area hazard and vulnerability map in the Gualaceozone, Ecuador.

Type Danger map

Content Landslide danger is the product of the phenomena map and the evaluation of the probability using 3 hazard and 3 intensity classes.

Scale Original scale: 1:25'000. An area of 130 km^2 is covered.

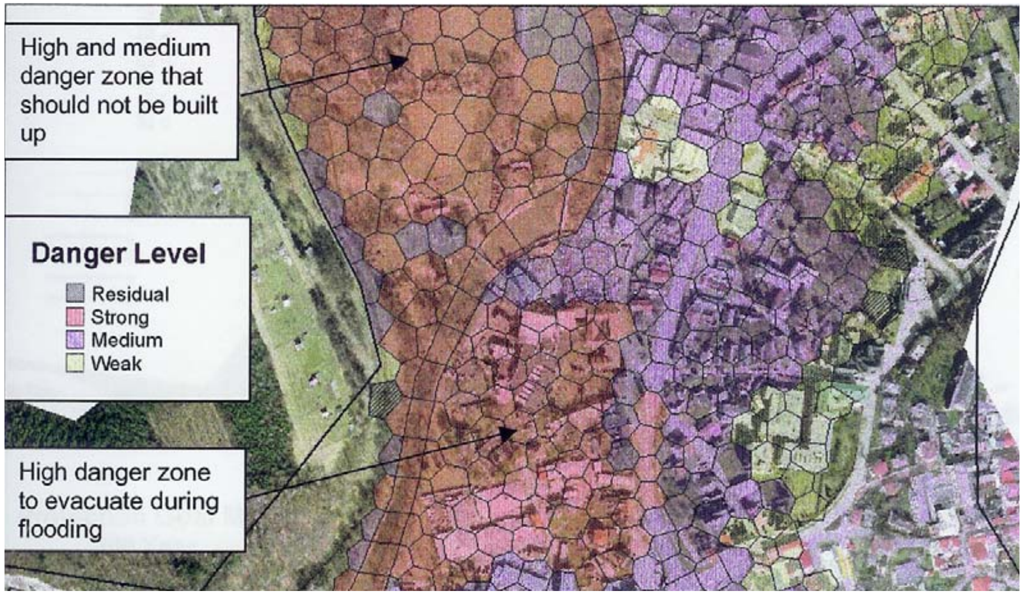
Comment *Experience while producing the map:* The production requires experienced collaborators. Costs and time requirements: moderate.

Experience while implementing the gained information: Map details and accuracy depend on the users. It was essential to have a technical map for the reconstruction of the road. Every landslide identified was considered in the studies and reconstruction of the road. Communication of hazard information is a large drawback if means such as radio, television or telecommunication are weak. Warning systems and training have to be developed at the grass root level.

Review of the Swiss system: The Gualaceo hazard map shows the adaptation/simplification of Swiss methodology. To facilitate communication/diffusion, simplified information is essential. The perception of hazard maps is not the same in all areas of the country, e.g. the yellow field meaning only a half meter of water level causes more damage in sense of social vulnerability in towns with mud houses than in cities with concrete housing.

Source SDC/SDR Report PRECUPA, 1995

5.1.4 Czech Republic



Title Extract from the Danger map of Usti nad Orlici

Type Danger map

Content Flood danger level according to 4 probability classes and 3 intensity classes. The danger level is given for irregular cells.

Scale Original scale: 1:3'000 (orthophoto)

Comment *Experience while producing the map:* Map production was complicated by the unavailability of the 30 and 300 year return period (RP) flood hydrographs. Hydrologic data was acquired from the Czech Hydrometeorological Institute and surveying firms produced the necessary topographic data.

Experience while implementing the gained information: The 100 year RP map is widely used (and legally binding) in the Czech Republic so that the 100 year RP map that was produced is being used in this case and the danger map served as an example for authorities to consider the future use of the Swiss hazard mapping system.

Review of the Swiss system: The Swiss danger map will most likely be useless in a foreign context until legal measures are taken to implement its use. When those legal measures are taken, communication concerning the interpretation and utility of the map must be done. The flood hydrographs commonly available in other countries do not usually coincide with those used in Switzerland, although they can most likely be generated. This is a minor problem except for the 300 year RP flood hydrograph which is relatively important for determining the weak danger zone.

Source SDC Report: FLAMOR: Flood Analysis and Mitigation on the Orlice River. Final Report, June 2003

5.2 General requirements when working with the Swiss system abroad

The Swiss approach clearly addresses two levels of accuracy: danger maps at the community level (scale normally 1:10’000 or finer) and hazard indication maps at the cantonal (state) level with scales normally 1:100’000 or finer. According to these two levels the basic products demand particular information, knowledge and know-how:

- **Topographic information** is essential for the production of danger maps and any other products. Depending on the purpose of the map a defined scale is required. In Switzerland topographic maps in a variety of scales are available without restrictions (1:5’000–1:500’000; even in digital form). In many countries such basic topographic data is not available or is classified (particularly detailed maps).
- **Scientific information:** Detailed hydrological and geological information as well as process-related information such as magnitude and frequency of past events is required. In Switzerland such information is generally available for the particular area or can be inferred from neighbouring areas. In many instances abroad this information is unavailable.
- **Modelling:** The simulation of processes with computer models requires digital input data. In Switzerland digital data (e.g. digital terrain models; geological and land-cover information) is available for most areas in a satisfactory resolution. This is hardly the case in developing countries.
- **Experienced specialists:** The Swiss approach requires well-educated specialists in various fields (geology, hydrology, hydraulics, etc.).
- **Time:** The sophisticated Swiss system is time-consuming and, therefore, is relatively expansive.

5.3 Experience with the Swiss system abroad

Advantages

- The methodology is transparent (guidelines) and comprehensible (it is based on detailed topographic, geological and hydrological data and information).
- The approach is process-oriented (e.g. scenarios for individual hazardous processes).
- There is a chain of instruments: Various maps are available, implemented according to a defined purpose.
- The residual risk is considered, including extreme events, which are important for emergency planning.
- The maps are readable and easy to understand (three classes for hazards, not overloaded).

Disadvantages

- Does not target the grass-root level. Even for municipal authorities it is sometimes difficult to understand and interpret.
- There is a lack of instruments for a quick hazard appraisal.
- The return periods used in Switzerland are difficult to explain and often provoke a lack of understanding.
- The blue colour in danger maps is often associated with flooding and not with a danger level.
- The notion of vulnerability and risk is less developed than that for hazards.

6 Framework

The Swiss methodology for the assessment of hazards and risks, for the representation of hazards on maps, as well as for the implementation of this information into planning processes requires a number of technical demands as described in chapter 4 and 5.2. In addition to these, the implementation of hazard and risk information needs to consider other aspects. Among them are:

- legal framework
- economic considerations
- social aspects
- stakeholders

6.1 Legal framework: an advantage but not an ultimate condition

The production of danger maps and related products and the implementation of the relevant hazard and risk information into planning processes should be based on a legal framework:

- In many countries only the emergency response (civil defence, civil protection) is legally regulated. Risk prevention and mitigation (including the necessary basis like hazard maps) are very often not mentioned. However, laws which define standards for the production (scientific criteria, etc.) and which control the implementation of hazard maps and the related information into planning processes are a major advantage. As experience reveals (e.g. Saxony, Japan), the hazard information from danger maps cannot be implemented into land-use planning when the respective legal base is missing.
- On a local level, a legal basis to implement hazard information into planning processes is not always required. Land-use decisions at the community level may be implemented without a legal framework, as examples in Nicaragua prove.
- National disaster reduction plans (Preparedness plans) need to be based on accurate hazard and risk information. Hazard and risk maps should serve as an indispensable basis to produce such preparedness plans.

6.2 Economic considerations: a good tool is not necessarily expensive

Hazard and risk analysis and the related maps are often considered as unnecessary and expensive. However, depending on the problems to be addressed and on the available basic information, there are solutions and instruments, which are more cost-effective than the Swiss approach. Quick hazard appraisals, mapping of large areas using simple models and approaches, or quick mapping of prevailing hazards and risks at the community level does not necessarily require large financial means. However, even under restrictive economic conditions, a quick hazard appraisal needs to be sound, transparent and understandable, and the resulting instruments readable by those addressed. Financial means need to be provided for:

- *Experts* (hazard and risk assessments must be done by well-educated specialists)
- *Data and information:* good basic information is the key for reliable instruments. Such information has to be bought or established (e.g. aerial photographs)
- *Production of instruments:* In order to have a good dissemination of the instruments, they should be provided to the end-users free-of-charge.
- *Dissemination:* The dissemination of instruments and the necessary awareness and capacity building for the application and implementation by the end-users is very important.

6.3 Social aspects: not every hazard is considered as risk

The socioeconomic and socio-cultural conditions in a community are important aspects to consider when working with hazard maps and related products:

- Risks from natural hazards are only one type of risk a society is exposed to. Other risks may affect a community or individual families (e.g. availability of safe drinking water, health considerations, food supply etc.). This context has to be carefully considered.
- The risk aversion plays a major role, particularly in western countries. An event, which causes 100 fatalities, is perceived differently than 100 events, which kill 1 person each.
- Livelihood conditions, beliefs and disaster experience are major factors controlling risk perception. The notion of hazard and risk need to be understood in order to work with hazard maps and related instruments. Therefore, awareness building for end-users and the implicated population is required.
- The instruments, which show hazard information, need to be adapted to the local context and need to be understandable and readable by those addressed.

6.4 Stakeholders: only combined efforts are successful

Risk and disaster management is a multi-stakeholder issue. The various responsible entities, including the directly affected communities need to collaborate and must enter into the risk dialogue. The following persons or institutions contribute:

- Scientific-technical personnel (geologists and geographers, land-use planners, agricultural, civil, environmental and forestry engineers, social scientists) are responsible for the proper assessment of risks, for the production of hazard and risk maps, and for the communication of this information to the authorities and the population at large.

- The research community provides data and information about hazards, socio-economic conditions, and risks in a particular area.
- Authorities (political and administrative level) are responsible for applying and implementing the information given with the instruments.
- The local population needs to understand the notion of risk and has to participate in the risk dialogue.

7 Recommendations

Hazard and risk maps and other inferred tools are indispensable instruments for all disaster reduction activities. However, hazard maps by themselves are not a disaster prevention activity. Only the implementation of this information in preventive or preparedness measures will have an impact.

In areas where natural hazards constitute a high risk, all development projects need to consider components of risk reduction. Under those conditions, instruments like hazard and risk maps:

- serve as tools for disaster-related decisions for the planning of development projects
- provide information for disaster proofing
- give evidence for maintenance activities
- can be used for overall or detailed land-use management and the planning of structural and non-structural prevention measures
- are a basis for disaster preparedness planning (emergency management)
- provide information for awareness raising among local communities

When ordering or producing such instruments it has to be considered that:

- the Swiss approach is one way of assessing and representing hazards and risks. The Swiss approach can be applied but needs to be adapted to the local context
- different return periods (as requested by the Swiss approach) might not be understood in a local context. Moreover, it might not even be necessary to have them established.
- the Swiss approach might be too sophisticated and not adequate for the problems to be addressed. An adaptation to the local context and to the problems is required.
- simple solutions might be appropriate according to the problems to be solved. However, even a simple solution needs to be technically sound, transparent and understandable.
- the scale of the map is appropriate according to the problem to be addressed.

The following tool-specific recommendations serve as a guideline. They have to be adapted to the local context:

Recommendations

	Recommended scale	Requirements for production	Requirements for implementation	Obstacles	Costs
Event register Event map	Written database (list) Map with individual events; scale: 1:10'000 to 1:50'000. Scale possible 1:100'000 to 1:1500'000, depending on area considered and density of data	Data and information about past events (databases, reports, newspapers, archives, interviews) Digital data handling (including GIS) recommended for large databases and for updates Updates must be regulated.	Transparency of information and easy to read Awareness of the local authorities. Publication of information and free access to database Means for regular updating	No data available No public access to data and information Memory of people limited to recent events Information about events is insufficient (e.g. exact location not known)	Cheap With further sophistication (digital data management) more expensive.
Risk profile	Written description; map according to geographical unit considered	Information from event register Data about vulnerability and capacity (VCA) Socio-economic data			
Hazard indication map	Municipal level: 1:25'000 Province level approx. 1:100'000 National level: up to 1:500'000	Information from event register Topographic map with adequate scale Field observations Modelling of processes (DTM necessary) is useful for areas > 250 km².	Transparency of information and easy to read Awareness of the local authorities. User know-how to read the map and know about accuracy of information Land-use restrictions can only be demanded within a legal framework Without a legal framework, only recommendations are possible. Digital representation of information seems more reliable	If scale is too coarse: over-interpretation is common Flood hazard indication should not to be used for local (village) land-use decisions	About 1 day per km² for a scale of 1:25'000 to 1:100'000 (multi-hazard; field observations) About similar expenditure for modelling of processes; cheaper for very large areas > 1000 km² possible.

	Recommended scale	Requirements for production	Requirements for implementation	Obstacles	Costs
Danger map	1:5'000 to 1:10'000 Any scale coarser than 1:25'000 is not advisable for a danger map.	Detailed information about hazards (frequency and intensities) Topographic map or satellite imagery at an adequate scale Multi-disciplinary team	Transparency of information and easy to read Awareness of the local authorities. Capacity of user to read the map and to understand the accuracy of the information Legal framework for land-use restrictions	Without regular updates the map looses its value (due major topographical changes or construction activity)	About 10 days per km² for a scale of 1:5'000 to 1:25'000 (multi-hazard field observations) 2-D modelling of flood-plains: 2 to 3 d per km² if data and programmes available.
Vulnerability map	Scale according to hazard indication or danger map	General or detailed information about position of vulnerable elements: population density and level of poverty number and value of buildings or buildings per km² infrastructure life support elements	Transparency of information and easy to read No direct implementation; needed as basis for the risk map.	Vulnerability data difficult to obtain	
Risk map	Scale according to hazard indication map	Hazard indication map General information about vulnerable elements (e.g. population density, building inventory etc.) Manual or digital superposition of hazards and vulnerable elements.	Transparency of information and easy to read Awareness of the local authorities. Capacity of the user to read the map and to understand the accuracy of the information	Availability of vulnerability data Misinterpretation of information	Cheap, if hazard map and vulnerability map are available
	Scale according to danger map	Topographic map or satellite imagery at an adequate scale Intensity maps for particular probabilities Map of vulnerable elements with information about value and potential damage.	No legal framework for priority setting (of further investigations) is needed		

8 Appendix

8.1 Swiss guidelines and recommendations

Most of the publications are available in German and French, few in English.
Some publications can be downloaded from:
http://www.bwg.admin.ch/service/katalog/e/index.htm

FOWG 1997: Empfehlungen: Berücksichtigung der Hochwassergefahren bei Raumwirksamen Tätigkeiten (in German and French) www.bwg.admin.ch/service/katalog/download/804201d.pdf

FOWG 1997: Empfehlungen: Berücksichtigung der Massenbewegungsgefahren bei Raumwirksamen Tätigkeiten (in German and French) www.bwg.admin.ch/service/katalog/download/310023d.pdf

FOWG 2001: Flood Control at Rivers and Streams. Wegleitungen des BWG – Directives de l'OFEG – Direttive dell'UFAEG – Guidelines of the FOWG. www.bwg.admin.ch/service/katalog/download/804801eng.pdf

FOWG 1995: Demands on flood protection (in German, French, Italian, English).
www.bwg.admin.ch/service/katalog/download/anf_hws_e.pdf

FOWG 2004: Verfahren zur Erstellung und Verwendung von Mikrozonierungsstudien in der Schweiz. Richtlinien des BWG – Directives de l'OFEG – Direttive dell'UFAEG (in German and French)
www.bwg.admin.ch/service/katalog/download/804806d.pdf

SAEFL: Naturgefahren. Symbolbaukasten zur Kartierung der Phänomene. Empfehlungen. 1995. ca. 60 S. (in German and French).

SAEFL: Kosten-Wirksamkeit von Lawinenschutz-Massnahmen an Verkehrsachsen. Vorgehen, Beispiele und Grundlagen der Projektevaluation. Praxishilfe. 1999. 110 S. (in German)

SAEFL: Risikoanalyse bei gravitativen Naturgefahren. 1999. 2 Bde. – Bd. 1: Methode. 115 S. – Bd. 2: Fallbeispiele und Daten. 129 S. (in German)

8.2 Further reading

FOWG 2003: Wörterbuch Hochwasserschutz (Dictionary of Flood Protection). Verlag Paul Haupt, Bern.

FEMA (Federal Emergency Management Agency, USA): "Guidelines for Determining Flood Hazards on Alluvial Fans" (www.fema.gov)

Govt. of Japan, 2003: Flood hazard map manual for technology transfer. Paper presented in: Int. Training Programme on Total Disaster Risk Management. ADRC, Kobe, Japan.

Kienholz, H., Ch. Graf 2000: Vom Gelände zur Karte der Phänomene. Kompendium. (in German)

Kienholz, H., 1977: Kombinierte geomorphologische Gefahrenkarte 1:10'000 von Grindelwald. Universität Bern, Geographisches Institut.

UN/ISDR, 2004: Guidelines for reducing flood losses. Available online at: www.unisdr.org