Arbeitsgemeinschaft Alpenländer

Comunità di Lavoro Regioni Alpine

Natural hazards in the regions of ARGE ALP

Legal base, institutional competence
and state of realization of natural hazard zoning

Natural hazards in the regions of ARGE ALP
Legal base, institutional competence and state of realization of natural hazard zoning

Arbeitsgemeinschaft Alpenländer – Comunità di Lavoro Regioni Alpine (ARGE ALP)

Author: Manfred Thüring
Istituto Scienze della Terra - SUPSI
C.P. 72
CH-6952 Canobbio
Switzerland
Internet: www.ist.supsi.ch
E-Mail: admin@ist.supsi.ch

2003

Contents

Summary

How do the regions of ARGE ALP deal with natural hazards? This report focuses on the legal and planificatory aspects of the zonation of natural hazards, i. e. of avalanches, landslides, rockfalls, flooding and debris flows. The analysis can be summarized as follows:

Legal base, institutional competence and state of realization of natural hazard zoning. Each region has reacted to this real threat on the legislative and planificatory base due to a historical cohabitation. A treatment of this threat and the corresponding procedures for the protection of the population and values can be found – in very different ways – in the legal systems of the regions. The organization of a state also has a strong impact on the legal description and especially on the assignment of the resulting competences. The predominantly federative character of the nations, which the regions of ARGE ALP are part of, expresses itself in the sharing of authorities and competences between the national, regional and community level; a fact which often results in an unclear distribution of the tasks.

Generally, the threat of natural hazards is being treated, more often by the integration of the topic into the laws on spatial planning, forests and water constructions, and more rarely within special laws.

Bavaria, or rather **Germany**, forms the exception, where natural hazards are not directly treated legally, refraining from a complete areal assessment of natural hazards by means of hazard zone plans, but rather concentrating on a case-by-case expert opinion.

In **Austria**, the legislation as well as the executive competence is situated nearly exclusively on the federal level. The “Forsttechnischer Dienst für Wildbach- und Lawinenverbauung” (WLV), a federal institution, implements the legal prescription given by the forest law of 1975, by its branch offices in the Länder, taking care of mass hazards. Flooding hazards caused by larger rivers fall into the competence of the “Bundeswasserbauverwaltung”, also a federal institution, which however delegates its competence to the respective offices in the Länder. The hazard zone plans are worked out on the community level, and do not have a direct legal validity. However, further national legal prescriptions exclude federal co-financing for the construction of protective measures, if the hazard zone planning is not respected. On the regional level corresponding laws integrate the federal hazard zone plans, typically within the laws on spatial planning and constructions. The state of realization is comparable and well developed in the ARGE ALP regions Salzburg, Tirol and Vorarlberg.

In **Switzerland**, the national level defines a legal framework, the executive competence, however, is delegated to the cantons. The legal bases are given by the national laws on spatial planning (1979), forests (1991) and water constructions (1991). The implementation is done in the cantons on two levels; on the cantonal level within the structure plan by means of a hazard-index map and on the community level by means of hazard zone plans. The Swiss ARGE ALP regions Graubünden, St. Gallen and Ticino have different states of realization with respect to their hazard zoning. Whilst Ticino started to work out the base data already at the beginning of the 1990s and nearly has concluded, Graubünden is currently elabo-

rating the zones, and St. Gallen is, after concluding a pilot-project, currently starting to develop activities.

In **Italy** there are parallel national and regional legal prescriptions. On the national level, law 183 of 1989 is most important, introducing the structure of the "Autorità di Bacino", which foresees the national hazard zoning based on hydrographic catchment basins, in order to identify areas prone to mass hazards. The elaboration of the plans has been delegated to the regions. On the regional level, there are further legal prescriptions, which should subordinate themselves to the zoning of the "Autorità di Bacino". The ARGE ALP regions South Tyrol and Trentino, due to their status of autonomous provinces, can partly evade this procedure, and have their own laws on spatial planning (Landesraumordnungsgesetz of 1997, resp. Legge provinciale 26/1987), which regulate construction activities in areas prone to natural hazards. These laws, however, do not have the resolution of hazard zone plans. The region Lombardia prescribes with law 41 of 1997 the elaboration of hazard zone plans on the community level, satisfying the prescriptions of the Autorità di Bacino.

A **structured procedure for natural hazard zoning** sketches the following steps. The base idea is given by the protection of the population and values by means of spatial planning initiatives. Here, in a step-by-step procedure, (map) documents must be elaborated: The identification and the assessment of natural hazards lead to hazard maps, the risk analysis assesses its consequences on the current or planned land use, and the final step of risk management defines the level of territorial safety and its respective cost. The whole sequence integrates natural hazards into the generally already existing land use plans on the community level and serves a structured land use planning.

Topics for a reasonable **cooperation on the interregional level** are given due to the largely differing procedures, on how land use planning is realized today in the different regions of ARGE ALP: An interregional knowledge exchange and tuning of procedures with regards to the whole sequence, i. e. the identification and assessment of hazards and concepts of risk analysis and risk management is useful.

Natural hazard maps. The cartographic data available in the regions of ARGE ALP varies strongly in quality, purpose and availability. Mostly, those documents have the character of hazard-index maps or inventories of historical events, which indicate the area, where a natural hazard is present, or identify past events in a cartographic way. Unfortunately, in the various regions of ARGE ALP, the natural hazards are identified, classed and mapped according to different criteria. The procedure to arrive at the final product of a hazard map (which identifies the state of hazard within the area where a hazard process is present), is not always done in a structured way, even though in the last years several initiatives produced well-structured procedures. Even less, the consecutive step of risk assessment is done. Risk management, however, is an important step for well-founded spatial planning.

The map data, available in the regions of ARGE ALP, thus, is inhomogeneous and has been created with widely diverging intentions. A **common map of natural hazards** for all the regions of ARGE ALP is thus, at least today, illusive.

.

Riassunto

Come viene affrontata la minaccia inerente ai pericoli naturali nelle regioni dell'ARGE ALP? Questo rapporto si concentra sugli aspetti legali e pianificatori della zonazione dei pericoli naturali, cioè di valanghe, scivolamenti, crolli, esondazioni e flussi di detrito. I risultati di questo rapporto possono essere riassunti, seguendo la struttura tematica del rapporto, quanto segue:

Basi legali, competenze istituzionali e stato di realizzazione nella zonazione dei pericoli naturali. Tutte le regioni hanno, dato la convivenza storica con la minaccia dei pericoli naturali, reagito sulla base legislativa ed esecutiva. Un trattamento, anche se molto diverso, di questa minaccia e conseguentemente le procedure per la protezione della popolazione e dei beni, possono essere ritrovate nei sistemi legali di tutte le regioni. Nella descrizione e la distribuzione delle competenze è visibile anche la forma costituzionale dello stato, in cui la regione ARGE ALP è integrata. Il carattere prevalentemente federativo degli stati si esprime in tal senso, che l'autorità e l'esecuzione viene condivisa da stato, regioni e comuni; spesso questa separazione è anche fonte di mancanza di chiarezza.

Generalmente, la minaccia dei pericoli naturali viene affrontata meno spesso con delle leggi speciali o, più spesso, tramite le leggi della pianificazione territoriale, delle foreste e della sistemazione dei corsi d'acqua.

La Baviera, o rispettivamente la **Germania** ne fa un'eccezione. I pericoli naturali non vengono trattati direttamente. In Baviera, ci si rinuncia ad un trattamento areale tramite piani di zone di pericolo, ma ci si concentra piuttosto su una valutazione di ogni caso tramite perizie.

In **Austria**, la legislazione e la competenza d'esecuzione sono ambientate in gran parte su livello federale. Il „Forsttechnischer Dienst für Wildbach- und Lawinenverbauung" (WLV), un'istituzione federale, implementa le basi legali, dati dalla legge forestale del 1975, tramite succursali in tutte le regioni Austriache; occupandosi di pericoli idrologici, geologici e di valanga. Il pericolo d'esondazione dei corsi d'acqua maggiori è nella competenza della "Bundeswasserbauverwaltung", anche questa un'istituzione federale. Quest'ultima però delega la sua competenza d'esecuzione agli uffici competenti nelle regioni. I piani delle zone di pericolo che vengono elaborati su livello comunale non hanno un valore giuridico diretto. Altre misure legali federali però escludono un co-finanziamento da parte dello stato per opere di protezione, se i piani delle zone di pericolo non vengono rispettati. Su livello regionale delle leggi rispettive, tipicamente leggi sulla pianificazione o la costruzione, integrano le carte delle zone di pericolo federali. Lo stato di realizzazione della zonazione è paragonabile nelle regioni ARGE ALP Salzburg, Tirol e Vorarberg, e su un alto livello.

In **Svizzera,** la confederazione definisce l'inquadramento legale e le procedure d'esecuzione, però delega l'esecuzione ai cantoni. Le basi legali sono date con le leggi sulla pianificazione territoriale (1979), sulle foreste (1991) e sulla sistemazione dei corsi d'acqua (1991). L'implementazione avviene nei cantoni tramite una procedura su due livelli; su livello cantonale nel piano direttore con una carta indicativa dei pericoli, e su livello comunale nel piano regolatore con dei piani delle zone di pericolo. Le regioni ARGE ALP

Svizzere, Grigioni, San Gallo e Ticino hanno degli stati di realizzazione diversi riguardo alla zonazione dei pericoli. Mentre il Ticino, che ha già iniziato le procedure all'inizio degli anni 1990 e che ha quasi terminato i lavori, i Grigioni stanno attualmente svolgendo questi lavori, e il San Gallo, dopo uno studio pilota, inizia le procedure.

In **Italia** esistono delle indicazioni legali statali e regionali parallele. Su livello statale la legge 183 del 1989 è fondamentale, istituendo l'Autorità di Bacino, che prevede la zonazione nazionale basata sui bacini idrografici dei fiumi, considerando i pericoli idrologici e geologici. L'elaborazione delle aree a rischio è stata delegata alle regioni. Su livello delle regioni esistono altre norme legali che dovrebbero sott'ordinarsi a quelli delle Autorità di Bacino. Le regioni ARGE ALP dell'Alto Adige e del Trentino, dato il loro stato di province autonome, si tolgono parzialmente di questo obbligo, e hanno delle leggi sulla pianificazione territoriale (Landesraumordnungsgesetz del 1997 e Legge provinciale 26/1987), che regolano l'attività di costruzione in aree minacciate dai pericoli naturali; queste zonazioni però non hanno la risoluzione di piani di zone di pericolo. La regione Lombardia prescrive con la legge 41 del 1997 la creazione di piani di zone di pericolo su livello comunale che vengono inseriti nei piani dell'Autorità di Bacino.

Un **procedimento strutturale per la zonazione dei pericoli naturali** prevede la seguente successione. L'idea di base è la protezione della popolazione e dei beni tramite misure pianificatorie. In questo procedimento occorre elaborare passo per passo, dei documenti (cartografici): l'identificazione e la valutazione dei pericoli naturali producono dei piani dei pericoli, l'analisi del rischio valuta le conseguenze sull'utilizzo del suolo, attuale o pianificato. La gestione del rischio deve stabilire il livello di sicurezza del territorio ed il suo rispettivo costo. Tutta la sequenza integra il riconoscimento dei pericoli naturali nella, normalmente già esistente, pianificazione territoriale su livello comunale e serve ad un utilizzo strutturato del suolo.

Spazio per una **collaborazione interregionale** sensata si presenta data la vasta divergenza su come la pianificazione dell'utilizzo del suolo viene fatta oggi nelle regioni di ARGE ALP: È desiderabile lo scambio interregionale su tutta la sequenza d'elaborazione, cioè sui temi dell'identificazione e la valutazione dei pericoli naturali e sui concetti dell'analisi e della gestione del rischio.

Carte dei pericoli. Le informazioni disponibili nelle regioni sono molto diverse e servono ad obiettivi divergenti. Nella maggior parte dei casi, si tratta di carte indicative dei pericoli, oppure di catasti di eventi pregressi, che indicano un perimetro pericoloso, oppure le località, dove degli eventi storici si sono verificati. I diversi pericoli naturali vengono classificati e cartografati secondo criteri ed intenzioni diversi. Il primo passo di una carta dei pericoli (cioè l'interna zonazione rispetto la pericolosità all'interno di una zona pericolosa) non viene sempre fatta in modo strutturato, ed ancora meno il passo successivo della redazione delle carte del rischio. La gestione del rischio però è fondamentale per l'integrazione dei pericoli naturali nella pianificazione territoriale.

Le informazioni cartografiche che sono disponibili nelle regioni sono quindi molto diversi e hanno differenti intenzioni. Una **carta unica dei pericoli naturali** per tutte le regioni dell'ARGE ALP quindi non è realizzabile in questo momento.

Zusammenfassung

Wie gehen die Regionen der ARGE ALP mit der Bedrohung durch Naturgefahren um? Dieser Report befasst sich mit den gesetzlichen und raumplanerischen Aspekten der Zonierung von Naturgefahren d. h. von Lawinen, Rutschungen, Steinschlag, Überschwemmungen und Murgängen. Die aus dem Projekt entstandenen Erkenntnisse lassen sich, der thematischen Struktur dieses Reports folgend zusammenfassen:

Gesetzliche Grundlagen, institutionelle Kompetenzen und Umsetzungsstand der Naturgefahrenzonierung. Alle Regionen haben durch das historische Zusammenleben mit Naturgefahren auf diese reale Bedrohung auf legislativer und exekutiver Basis reagiert. Eine entsprechende – wenn auch sehr unterschiedliche – Behandlung dieser Bedrohung und der notwendige Schutz von Bevölkerung und Sachwerten finden sich in den Rechtssystemen der Regionen. Bei der rechtlichen Umschreibung und der Verteilung der Kompetenzen ist ebenso die Staatsform, in der die ARGE ALP-Regionen eingebunden sind, sichtbar. Der durchwegs föderative Charakter der jeweiligen Staaten äussert sich darin, dass Autorität und Ausführung auf Staat, Regionen und Gemeinden verteilt sind; Oft hat diese Kompetenzverteilung auch Unklarheiten zur Folge.

Im Allgemeinen wird auf die Bedrohung durch Naturgefahren seltener mittels spezifischer Gesetze, und häufiger durch die Integration der Thematik in die Gesetze von Raumplanung, Wald und Wasserbau reagiert.

Die Ausnahme bildet Bayern, bzw. **Deutschland**, wo Naturgefahren in der Gesetzgebung nicht direkt behandelt werden. In Bayern wird von einer flächendeckenden Behandlung der Naturgefahren mittels Gefahrenzonenplänen abgesehen, und vielmehr Fall für Fall mittels Gutachten abgeklärt.

In **Österreich** sind Gesetzgebung und Kompetenzen bezüglich Naturgefahren weitgehend auf Bundesebene angesiedelt. Der Forsttechnische Dienst für Wildbach- und Lawinenverbauung (WLV), eine Bundesinstitution, setzt die rechtlichen Vorgaben, gegeben durch das nationale Forstgesetz von 1975, mittels Niederlassungen in den Ländern um, und kümmert sich um Massengefahren. Die Überschwemmungsgefahr grösserer Gewässer fällt in den Kompetenzbereich der Bundeswasserbauverwaltung, ebenfalls einer Bundesinstitution; Diese tritt jedoch die Ausführungskompetenz an die jeweiligen in den Bundesländern vorhandenen Landeswasserbauverwaltungen ab. Die erarbeiteten Naturgefahrenzonenpläne werden auf Gemeindeebene erarbeitet, haben selbst jedoch keine direkte Rechtsgültigkeit. Weitere nationale rechtliche Vorgaben schliessen jedoch finanzielle Unterstützung beim Bau von Schutzmassnahmen aus, falls die Gefahrenzonenpläne nicht respektiert werden. Auf regionaler Ebene integrieren typischerweise Gesetze der Raumplanung oder des Bauwesens die von den Bundesbehörden ausgearbeiteten Gefahrenzonenpläne. Der Ausführungsstand in den ARGE ALP-Regionen Salzburg, Tirol und Vorarlberg ist vergleichbar und weit fortgeschritten.

In der **Schweiz** gibt der Bund zwar die rechtlichen Rahmenbedingungen und Vorgehensweise vor, verpflichtet aber die Kantone zu deren Umsetzung. Die Grundlagen liefern die nationalen Gesetze zur Raumplanung (1979), Wald (1991) und Wasserbau (1991). Die Umsetzung erfolgt in den Kantonen auf 2 Ebenen; Auf Kantonsebene innerhalb

des Richtplans, mittels einer Gefahrenhinweiskarte und auf Gemeindeebene mittels Gefahrenzonenplänen. Die ARGE ALP Regionen Graubünden, St. Gallen und Tessin weisen einen unterschiedlichen Umsetzungsstand bezüglich der Naturgefahrenzonierung auf. Während das Tessin die Erarbeitung der Grundlagen anfangs der 1990er Jahre begonnen und mittlerweile praktisch abgeschlossen hat, ist Graubünden mitten in deren Erarbeitung und St. Gallen dabei, nach Abschluss eines Pilotprojektes, die Arbeit aufzunehmen.

In **Italien** existieren parallele staatliche und regionale rechtliche Vorgaben. Auf Staatsebene ist das Gesetz 183 von 1989 richtungweisend, das die Struktur der „Autorità di Bacino" einführt, welche die nationale Gefahrenzonierung aufgrund der hydrographischen Einzugsgebiete der Flüsse bezüglich hydrologischer und geologischer Gefahren vorsieht. Die Ausarbeitung der Gefahrenpläne durch die Autorità di Bacino wurde an die Regionen abgetreten. Auf Ebene der Regionen existieren wiederum eigene Vorgaben, die sich prinzipiell denjenigen der Autorità di Bacino unterzuordnen haben. Basierend auf deren Status der Autonomie entziehen sich die ARGE ALP Regionen Bozen-Südtirol und Trentino teilweise dieser Verpflichtung, und haben eigene Gesetze zur Raumplanung (Landesraumordnungsgesetz von 1997, bzw. Legge provinciale 26/1987), welche Bauauflagen in Naturgefahrengebiete vorschreiben. Diese Zonierungen haben jedoch nicht die Auflösung von Gefahrenzonenplänen. Die Region Lombardei schreibt mit dem Gesetz 41 von 1997 die Erstellung von Gefahrenzonenplänen auf Gemeindeebene vor. Diese werden in die Pläne der Autorità di Bacino integriert.

Ein **strukturiertes Vorgehen in der Naturgefahrenzonierung** sieht folgenden Ablauf vor: Der Grundgedanke ist der Schutz von Bevölkerung und Sachwerten durch raumplanerische Massnahmen. Es müssen schrittweise (Karten-) Dokumente erarbeitet werden: Die Identifikation und Bewertung von Naturgefahren führen zu Gefahrenkarten, die Risikoanalyse untersucht ihre Konsequenzen auf die aktuelle oder geplante Bodenutzung, und das abschliessende Risikomanagement muss den Grad der territorialen Sicherheit und die entsprechenden Kosten definieren. Die gesamte Abfolge dient der Integration der Naturgefahren in die meist schon existierenden Gemeindenutzungsplanung.

Themen für eine sinnvolle **Zusammenarbeit auf interregionaler Ebene** sind gegeben durch die heute weitgehend unterschiedlichen Prozeduren der Landnutzungsplanung in den Regionen der ARGE ALP: Ein interregionaler Austausch über die gesamte Abfolge, d. h. bezüglich Identifikation und Bewertung von Naturgefahren, sowie über Verfahren zur Risikoanalyse und Risikomanagement ist sinnvoll.

Naturgefahrenkarten. Die in den Regionen vorhandenen kartographischen Informationen sind sehr unterschiedlich und dienen verschiedenen Zwecken. Meist handelt es sich dabei um Gefahrenhinweiskarten oder um Ereigniskataster. Die Naturgefahren werden mit verschiedenen Absichten klassiert und kartiert. Der Schritt zu einer Gefahrenkarte (die eine Gefährdungszonierung innerhalb des Gefahrenraumes bedeutet) wird selten systematisch gemacht, und noch weniger der darauf folgende Schritt der Risikoanalyse bzw. des Risikomanagements; das jedoch ein wichtiger Schritt für die Einbindung der Naturgefahren in die Raumplanung darstellt.

Die in den Regionen vorhandenen Kartendaten sind stark verschieden in Informationsgehalt, Qualität und Verfügbarkeit. Eine **gemeinsame Karte der Naturgefahren für alle ARGE ALP-Regionen** ist aus diesen Gründen zum jetzigen Zeitpunkt nicht sinnvoll.

1. Introduction

Natural hazards in the regions of ARGE ALP – Legal base, institutional competence and state of realization of natural hazard zoning.

The working community of ARGE ALP is a union of 10 Alpine regions confronted with the reality of a mountainous landscape (Figure 1.1). The natural environment is characterized by a pronounced topography, where natural hazards such as avalanches, rockfalls or torrential hazards present periodical phenomena.

Figure 1.1: The regions of ARGE ALP take a central position in the Alpine arc.

The economic and social developments after World War 2 have led to an intensification of the use of the Alpine space – as passage, settlement or economic area. This growing use, motivated by tourism, mobility, leisure society, settlement outside of urban centers, etc., has led to an increased damage potential. Consequently more and more often confrontations between anthropogenic interests and natural hazards happen, which consequently are seen by the population as danger, threat and risk. The international natural hazard database [3] lists a clear increase of natural hazard events since the 1960s. A result of this is the sensitization of the mass media with respect to natural hazards [30].

The increased potential is directly reflected in the economic aspects of the topic. Less prominent are the financial resources needed for the prevention of natural hazards, much more are the material consequences of a natural hazard event. The increased settlement and construction activity in dangerous areas on the one hand, and an increased need for insurance on the other have led to a dramatic increase of the material losses (Figure 1.2). For example, only the disastrous precipitations in October 2000 in Northern Italy and Southern Switzerland have costed the lives of 38 people and led to economic losses of 8.5 billion US$ and insured damages of 470 million US$ (Munich Re).

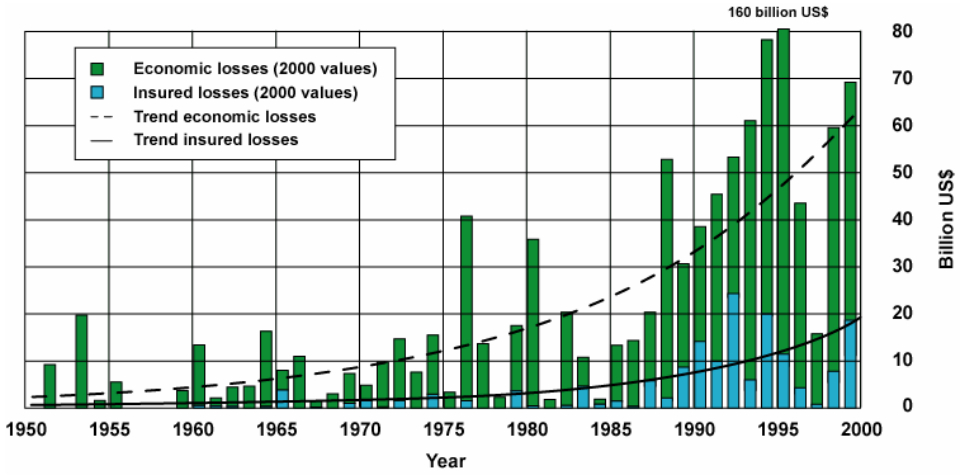

Figure 1.2**:** Worldwide economic losses and insured damages due to natural hazards from 1950 to 2000 (Munich Re).

The results of climate research indicate an increase of natural hazard events in the future, as a consequence of a changing climate: "An increase in temperature of 1 to 2 °C would melt away up to three fourths of today's glacier area and raise the permafrost boundary by 200 to 700 m. Thawn areas of permafrost, areas freed by the glaciers and increased movements of instable slopes in lower elevations increase the risk of rockfalls, landslides and debris flows" [8].

The topic of natural hazards thus might see an increasing importance in the future, as a consequence of the unfortunate combination of the above cited effects of land use, insurance trend and climate change. These aspects have led to a change in the protection from natural hazards – in the younger past – going from a punctual hazard reduction by direct intervention in the field to a rather areal treatment of the topic as an integral part of spatial planning.

The topic of natural hazards covers a wide area: Ranging from the protection by direct intervention in the field (e. g. by rockfall barriers) to a structured and regulated usage of the available land resources, to emergency help during and after a natural hazard event.

This report focuses on the treatment of natural hazards on the levels of legislation and spatial planning. It tries, for all the regions that participated, to answer the following questions:

- Is there a legal base for the treatment of natural hazards? If yes, how are natural hazards dealt with on the levels of legislation and spatial planning?
- Who is responsible for the realization of the legal prescriptions? How is the state of realization?
- From this analysis, is it possible to develop a model strategy for dealing with natural hazards? Which are the possible contents of an interregional cooperation?
- Are there cartographic documents, which give an overview of the situation?
- Is it possible to compile a unique map of natural hazards for the regions of ARGE ALP?

The following chapters are dedicated to the respective topics. With the exception of Baden-Württemberg all regions of ARGE ALP have contributed to the project, supplying a regional representative:

Region	Representative
Bayern	A. Loipersberger, Bayerisches Landesamt für Wasserwirtschaft
Bozen-Südtirol	M. Sperling, Provinz Bozen-Südtirol, Abteilung für Wasserschutzbauten
Graubünden	A. Florin, Amt für Wald, Kanton Graubünden
Lombardia	R. Laffi, D. Mazzoccola, Struttura Rischi idrogeologici e sismici, Regione Lombardia
Salzburg	F. Zaunbauer, Landesforstdirektion Salzburg
St. Gallen	W. Peyer, Planungssamt St. Gallen
Ticino	M. Thüring, Istituto Scienze della Terra-SUPSI
Tirol	J. Neuner, Forsttechnischer Dienst für Wildbach- und Lawinenverbauung, Sektion Tirol
Trentino	R. de Col, S. Plotegheri, Provincia Trentino, Servizio prevenzione calamità pubbliche
Vorarlberg	P. Starck, W. Bauer, Amt der Vorarlberger Landesregierung, Abteilung Raumplanung und Baurecht

2. Legal base, institutional competence and state of realization of natural hazard zoning

Does a legal base exist for natural hazard zoning? Who is in charge for its implementation, and how is the state of realization?

The situations in the various regions with regard to the legal bases and institutional competences of natural hazard zoning, as well as the state of realization are the result of a combination of regional and national aspects in a historical and cultural context. Even though the aim, i. e. the mapping and zoning of natural hazard prone areas to protect the population and values, is generally the same for all the regions of ARGE ALP, different solutions have developed.

The following sections focus on the different situations that have developed in the various regions of ARGE ALP. Taking into account the complexity of the topic, the target of this analysis is not its completeness, but rather the indication of the chosen solution procedure and its state of realization.

2.1 International organizations

International Decade of Natural Disaster Reduction (IDNDR)

The United Nations proclaimed the years 1990-2000 as the *International Decade of Natural Disaster Reduction* (IDNDR). The main target was to mitigate the consequences of natural hazard events to people and values, as well as the social and economic consequences. Until the year 2000, the nations were to realize an ambitious catalogue of actions, e. g. to identify the dangers on the national level, determine their geographic extension, temporal frequency and effects, and change the regulations of land use in order to attain a reduction of risk. These very ambitious targets of IDNDR could hardly be attained. The main effects may have been in the sensitization of the population and decision takers, an aspect which was part of the original main targets.

The IDNDR then developed into ISDR, the *International Strategy for Disaster Reduction* (www.unisdr.org), which sees itself mainly as a communication platform. The ISDR is represented by national platforms in the various member nations.

Alpine convention

The alpine convention (www.cipra.org), an agreement to protect the Alpine environment, has been signed by all nations, to which the ARGE ALP regions belong. The agreement dedicates several articles to natural hazards [2]:

The protocol "regional planning" states the necessity to include natural hazards into spatial planning and demands the urban planning to include the protection from natural hazards. The alpine convention demands the definition of areas where construction activities are to be limited as much as possible in rural and urban areas. In the protocol "soil conservation" this demand is being concretized: Areas threatened by natural hazards are to be mapped and put into an inventory and if necessary, natural hazard zones are to be defined. The protocol "transport" obliges the partners to protect traffic lines from natural hazards.

On the international level, several initiatives exist for the design of inventories and maps of geological natural hazards, on the European [24] and worldwide [9,23] level.

2.2 Germany

Federal level

On the federal level, natural hazards are not treated in particular regulations in Germany. The federal construction law (Bundesbaugesetz) points out to the necessary suitability of the ground when planning a construction. General formulations of the protection of the population can also be interpreted in the sense of the protection from natural hazards. A systematic inventory of natural hazards does not exist, but there are a few punctual initiatives, e. g. in Rheinhessen (in [31]).

Bayern

Natural hazards are treated in a sectorial way in several laws, e. g. the Bavarian forest law of 1982 (Bayerisches Waldgesetz, BayWaldG, BayRS 7902-1-E, last revision 1997), or the Bavarian water law of 1994 (Bayerisches Wassergesetz, BayWG, BayRS 753-1-U, last revision 2001). The Bavarian forest law points out to the protective function of the forest in case of avalanches, geological and hydrological hazards. Natural hazards are also treated in a general manner in several laws (Raumordnung, Landesplanung, Katastrophenschutz and Sicherheit), where among other the protection of lives and health of the population and values are treated. Natural hazard zoning as a stand-alone tool of planning does not exist, but rather the expertise of single cases.

The institutional competences for the mapping and assessment of natural hazards are for hydrological and avalanche hazards at the office of water management (Bayerisches Landesamt für Wasserwirtschaft) and for geological hazards at the geological survey (Bayerisches Geologisches Landesamt) and for the maintenance of the protective forest at the forest administration (Bayerische Forstverwaltung).

Since 1999 an information system for Alpine natural hazards (Informationssystem Alpine Naturgefahren) is under development. This system, which with limited functionality shall also be accessible for the public, concentrates the information available in different offices of the Bavarian administration. The target scale is 1:25'000. Among other offices of the Bavarian administration, the office of water manage-

ment contributes its avalanche inventory and data regarding torrential hazards and the geological survey contributes its data regarding geological hazards.

The GIS-based documentation and information system *Georisk*, developed since 1987 by the geological survey contains geographic and metadata regarding geological hazards (i. e. rockfalls, landslides and debris flows). It contains information on more than 2000 sites in the form of hazard-index maps. The system serves planners, road construction offices, communities and other offices of the Bavarian administration as a decision support, containing data on location, geology, type, activity and extension of mass hazards. The levels of activity of the hazards are color-coded as follows:

- Red: Clear indications for active mass movements.
- Orange: Occasional indications for active mass movements.
- Yellow: Based on geological and morphological evidence, active mass movements cannot be excluded.
- Grey: No indications to mass movements. Not evidenced on the maps, i. e. white.

The information contained in Georisk has the character of a hazard-index map. Figure 4.1 shows an extract of Georisk.

At the office of water management, within a project of integral torrent protection (Integrales Wildbachschutzkonzept), hazard maps of slope dynamics were developed on several test areas [25]. As a result, several hazard levels were evidenced (active/highly unstable, unstable, potentially unstable, unstable and momentarily stable).

2.3 Italy

Federal level

Italy practices the principle of a legal framework on the national level, leaving the concrete elaboration of a legal task to regions and provinces. This principle has been introduced with the constitution of the Italian regions at the beginning of the 1970s. A particular situation is given by the fact that several regions and provinces (e. g. Trentino and Bozen-Südtirol) have the status of autonomous provinces or regions, which includes also a certain legislative independence from national prescription. The consequence is a very complex legal situation in Italy, also regarding natural hazards.

In the remote past, many laws dealing with natural hazards are the direct consequence of natural catastrophes, sequence of natural catastrophes, but hardly any of them targeted on a principle and areal treatment of the problem, but rather on the provision of financial, logistic and reconstructive helps for the necessary interventions after a natural hazard event (e. g. law 185/1952 as a consequence of the flooding of the river Po in 1951 and law 102/1990 as a consequence of the 1987 event in Valtellina).

A more principle treatment of natural hazards on the national level was done for the first time with the law on soil protection 183 of 1989 (Legge 183/1989 sulla difesa del suolo). Closely related are the decretes D. P. C. M. of March 23, 1990, D. P. R. of April 14, 1994, D. P. R. of July 18, 1995 and law 180/1998.

Law 183/1989 introduces the soil protection on the level of hydrographic catchment basins (e. g. of the rivers Po and Adige) with an authority which is located above the existing, local structures. As the competent, executing instrument, the *Autorità di Bacino* (www.autoritadibacino.it) was created as a national-regional organ, which is responsible for the elaboration of the plans of the catchment basin (piano di bacino) and the planned sub-initiatives (piani di stralcio). In the studied area of northern Italy, the most important catchments are the ones of the rivers Po for Lombardia (www.adbpo.it) and Adige for Bozen-Südtirol and Trentino (www.bacino-adige.it).

After the introduction of the law 183/1989 other laws were realized, following events of natural hazards, which have led to a step-wise evolution of the legal treatment with respect to natural hazards on the national level. The law 102/1990 (disaster of Valtellina in 1987) takes up several ideas of law 183/1989, such as e. g. the concepts of hazard and risk and the structuring on the level of catchment basins, where measures are to be realized in order to prevent future events. Among those measures, there are not only constructive interventions, but also spatial planning and future land use. Those aspects are reused in the law 180/1998 for the creation of the natural hazard zones plans, P. A. I. (Piano stralcio per l'Assetto Idrogeologico) of law 183/1989.

These plans distinguish between hydrological and geological hazards on a level of synthesis (map scale 1:25'000) and a level of detail (map scale 1:10'000) as described in the executive norms (norme di attuazione).

Areas prone to *hydrological hazards* are divided into 4 levels (Pericolo idraulico, P. I.), based on return period T_R and flooding height *h* of an event:

- Very high hydrological hazard (P. I. 4). Areas with flooding events with $T_R \leq 30$ years and flooding h ≥ 30 cm.
- High hydrological hazard (P. I. 3). Areas with flooding events with $T_R \leq 30$ years and h < 30 cm and areas with events of $30 < T_R \leq 100$ years and h ≥ 30 cm.
- Medium hydrological hazard (P. I. 2). Areas with flooding events $30 < T_R \leq 100$ years and h < 30 cm and areas with events $100 < T_R \leq 200$ years.
- Moderate hydrological hazard (P. I. 1). Areas with flooding events with $200 < T_R \leq 500$ years.

Areas prone to *geological hazards* are divided into 3 levels of hazards (pericolo di frana, P. F.) on levels of synthesis (1:25:000) and detail (1:10'000) as follows:

- Elevated hazard (P. F. 3): Areas prone to active or currently not-active phenomena in geomorphologically unfavorable conditions.
- Mean hazard (P. F. 2): Areas apparently stable and within lithologies that are intrinsically unfavorable with respect to slope stability.
- Moderate hazard (P. F. 1): Areas apparently stable in lithologies with unfavorable characteristics regarding slope stability.

Furthermore, the executive norms give definitions for parameters return period, hazard, vulnerability, damage, risk, etc.

The areas to be identified by the P. A. I. must be inserted in the emergency planning of the Civil Protection (law 225/1992).

By the year 2002, of the total 37 Autorità di Bacino in Italy, 29 have approved and adopted their P. A. I., 6 have nearly concluded their phase of

elaboration and 2 have not yet started the procedure. The autonomous provinces of Bozen-Südtirol and Trentino elaborate their own P. A. I.

The event of Sarno (Campagna) of 1998 has led to the law 267/1998. This law foresees that the zonation by the Autorità di Bacino includes also subplans (P. A. I.), which identify zones which are hazard prone. In those areas, where people and infrastructure are exposed to hazards, constructive interventions have to be realized, as well as projects of redevelopment. In the case of the river Po, the Autorità di Bacino has charged the regions to identify the areas of elevated danger. Corresponding financial means have been approved.

A further event of natural hazards (Soverato, Calabria in 2000) has led to the law 365/2000. Within this law, it was tried to speed up the procedure to establish the P. A. I., and a series of measures were introduced, which have not yet been specified by the past legal prescriptions.

On a national level, the following institutions deal with natural hazards: The Istituto di Ricerca per la Protezione Idrogeologica (I.R.P.I., www.irpi.cnr.it), and the geological survey of Italy (Servizio Geologico d'Italia, www.dstn.it/sgn). I.R.P.I. was established in 2001, is a member of the Consiglio Nazionale delle Ricerche (C.N.R., www.cnr.it) and has several branch offices (Perugia, Bari, Cosenza, Padova, Torino).

Worth mentioning is also the system SICI (Sistema Informativo sulle Catastrofi Idrogeologiche) by the Gruppo Nazionale per la Difesa dalle Catastrofi Idrogeologiche (GNDCI), another member of C.N.R., an online-archive of thousands of historical geological and hydrological natural hazard events (sici.gndci.pg.cnr.it).

Another initiative, which developed out of law 183/1989, is the national project IFFI (Inventario dei Fenomeni Franosi in Italia) which was introduced in 1997. It has the aim to identify and map the areas prone to mass hazards in Italy. IFFI shall serve as a tool for an adequate use of land resources and foresees the collection of data according to common standards within an electronic database. The project has the following key features:

- Elaboration of standardized documentation regarding mass movements.
- Development of a national, electronic system (database-geographic information system, reference scale 1:25'000) for all mass phenomena in Italy.
- Contribution to the integration of natural hazards in spatial planning on a national level, regarding qualitative, quantitative and typological assessment of natural hazards.

The project IFFI is currently under development by the Italian geological survey and is realized by the Italian regions and provinces.

Bozen-Südtirol

The province of Bozen-Südtirol has the status of an autonomous province, implying a certain legislative autonomy. Its laws are available on the internet (LexBrowser, www.provinz.bz.it).

Natural hazards are integrated in the provincial law on spatial planning (Landesraumordnungsgesetz) of 1997, which also treats construction concessions, that must be asked for at the

municipality of a community. Construction activities are not allowed on terrains prone to landslides, avalanches and rockfalls. Construction projects which have a greater impact on the subsurface must be accompanied by a geological report. The law foresees the periodical control by aerial photographs of the complete territory of Bozen-Südtirol, since the whole province is prone to natural hazard phenomena. The execution ordinance (Durchführungsverordnung zum Landesraumordnungsgesetz) of 1998 specifies in more detail the legal charge, where the geological risk includes 3 classes regarding natural hazards, as follows:

- *High geological risk*. Absolute prohibition to construct. For existing settlements measures for control, safety or protection must be taken. If not possible the population must be evacuated. Protective measures and infrastructures can be constructed, if in agreement with a geological-geotechnical report.
- Zones with *controllable geological risk*. Constructions are possible, respecting the geological conditions.
- *Geologically stable zones*. No limitations regarding geology, if the constructions do not have a considerable impact on the subsurface. If it is the case, a geological-geotechnical report must be made.

In Bozen-Südtirol several administrative offices deal with natural hazards. The Hydrographisches Amt is competent in avalanche hazards, maintaining an avalanche inventory and hazard map (Lawinengefahrenkarte/Carta di localizzazione probabile delle valanghe). The Abteilung für Wasserschutzbauten is in charge for flooding hazards and is currently developing the project DOMODIS (Documentation of Mountain Disasters) for Bozen-Südtirol. The Abteilung für Geologie und Baustoffprüfung is competent in mass hazards, maintaining the GIS/database system for mass movements KDM/CARFRA (Thematische Kartographie Kataster der Massenbewegungen/Cartografia Tematica Catasto delle frane). This information system compiles data on geology, geomorphology, historical events, damages created, land use and current situation of geological hazard phenomena.

Figure 4.2 displays an extract of the data of the Hydrographisches Amt (avalanches), and the Abteilung für Geologie und Baustoffprüfung (geological hazards). The information has the character of a hazard-index map.

Some map and metadata regarding natural hazards in Bozen-Südtirol is available on the internet as part of the online GIS-application EarthBrowser (www.provinz.bz.it/hochbau/1106/Earthbrowser), which shows natural hazard data together with geographic base information (satellite images, orthophoto, lot maps). It is the aim of this application to bundle the available geological information (zones of geological risk, law 180/1998, registry of debris flows, project IFFI), earthquake epicenters and a geological base map. The natural hazard data has the character of a hazard-index map.

Besides this, Bozen-Südtirol is part of the Autorità di bacino of the river Adige (www.bacino-adige.it). Bozen-Südtirol has lately adopted the Swiss procedure for hazard assessment (see section Switzerland, federal level).

Lombardia

The laws of the region Lombardia are available on the internet (www.regione.lombardia.it). The legal situation regarding natural hazards can be found in [1].

The regional law 34 of 1973 (L. R. 34/1973) was the first step into the direction of the integration of natural hazards into the regional legislation. It focused on the protection of the population in case of natural catastrophes by direct interventions in the field. The regional law L. R. 33/1988 led for the first time to a structured procedure for the natural hazard zoning on the level of the provinces, but lacked a precise indication for a concrete procedure.

Later (D. G. R. 5/36147 of 1993) the procedure was concretized and the analysis of the geological component in the spatial planning became mandatory.

With the regional law L. R. 41/1997 and D. G. R. 6/37918 the initiative was further developed and located on the community level. Nowadays, the communities have the obligation to respect the geological situation in their spatial planning, in order to mitigate geological, hydrological and seismic hazards. The regional law 41/1997 has the following key features:

- The communities must study the compatibility of the planned land use with existing or possible natural hazards by means of geological studies.
- Creation of an inventory of the communities, which are prone to an elevated risk or where in the past natural hazard phenomena took place. Prioritarily in these communities, the compatibility of land use and hazard has to be evaluated.
- Possibility of financing of geological studies on community level based on the above cited priorities.

The regional law 41/1997 is currently being put into action in the communities

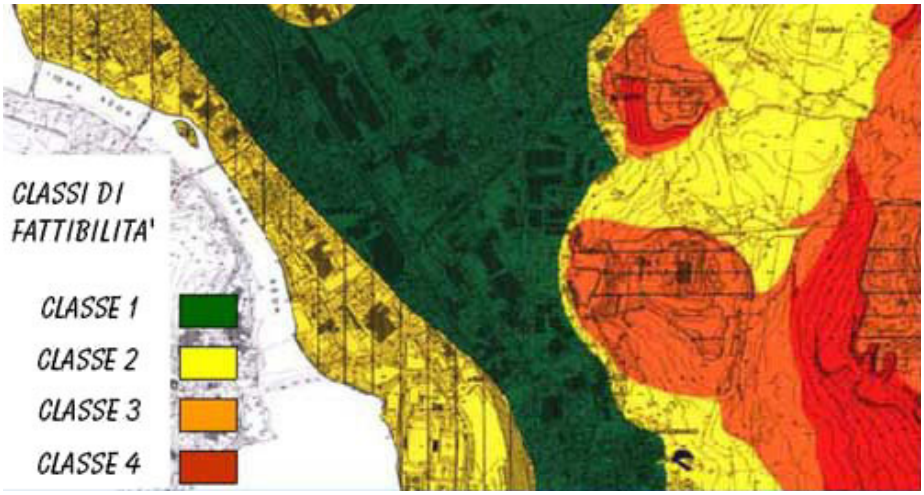

Figure 2.1: Example of hazard zoning (Classe 1 - 4) of a community in Lombardia according to the regional law L. R. 41/1997.

and should lead to an exhaustive and high resolution knowledge of the natural hazard situation on the community level in Lombardia. Until autumn 2000, for about 30% of the communities of Lombardia geological studies were elaborated for being integrated into the land use plans. The necessary studies can only be carried out by geologists registered at the Geological Association of Lombardia (Ordine dei geologi della Lombardia, www.geologi.it/lombardia).

In the above cited geological studies, a community is divided into 4 zones (classi di fattibilità), regulating construction activities (Figure 2.1). The different zones are:

- Zone 1 (classe 1): *No particular limitation*. This zone contains community areas, which have no limitation on construction activities.
- Zone 2 (classe 2): *Minor limitations*. Contains areas, where constructive interventions in the field render a later construction activity possible without limitations.
- Zone 3 (classe 3): *Considerable limitations*. Here further detailed investigations regarding natural hazards and the corresponding permissible land use must be made. Monitoring systems shall help to keep the situation under control.
- Zone 4 (classe 4): *Feasibility with great limitations*. An existing severe hazard practically excludes future usage, if not suitable interventions are realized. Furthermore, plans for protection of the population should be worked out. Monitoring systems shall also help to observe an existing hazard.

As a consequence of the legislation of the past years the Struttura Rischi idrogeologici e sismici of the Region Lombardia has worked out base information to study natural hazards [21], delivering the base for the realization of the legal obligation, concentrating in particular on the problem of the assessment of natural hazards. In this review a series of methods for the assessment of hazard and risk of geological, hydrological and seismic hazards are presented and applied to different test areas in the region of Lombardia.

A series of map information regarding natural hazards has been worked out by the Struttura Rischi idrogeologici e sismici of the region Lombardia in collaboration with other institutions:

- The *Carte dei dissesti 1:25'000* are inventory maps, which have been produced together with research institutions (e. g. C.N.R., Università di Studi di Milano). These maps are hazard-index maps for geological and hydrological hazards. The zones are attributed with a minimum of information (typology, material, age of instability, etc).
- The atlas *SCAI* (atlas of the unstable inhabited urban centers, Atlante Studio dei Centri Abitati Instabili). The atlas contains the communities of 3 provinces of Lombardia which are threatened by geological and hydrological hazards. This initiative is based on specifications of law 445/1908.
- The *Atlante dei conoidi* (atlas of alluvial fans). Often the geographically favored positions on alpine alluvial fans are used for settlements. The result is an elevated hydrological hazard due to torrential activity. The atlas contains information of more than 100 alluvial fans in Lombardia. For about half of them a multi-level hazard zoning has been carried out.
- *Carte inventario delle frane e dei dissesti* (Inventory maps of unstable areas). These maps are produced since 1998 and give an

overview of the hazard situation in Lombardia at a scale of 1:10'000. The maps are produced in cooperation of the Struttura Rischi idrogeologici e sismici and C.N.R. - I.R.P.I. of Perugia; the data is collected by different administrations [34]. Until the year 2002 this inventory should be completed for the whole territory of Lombardia (Figure 4.3).

The Lombardian GIS lists the data available (www.regione.lombardia.it, sistema informativo territoriale) regarding mass movements and avalanches [35].

Trentino

Trentino, like Bozen-Südtirol, has the legal status of an autonomous province, with a partial legislational autonomy. The laws of Trentino are consultable on the internet at www.provinica.tn.it. In Trentino the province law 26 of 1987 (legge provinciale 26/1987) forms the base for the natural hazard zoning. Based on law 26/1987 the geological survey of Trentino (Servizio geologico), together with other offices, has worked out the *Carta di sintesi geologica* (www.gis.provincia.tn.it/website/csg).
This map of geological synthesis can be queried over the internet and covers the whole Trentino territory at a scale of 1:10'000 and is part of the spatial plan of Trentino (Piano Urbanistico Provinciale, P. U. P.). In this map, areas of importance for the spatial planning are indicated; based on the geological situation, geomorphological processes, hydrological and geological hazards and the urban development. At the beginning of 2002 the third edition of the P. U. P. came into force.

The map of geological synthesis specifies two zones of natural hazards, which are (Figure 2.2):

- Zones of elevated geological, hydrological and avalanche hazard (Figure 2.2, zones 1). In these zones any change of land use is forbidden. Existing constructions can be extent in a limited manner or reconstructed from scratch. Expert opinions must proof the safety of persons. Buildings with seasonal

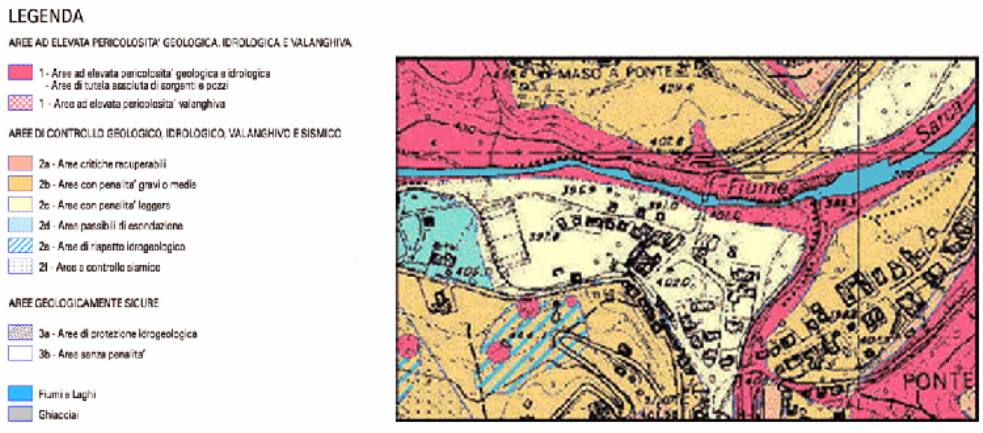

Figure 2.2: Extract of the Geological Synthesis Map (Carta di sintesi geologica) of the autonomous Province of Trentino with respective legend.

Flooding and debris flow			
Criteria	Zones	Design event	Frequent event (1-10 years)
1) Standing water	WR	d ≥ 1.5 m	HQ10 > 50 cm, HQ1 > 20 cm
	WG	d < 1.5 m	HQ10 < 50 cm, HQ1 < 20 cm
2) Moving water	WR	h ≥ 1.5 m	HQ10: h ≥ 0.25 m
	WG	h < 1.5 m	HQ10: h < 0.25 m
3) Erosion channels	WR	d ≥ 1.5 m	Erosion channels possible
	WG	d < 1.5 m	Run-off without erosion channel, see 2)
4) Debris deposits	WR	h ≥ 0.7 m	Debris deposits possible
	WG	h < 0.7 m	No debris deposits, see 2)
5) Lateral erosion due to base erosion	WR	Upper rim of lateral erosion	–
	WG	Safety strip	
6) Debris and mud flows	WR	Border of deposit	–
	WG		
7) Backstepping erosion	WR	Possible extent	No assessment
	WG	Note criteria 3), 5)	
Avalanches			
8) Pressure	LR	P > 10 kN/m^2	P > 3 kN/m^2
	LG	1 < P < 10 kN/m^2	1 < P < 3 kN/m^2
9) Height of deposits	LR	h < 1.5 m	h > 0.5 m
	LG	0.2 < h < 1.5 m	0 < h 0.5 m

Table 2.1**:** Criteria for the delimitation of hazard zones according to the Austrian system by WLV. Notes: Red zone (WR), yellow zone (WG) of torrential hazard; Red zone (LR), yellow zone (LG) of avalanche hazard. Depth d and height h of hazards [19].

usage in zones of avalanche hazard are excluded, if expert opinions prove no danger for persons.

- Zones with restrictions due to geological, hydrological, avalanche and seismic hazards (Figure 2.2, zones 2). Each change in usage can lead to a hazardous situation, due to the poor geotechnical or geomechanical condition of the ground, existing slope inclination, or possible exposition to natural hazards, such as flooding, avalanches, geological mass hazards and phenomena due to seismic activity. There is a further internal division in this zone. The sub-zones focus on natural hazards: Zones, which can be made utilizable after the realization of interventions in the field (zones 2a); zones, where flooding must be expected due to the land morphology and hydrology (zones 2e), and zones, where special construction directions have to be respected due to seismic hazards (zones 2f).

- Geologically safe zones (Figure 2.2, zones 3). In these zones no limitations due to natural hazards are foreseen.

The inventory of avalanches is accessible over the internet at www.gis.provincia.tn.it, and has the character of a hazard map. Besides this, Trentino is part of the Autorità di bacino of the river Adige (www.bacino-adige.it), who has its seat in the province capital Trento.

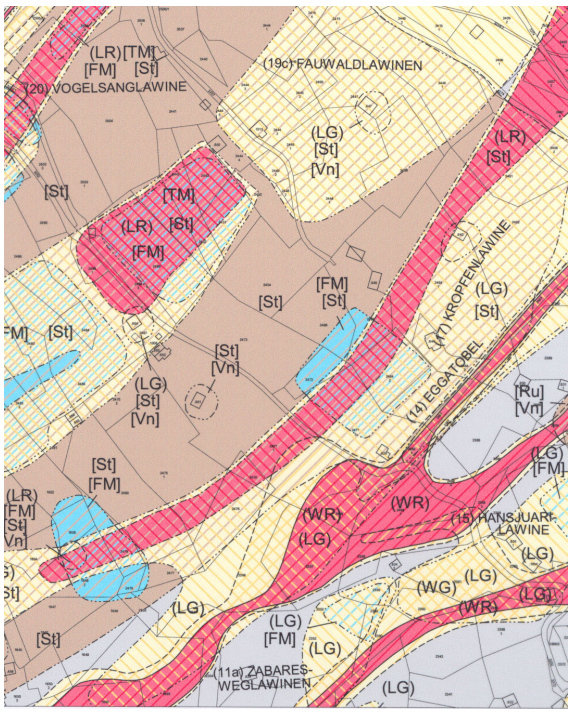

Figure 2.3: Land Vorarlberg: Natural hazard zones elaborated by WLV, section Vorarlberg. Data of Vorarlberg GIS-system VoGIS.

2.4 Austria

Federal level

The Austrian federal and regional legislations are accessible over the internet at www.ris.bka.gv.at. Austria defines the legal framework regarding natural hazards with the forest law of 1975 and the various ordinances and guidelines and implements its federal executive organ “Forsttechnischer Dienst für Wildbach- und Lawinenverbauung” (WLV) for the creation of hazard zone maps in the various Länder. The Länder integrate the hazard zone plans in their regional spatial planning, typically by inserting them into laws of construction and spatial planning.

In Austria repeated flooding events in 1882 initialized the recognition of natural hazards in the national legislation. In 1884 the law which regulates interventions on torrents (Vorkehrungen zur unschädlichen Ableitung von Gebirgswässern, RGBL Nr. 117/1884, revisions BGBL Nr. 316/1934, 54/1959) was introduced. Also in 1884 the corresponding federal office, which later

changed its name to “Forsttechnischer Dienst für Wildbach- und Lawinenverbauung (WLV)” was founded.

Today, the forest law of 1975 (Forstgesetz 1975, BGBL Nr. 440/1975, revisions Nr. 231/1977, 142/1978, 576/1987) is the legal base for the natural hazard zone planning on the Austrian federal level. The law recognizes the protective function of the forests with regards to natural hazards. The forestry spatial planning foresees the cartographic mapping of avalanche and torrential hazards by means of hazard zone plans. The execution is left to WLV.

For flooding hazards of larger rivers, laws of water resources management apply: Wasserbautenförderungsgesetz of 1985 (BGBL Nr. 565/1979), Änderung des Wasserbautenförderungsgesetz 1985 (BGBL Nr. 487/1985). This law delegates the federal competence to the corresponding offices of water resources management in the Länder. Post-event interventions are regulated in the Katastrophengesetz (BGBL Nr. 201/1996).

In the ordinance of 1976 (Verordnung von 1976 über die Gefahrenzonenpläne, BGBL Nr. 435/1976, Nr. 436/1976) and several guidelines [6,11,12,19], the procedure for the creation of natural hazard zone plans is concretized. These maps serve as the basis for the planning and execution of interventions by WLV. The areas of torrents and avalanches are defined in a list elaborated by federal and Länder authorities. This list defines also the distributions of competence between WLV and the offices of water resources management in the Länder.

A hazard zone plan usually covers a community’s territory and consists of a larger-scaled hazard map indicating hazardous areas due to torrents, avalanches, and rockfalls and landslides, having the character of a hazard-index map, and a finer-scaled hazard zone plan. The following hazard zones and index areas are distinguished; they are determined not on the complete community area, but rather on a restricted perimeter (Raumrelevanter Bereich), which is given e. g. by the actual urbanization [19]. There are two hazard zones, red and yellow, the planning is based on events of 150 years return period (Figure 2.3):

- *Red hazard zone*: Permanent land use for settlement or traffic is not possible or only with excessively high cost.
- *Yellow hazard zone*: Permanent land use is limited due to existing hazard.
- *Blue zone*: Areas which are needed for the interventions realized by WLV, or which have a protective function. Interventions are of forestry, biological or technical nature.

There are two index areas, which can also be outside of the restricted perimeter:

- *Brown area*: Indicates other hazards, not due to avalanches or torrents, such as rockfalls and landslides. They can also include areas which touch the authority of the Bundeswasserbauverwaltung, e. g. influencing the run-off behavior upstream of large rivers.
- *Violet area*: Includes areas, whose protective function depends on the characteristics of the terrain.

Guideline [19] states in more detail how hazard zones are to be delimited. Table 2.1 summarizes the criteria for the delimitation of yellow and red zones.

The adoption of the hazard zone plans is done in a step-wise procedure: In a first step, the draft of a community hazard plan is sent to the mayor and the community for a public review. The

draft is then, together with possible comments and revisions, reviewed by an expert jury and examined for its correctness. This expert jury is composed of representatives of the federal ministry, the WLV, the region and the community, and takes its decisions based on a simple majority. With the consecutive approval by the federal minister, the hazard zone map has its validity. If the plans need to be adapted, the same procedure is employed.

Besides the hazard zone plans, there also exists a pre-stage, the so called "Gefahrenzonengutachten", an expert opinion, which usually has a very good technical level, but has not run through the procedure of approval.

Since existing hazard zone plans do not have direct legal value in the Länder, corresponding federal legal norms have been developed to regulate the consequences, if the hazard zone plans are not respected: The guidelines [4,10] state that, in case of not respecting the natural hazard zone plans, no protective interventions are financed by the federal authorities. This procedure practically excludes abuse, since protective measures usually have a 60-70 % federal co-financing.

In Austria, the institutional competences regarding natural hazard zoning and mapping are located predominantly on the federal level. Two offices of the Federal Ministery of Agronomy and Forestry, Environment and Water Economy (Bundesministerium für Land- und Forstwirtschaft, Umwelt und Wasserwirtschaft, BMLFUW, www.bmlf.gv.at) deal with natural hazards.

The Forsttechnischer Dienst für Wildbach- und Lawinenverbauung (WLV) is present in all the Austrian regions

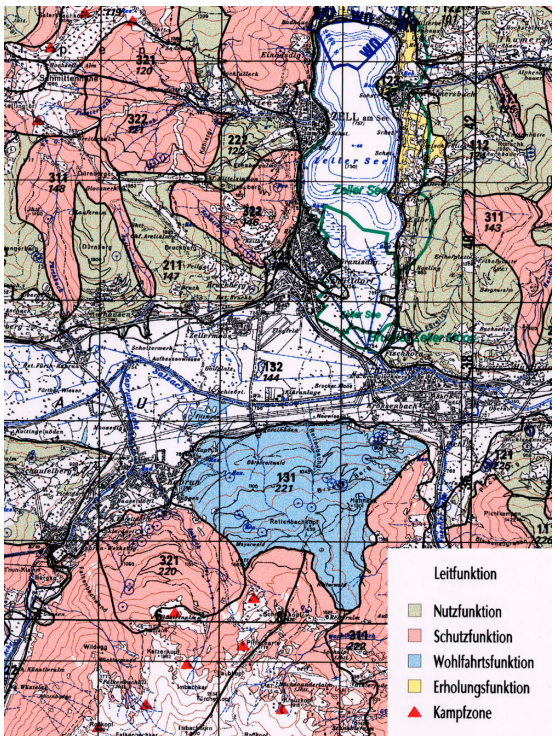

Figure 2.4: Land Salzburg. The forest development plan (Waldentwicklungsplan) includes the protective forest concept (Schutzwaldkonzept), a cooperation of the federal WLV and the office of forest management of Salzburg.

(Länder) by 7 sections and 29 regional offices (Gebietsbauleitungen). The tasks of this service regarding natural hazards include the protection of the population from torrential activity, erosion and avalanches. It conducts activities in the assessment, mapping, expert opinion and consulting, and plans and realizes technical and biological and forestry interventions. Within WLV there is a geological office, which concentrates on geological hazards.

Research activities regarding natural hazards, which originally were conducted within WLV, today, are done by the Federal Office and Research Centre for Forest (Bundesamt und Forschungszentrum für Wald, BFW, fbva.forvie.ac.at).

The competence of the federal administration for water engineering (Bundeswasserbauverwaltung) is delegated to corresponding existing offices of water resources management in the various Länder.

The separation of competences between these offices and WLV is based on the size of a water body and its catchment area: Focusing on torrents in higher elevations, WLV does not treat main water courses. The actual distribution of competences is done on the Länder-level, where a list of water courses indicates which authority is competent.

At the beginning of 1997, of the about 1700 Austrian communities, which are prone to natural hazards, about 50% were in possession of a natural hazard zone plan. The land Kärnten was the only land, which by 1997 had a complete coverage.

Salzburg

In Salzburg, the legal bases are mainly given by the federal forest law of 1975 (see section Austria, federal level), which defines the procedure for hazard zone mapping on the federal Austrian level [19]. The execution is delegated to the Forsttechnischer Dienst für Wildbach- und Lawinenverbauung (WLV), which is present by a branch office in Salzburg, and the office of forest management (Forstdirektion) of the Land Salzburg.

On the regional level, the law on spatial planning of 1998 (Salzburger Raumordnungsgesetz LGBL Nr. 44/1998, 68/2000) and the law on constructions of 1968 (Bebauungsgrundlagengesetz, BGBL Nr. 69/1968, 8/2001) state that construction activities cannot be carried out in areas prone to flooding, avalanches, debris flows, rockfalls etc. The Wildbach- und Lawinenverzeichnis (LGBL Nr. 30/2000) identifies the avalanches and torrents on the Salzburg territory.

By the year 2000 about 85% of the communities were in possession of natural hazard plans worked out by WLV.

Together with WLV, section Salzburg and the Landesforstdirektion, the rotection forest concept (Schutzwaldkonzept) was developed, which identifies areas with protective function from natural hazards (i. e. protection from erosion, karst, rockfall, flooding and avalanches) of the whole territory of Salzburg. Figure 2.4 shows an extract of the forest development concept, which the protection forest concept is a part of. Figure 4.4 shows an extract of the protection forest concept. This data is also included in the internet GIS-application of Salzburg, SAGIS, consultable at www.salzburg.gv.at.

Tirol

In Tirol, the legal bases regarding natural hazards are a combination of federal and regional legislations. The main part is given by the federal forest law of 1975 (see section Austria, federal level) and the successive ordinances and guidelines [19] which define the procedure for hazard zone mapping on the federal Austrian level. The execution is delegated to the Forsttechnischer Dienst für Wildbach- und Lawinenverbauung (WLV), which is present by a branch office in Innsbruck, Tirol.

On the regional level, the law on spatial planning (Tiroler Raumordnungsgesetz, 1997, LGBL Nr. 10/1996) and the law on constructions (Tiroler Bauordnung, 1998, LGBL Nr. 7/1998) implement the legal federal message. These laws specify that in areas prone to natural hazards, construction activities are greatly restricted. They state that the assessment has to include areas which are prone to avalanches, flooding, torrents, rockfall, landslide and other natural hazards, as well as the magnitude of the hazard. The respective situation must be assessed using existing hazard zone plans. The law on spatial planning further regulates in a general manner land use and the conditions of its usage (e. g. protective measures).

According to the federal prescriptions, in *red* hazard zones according to WLV, it is not possible to construct – with a few exceptions. In *yellow* zones, new settlements cannot be realized. If already existing, only densification is possible, but no extension into the direction of the hazard source. In case of minor hazard in a yellow zone, it is possible to construct.

Today, for the about 300 communities of Tirol, which are prone to natural hazard phenomena, there exist natural hazard zone plans, either in the form of officially accepted hazard plans or as expert opinions (see Austria, federal level). At the beginning of 2000 about 50% of the communities had hazard plans accepted by the federal authorities.

The internet GIS application of Tirol, tiris (tiris.tirol.gv.at), partially includes geographic data regarding natural hazards.

Vorarlberg

In Vorarlberg, the legal bases are mainly given by the federal forest law of 1975 (see section Austria, federal level), which defines the procedure for hazard zone mapping on the federal Austrian level [19].

On the regional level, these zones are integrated in the legislation of the Land, in the laws of construction of 1972 (Baugesetz, LGBL Nr. 39/1972, revisions Nr. 33/1976, 34/1981, 2/1982, 34/1994, 15/1996, 72/1997, 64/2000) and its new issue (LGBL Nr. 52/2001, 23/2003) and the law on spatial planning of 1996 (Gesetz über die Raumplanung, LGBL Nr. 39/1996, revisions Nr. 72/1996, 33/1997, 48/1998, 43/1999, 58/2001).

Both regional laws account for natural hazards, excluding areas from possible construction intentions, if they are not suitable due to avalanche, flooding, debris flow, rockfall and landslide hazards.

The elaboration of the hazard zones is delegated to the Forsttechnischer Di-

enst für Wildbach- und Lawinenverbauung (WLV), present by a branch office in Bregenz, Vorarlberg. By the year 2000 about 80% of the 96 communities of Vorarlberg have approved hazard plans, elaborated by WLV.

Figure 2.3 shows the example of a community hazard zone plan, Figure 4.7 displays a more regional view of the hazard zone plan of Vorarlberg, both elaborated by WLV.

2.5 Switzerland

Federal level

Swiss federal and cantonal laws can be consulted on the internet at www.admin.ch. The federal laws are available in German, French and Italian; the cantonal laws are available in the respective official cantonal languages.

In Switzerland the avalanche winter of 1951/52, which costed the lives of 98 persons, initialized the legal treatment of natural hazards. Today, on the Swiss federal level, natural hazards are faced with several laws on spatial planning, forestry and water engineering. According to the federative character of Switzerland, its legislation is a combination of competences on the national and cantonal level. Federal laws describe in a general way a legal request of national interest. A more precise formulation, as well as the execution and the major part of the competences remain in the hands of the cantons. The federal authorities, on the other hand, have instruments to control that laws and ordinances are respected.

The central point regarding natural hazard zoning is given by the law on spatial planning of 1979 (SR 700) and the ordinance of spatial planning of 2000 (SR 700.1). The law generally obliges the confederation, cantons and communities to respect the natural circumstances in spatially effective activities, which includes natural hazards as

Process	Intensity		
	Low	Medium	High
Avalanche	$P < 3kN/m^2$	$3\ kN/m^2 < P < 30kN/m^2$	$P > 30kN/m^2$
Flooding	$h_f < 0.5m$ or $v_f \cdot h_f < 0.5m^2/s$	$0.5 < h_f < 2m$ or $v_f \cdot h_f < 0.5m^2/s$	$h_f > 2m$ or $v_f \cdot h_f < 2m^2/s$
Bank erosion	$h_u < 0.5m$	$0.5m < h_u < 2m$	$h_u > 2m$
Debris flow	-	$h_f < 1m$ or $v_f < 1m/s$	$h_f > 1m$ and $v_f > 1m/s$
Rockfall	$E < 30$ kJ	30 kJ $< E < 300$ kJ	> 300 kJ
Landslide, permanent	$v_f \leq 2cm/year$	2 cm/year $< v_f \leq 10cm/year$	$v_f > 10cm/year$
Landslide, spontaneous	$h_f < 0.5m$	$0.5m < h_r \leq 2m$	$h_r > 2m$

Table 2.2: Classes of hazard intensities for different processes [5,13,14,15,27]. (E kinetic energy, P pressure, h_f height of flow, h_r depth of slide surface, h_s depth of collapse, v_f velocity, h_u depth of river bank erosion).

well. The analysis and assessment of natural hazards is done on two levels of different spatial resolution:

- *Cantonal structure plan*: The cantons integrate in their existing structure plans areas at a scale of about 1:50'000, which are considerably threatened by natural hazards. The structure plans are legally binding for the authorities and have to be reviewed, and if necessary adapted, every 10 years.
- *Community land use plan*: The communities are responsible to edit land use plans at a scale of about 1:5'000, which contain also areas prone to natural hazards. The land use plan is legally binding for everyone.

The forest law of 1991 (SR 921.0) and the forest ordinance of 1992 (SR 921.01) also deal with aspects of natural hazards. The cantons are obliged to work out elemental information for the protection from natural hazards; in particular inventories of hazards and hazard maps. The cantons are obliged to respect the technical guidelines worked out by the federal agencies [5,13,14, 15,17].

The law on water engineering of 1991 (SR 721.100) and the ordinance on water engineering of 1994 (SR 721.100.1) concentrate, in analogy to the forest law, on flooding hazards and oblige the cantons to elaborate the corresponding hazard maps and inventories.

The forest and water engineering laws also describe the financial contributions of the federal authorities to the cantons: In consideration of the financial power of a canton, the confederation determines the amount of financial support

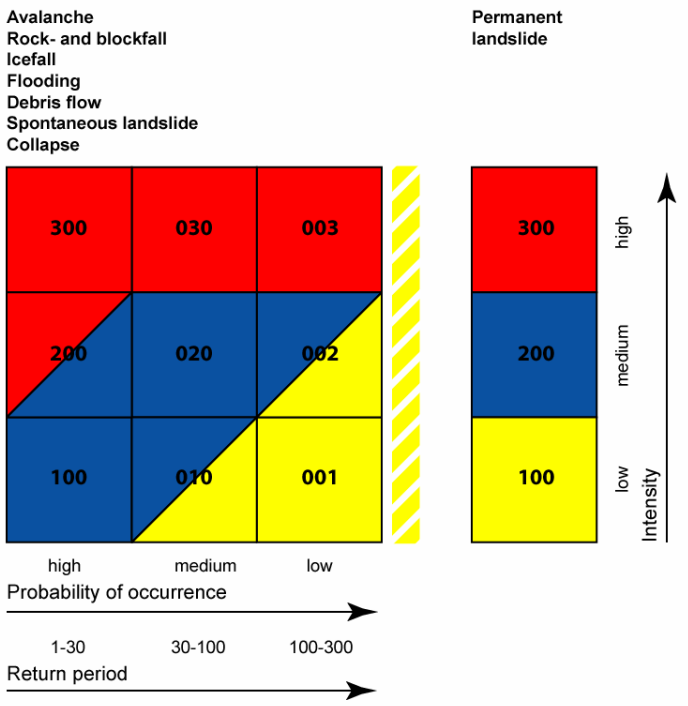

Figure 2.5 : The 3 hazard levels used in Switzerland, yellow, blue and red indicate the degree of hazard based on the parameters intensity and probability of occurrence for a natural hazard process. Modified after [27].

for measures that contribute to the protection from natural hazards: E. g. hazard maps, monitoring and early warning networks, creation of protective forest and protective works.

As a consequence of the forest and water engineering laws, the electronic system for the documentation of hazard events StorME was introduced by the federal authorities. The cantons comply with their obligations to keep a hazard inventory by registering events of natural hazards (avalanches, flooding, rockfalls and landslides) into StorME. Usually the forest administrations of the cantons are responsible for the data-entry into StorME.

The federal laws and ordinances are concretized and complemented by the cantonal legislations. The respective cantons are listed below.

Competences. On the Swiss federal level (www.admin.ch) several organizations and institutes deal with different aspects of natural hazards.

Within the ETH board (www.eth-rat.ch), a part of the Federal Department of the Interior, several institutions deal with natural hazards – focusing on research activities: The Swiss Federal Institute for Forest, Snow and Landscape Research (www.wsl.ch) has a research group on natural hazard and maintains a national database since 1972, which reports regularly the damages created by natural hazards. Its branch office Swiss Federal Institute for Snow and Avalanche Research Davos (www.slf.ch) focuses on avalanche hazards. In order to concentrate the resources in the ETH-board regarding natural hazards the Natural Hazard Competence Centre (CENAT, www.cenat.ch) was founded in 1995.

In the federal administration several offices deal with natural hazards. They especially work out homogenous guidelines for the assessment of and protection from natural hazards. Most important are, in the Federal Department of Environment, Transport, Energy and Communications, the Swiss Agency for the Environment, Forests and Landscape (SAEFL, www.umwelt-schweiz.ch), and the Federal Office for Water and Geology (www.bwg.admin.ch), which has a section “Natural Hazards”.

PLANAT (National platform of natural hazards, www.planat.ch) is a commission in charge of the conceptual coordination in the area of the prevention of natural hazards.

These offices and organizations elaborate guidelines regarding natural hazards on the federal level, which the cantons are obliged to respect. There are guidelines and recommendations on the assessment, mapping and risk analysis and management of natural hazards. Below, the prescribed procedures are sketched; they include the step-wise development of hazard-index maps, hazard maps and the risk analysis with different depths of resolutions.

Natural hazard assessment. The assessment of natural hazards is done according to the degree of danger using the two parameters *intensity* and *probability* (frequency or return period) for each corresponding natural hazard type [5,13,14,15].

In order to determine the *intensity*, different characteristics of the natural hazards are used, and divided into 3 classes (low – medium – high). The class formation is done according to the possible damaging effect on the most important usage type, the settlement area. The 3 steps of intensity are thus oriented on its impact on people, animals and values, such as *low* – also outside of buildings, people and animals are hardly endangered, damages on buildings have to be taken into account; *medium* – people and animals are highly in danger outside of build-

ings, inside of buildings they are hardly endangered, damages on buildings have to be taken into account; *high* – also inside of buildings, people and animals are highly endangered, serious damage on buildings have to be considered, including immediate destruction.

Table 2.2 summarizes the different scales for intensity for the different natural hazard processes [27].

Class	Probability of occurrence [%]	Return period [years]
High	100-82	1-30
Medium	82-40	30-100
Low	40-15	100-300

Table 2.3: Probability of occurrence and return period of an event.

The parameter *probability* is based on the class formation of the return period, where the class boundaries are set at 30 and 100 years. using the probability of occurrence $p=1-(1-1/T)^n$ of a hazard process with return period T within a period of usage n (Table 2.3).

The two parameters intensity and probability are displayed in a 3·3 matrix to form degrees of hazard. The matrix fields are colored in yellow, blue and red, indicating increasing danger (Figure 2.5). For non-permanent processes there generally is the possibility to indicate the residual hazard in the hazard map.

The numbers indicated in Figure 2.5 show the exact context between intensity and probability of occurrence [27].

The hazard levels are chosen so that a certain type of behavior and usage can be inferred. They indicate the degree of hazard for people, animals and considerable values. The different hazard levels are shown in Table 2.4 with the respective consequence on land use.

Risk analysis. After the hazard assessment, in a next step, the assessment of the risk can be done. It is part of the risk concept, which foresees, besides the risk analysis, the risk assessment and risk management. The procedure proposed in [17] considers the risk due to natural hazards as a function of the probability of an event and the possible damage it can create.

The consecutive steps of risk assessment and risk management determine which risk is acceptable, or which measures have to be taken in order to attain the envisaged safety.

Hazard zone	Hazard	Land use meaning
Red	Considerable	Prohibition
Blue	Medium	Regulation
Yellow	Minor	Indication
Yellow-white	Residual (high intensity, very low probability)	Indication
White	Based on actual knowledge no or negligible hazard	No limitation

Table 2.4: Hazard zones and their meaning for spatial planning.

The practical guide [17] for the risk analysis is based on a three-step model, where each step is an independent method for the risk analysis for gravitational hazards. The depth of

resolution increases from step 1 to 3. A risk can be analyzed on several levels, based on the wanted depth of resolution, or on the quality of base information, which is available.

On **step 1** of the risk analysis, the hazard map is overlain by the map of land use, attributing different protection targets to the different types of land use, in the form of maximum tolerable values of intensity and frequency for a hazard process. If the actual hazard due to a single hazard process surpasses the admissible hazard, there is a protection deficit. A scale of the protection deficits is created and values are attributed to it.

On **step 2** the risk, which resulted from step 1 can be quantified based on generalized assumptions, without the need of data assessment in the field, if the hazard assessment is available.

On **step 3**, the risk is assessed specifically on each single object. The result is a quantification of damages to people and values at a superior depth.

As a consequence of the forest law of 1991 the federal inventory for natural hazard events StorMe was created [22]. The cantons are obliged to fill in data on natural hazard events on their territory. The aim is a national database of natural hazard events. There also exists an inventory for protective works, ProtectMe, which serves as a national database.

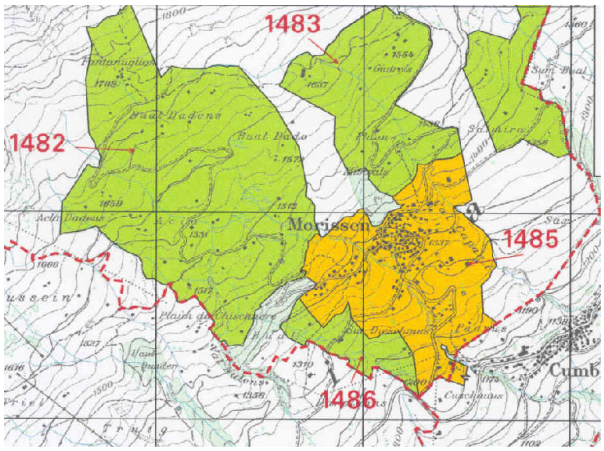

Figure 2.6: Canton Graubünden. The detailed assessment of natural hazards is done only within a restricted area, where different zones are identified based on the damage potential. Example: Community of Morissen/GR. Yellow: Permanently inhabited area. Green: Not permanently inhabited area.

Graubünden

The legislation of Graubünden can be consulted at www.gr.ch. Since the 1970s, the identification of hazard zones is part of the community land use planning. Due to historical reasons the procedures focused on avalanche hazards neglecting mass hazards due to water, fall and slide processes. The more recent legislation corrects this

fact and implements the federal legislation and directives.

On the cantonal level, the laws of Graubünden on spatial planning, forestry and water management deal with natural hazards. Back to the 19th century dates the "Gesetz über Bewuhrung und Verbauung der Flüsse und Wildbäche" of 1870 (807.700) and its executive ordinance of 1880 (807.710). These coordinate the measures for the corrections of rivers and torrents. The law on spatial planning of 1973 (Raumplanungsgesetz, 801.100) and the corresponding ordinance (Raumplanungsverordnung, KRVO, 801.110) of 1986 foresee the identification of natural hazard zones, where people and values are prone to hazards. The hazard zones are divided into two levels: Hazard zones of low danger (planned constructions need a permit by the cantonal assurance building insurance (Kantonale Gebäudeversicherung, www.gva.gr.ch). In hazard-prone areas, restrictions in the form of protective measures are applied, and in areas of elevated hazard no constructions, which serve the stay of people and animals, are allowed.

The introduction of the framework legislation on the federal level in the 1990s, required corresponding adaptations of the cantonal laws. The cantonal forest law of 1995 (Kantonales Waldgesetz, kWaG, 920.100) and the corresponding ordinance of 1994 (KWaV, 920.110) delegate the competence for the identification of hazard zones to the cantonal forest administration and a hazard zone commission. The definition of the hazard zones is done on the community level as part of the land use plan according to the law on spatial planning.

Furthermore, measures which can get co-financing are defined (such as protective measures, monitoring, hazard inventories). The guidelines for hazard zone planning of 1997 (Richtlinien für die Gefahrenzonenplanung, 801.500) shall guarantee a homogenous elaboration of the natural hazard zones.

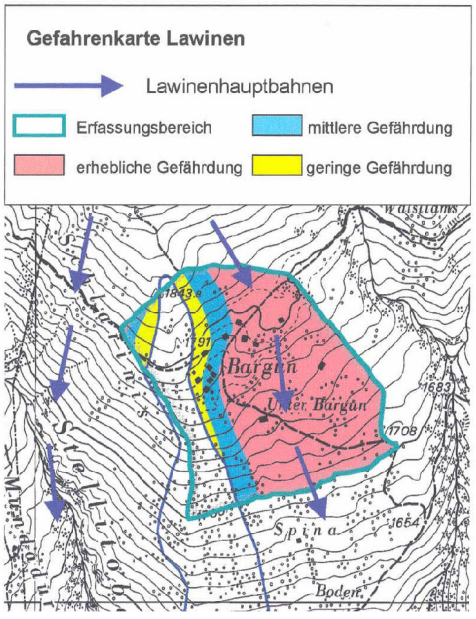

Figure 2.7: Example of an avalanche hazard map in Canton Graubünden indicating 3 hazard zones (red, blue, yellow).

The new cantonal structure plan, which came into force in 2002 (RIPI, www.richtplan.gr.ch) sets the framework conditions for the treatment of natural hazards in the sense of the federal legislation, by means of a complete recognition of current potential natural hazards as a part of risk management. To reach this objective, under the leadership of the cantonal offices of forest, spatial planning and the natural hazard commission (Amt für Wald, Amt für Raumplanung, Naturgefahrenkommission) several initiatives have been started; among others, the creation of a hazard information system, which identifies the areas prone to natural hazards and includes the natural hazard zones as well as the constructive interventions against natural hazards, and the elaboration of base information for the hazard assessment. The communities are obliged to integrate the adaptations of their land use plans according to the results of the cantonal hazard assessment.

Since 2001 the office of forest (Amt für Wald) has an office for natural hazards, which mainly deals with aspects of identification, assessment, and zoning of natural hazards, and takes care of the national inventory of past events StorME for Graubünden.

The natural hazard zoning is done only on restricted areas (Erfassungsbereiche). These are divided internally into several zones, in correspondence to the existing damage potential (e. g. permanently settled areas, or tourism areas, Figure 2.6).

In these areas, the hazard zoning according to the federal prescriptions is carried out, which foresees the separate assessment of each hazard process, avalanche, flooding, rockfall and landslide (Figure 2.7). According to the damage potential in the various zones, the hazard assessment is done for the whole area or on a single object.

Until the end of 2002, the restricted areas (Erfassungsbereiche) of all of the about 200 communities were to be defined. Since 2001 the hazard maps are produced on the community level, where about 10 to 15 communities can be worked off by the Amt für Wald. These hazard maps are the basis, together with the internal structure of the restricted areas, for the risk analysis to be carried out in the land use plan in the communities.

St. Gallen

The legislation of Canton St. Gallen (www.gallex.ch) adopts the federal laws, even though earlier cantonal laws mention natural hazards. The cantonal law on spatial planning and public law on construction of 1972 (Gesetz über die Raumplanung und das öffentliche Baurecht, sGS 731.1, Verordnung über die kantonale Raumplanung, sGS 731.11) foresees that dangerous situations due to natural hazards are to be integrated into the community land use plans. Also the cantonal law on water constructions of 1969 (Wasserbaugesetz, sGS 734.11) foresees measures for the protection from flooding and river bank erosion. Already the cantonal structure plan 87 integrates natural hazards as a pre-orientation (analysis of possible natural hazard threat). However, for the concrete implementation, the completion of the federal legislation was awaited.

The cantonal introductory law for the federal forest law of 1998 (Einführungsgesetz zur eidgenössischen Waldgesetzgebung, sGS 651.1) and the corresponding ordinance of 1999 (Verordnung zum Einführungsgesetz

zur eidgenössischen Waldgesetzgebung, sGS 651.11) implement the federal forest law; where hazard maps and hazard inventory are introduced.

Within a pilot project in 1999 the implementation of the federal procedures was defined (Figure 2.8). It sketches a two-step analysis on the levels of the cantonal structure plan and the community land use plans: Detailed analysis in urban areas by means of integration of natural hazard zoning into land use planning (hazard zone mapping, risk analysis) and hazard-index map on the cantonal level for the remaining areas. Excluding earthquakes, all mass hazards are integrated (avalanches, fall processes, water hazards, and landslides).

The production of base information (hazard map, hazard-index map, risk- and protection deficit map) is done by the cantonal authorities (supervision by the office of forest). The implementation is done by the communities within their land use plans, where hazard-prone areas are overlaid on the existing land use zones. According to the reglementation of the cantonal construction law (Mustervorschrift des kantonalen Baurechts für Baureglemente der Gemeinden) the following areas are to be identified (Figure 2.5) [18]:

- *Red hazard zone*: Existing constructions may be maintained and renewed. Further measures, e. g. measures of object protection may be mandatory. New constructions are not allowed.
- *Blue hazard zone*: Existing constructions may be maintained and renewed. Constructive changes are only allowed, if the necessary measures of object protection are realized. Changes of constructions that go beyond this are only tolerated, if the necessary measures of object protection are realized.
- *Yellow hazard zone*: Existing constructions can be modified. For public buildings, constructions where greater amounts of people meet or constructions of elevated value or high damage potential, the object protection measures are mandatory. For the remaining constructions, the object protection

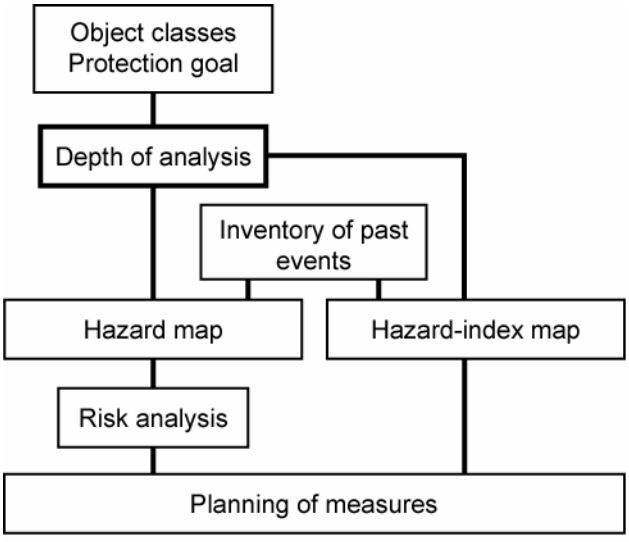

Figure 2.8: Canton St. Gallen: The cantonal procedure implements the federal concepts on a two-step procedure based on the depth of analysis.

measures are recommended.

- Planned constructions which are outside of the above mentioned zones have to respect the hazard-index map defined within the cantonal structure plan. If an existing hazard is identified, an object targeted assessment has to be conducted. The measures of object protection are mandatory.

The above mentioned measures of object protection [27] were developed in parallel to the pilot project by the cantonal building insurance of St. Gallen in 1999 (www.gvasg.ch). The mapping of natural hazard phenomena is currently developing. Based on the planned hazard analysis, the land use plans will have to be controlled and adapted in the about 90 communities of the canton.

Since 1952, there is an avalanche inventory, since 1997 the national inventory of past events StorME is operative (about 300 registered events until June 2001, Figure 4.5) and is being maintained by the regional forest offices (Kreisforstämter) and street inspectorates (Strasseninspektorate).

The Internet GIS application of the Canton St. Gallen, Geoportal (www.geoportal.ch), indicates the cantonal structure plan and the communities' land use plans, including areas prone to natural hazards as hazard-index maps.

Ticino

Historically, the flooding events of 1868 led to the first recognition of natural hazards in the legislation of Ticino (Legge sulla pulizia delle foreste, 1876; legge sulla pulizia delle acque, 1877), indicating the importance of the maintenance and the protective function of the forest and the corrective interventions on water courses.

The flooding events of 1978 led to a cantonal law on natural hazards. This law of 1990 (Legge sui territori soggetti a pericoli naturali del 1990, LTPN) and

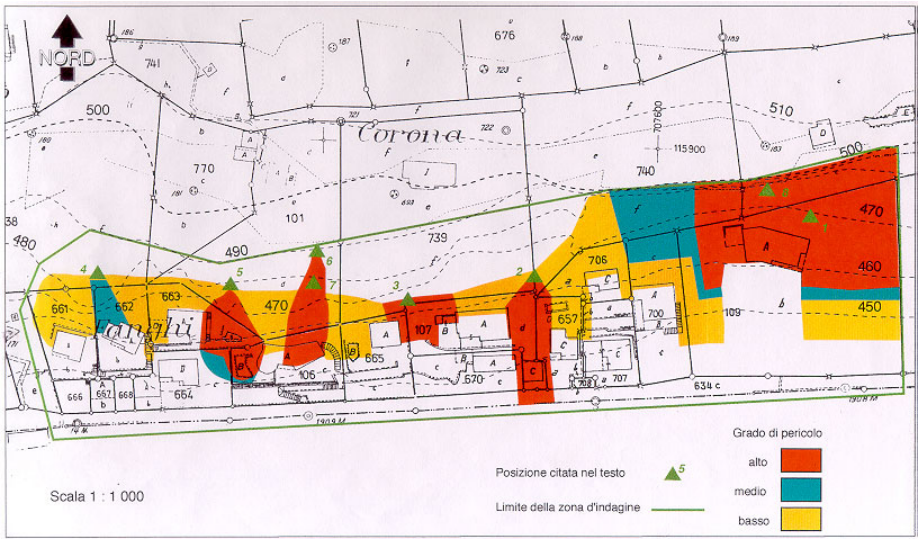

Figure 2.9: Ticino: In hazard-prone urban areas, hazard zoning was conducted on a detailed level.

the executive decrete of 1995 (Decreto esecutivo concernente l'accertamento dei territori soggetti a pericoli naturali, 1995) organize the identification of hazard zones, the protective measures to take, and the interventions that are to apply on areas prone to natural hazards. The recommendations of 1995 [36] specify in detail the procedures.

The law LTPN foresees the development of an inventory of natural hazards and natural hazard zone maps (technical reports on community level, scale not below 1:10'000). The hazard zone maps have to identify the type and magnitude of hazard.

This cantonal law was introduced before the federal laws became effective, and still today is unique on the Swiss cantonal level.

The executive competence was given to the forest administration (Sezione Forestale del Cantone) and the geological survey (Istituto Scienze della Terra-SUPSI) of the Canton.

The cantonal law that applies the federal law on spatial planning of 1990 (Legge cantonale di applicazione della legge federale sulla pianificazione del territorio, LaLPT, 1990, regolamento della legge cantonale di applicazione della legge federale sulla pianificazione del territorio RLaLPT, 1991) concretizes the federal law on spatial planning of 1979 (see Switzerland, federal level). On the cantonal level, the cantonal forest law of 1998 (legge cantonale sulle foreste, LCFo, 1998, regolamento della legge cantonale sulle foreste, RLCFo, 2002) recognizes the protective potential of the forests with respect to natural hazards. The cantonal law which introduces the federal law on water constructions is currently under elaboration.

The law LTPN proposed to act on 3 levels: Create a plan of the areas prone to natural hazards, establish a plan for the protective interventions and improve the operative level.

In a *first phase* in the first half of the 1990s, a preliminary study on the community level was carried out in nearly all the communities of Ticino (about 250), in order to identify areas prone to natural hazards (scale 1:5'000 to 10'000). Considered were geological, hydrological and avalanche hazards.

In a *second phase*, which started in the second half of the 1990s and still is operative, detailed studies according to the federal recommendations [5,13,14, 17] are carried out in those communities, which showed significant hazards in the first study phase (about 50 communities, e. g. Figure 2.9). Those hazard zone plans are then integrated into the land use plans of the communities.

The procedure of approval of the hazard zone plan foresees the following steps:

- The hazard zone plan is presented to the population of the community in the town hall.
- The hazard zone plan is published for three months.
- There is the possibility for objections until 30 days after the closure of publication.
- The hazard zone plan is approved by the cantonal authority, the State Council (Consiglio di Stato).
- The hazard zone plan has its legal value and is published by the corresponding community.

In Ticino, the following institutions deal with natural hazards: The Istituto Scienze della Terra (IST-SUPSI, www.ist.supsi.ch), is an institute of the University of Applied Sciences of Southern Switzerland, (SUPSI, www.supsi.ch). The cantonal office of forest (Sezione Forestale del Dipartimento del

Territorio, www.ti.ch), deals particularly with avalanches and the interventions in hazard-prone areas. On an administrative level, the office of forest manages the federal inventory of past events StorME for Canton Ticino. A cantonal natural hazard commission deals with the legal aspects of natural hazard zoning.

Figure 4.6 shows an extract of the natural hazard map data of Ticino. The displayed data has the character of a hazard-index map.

3. Interregional cooperation

How could a structured procedure for natural hazard zoning look like? What are the possible contents of interregional cooperations?

3.1 Structured procedure for hazard zone planning

In a more detailed view, the situations encountered in the various regions of ARGE ALP cover a wide spectrum of different solutions and procedures regarding the legal and planificatory treatment, as well as the identification and assessment of natural hazards. Since natural hazards have an interregional and international character, a coordinated procedure seems to make sense. It is left to the reader to judge, if an interregional organization like ARGE ALP, or rather an international organization, such as the European Community, is more suitable for the development of a coordinated procedure.

Based on the analysis made in this study, an idealized procedure is composed of the following steps (Figure 3.1):

- Definition of the legal base.
- Assignment of the executive competences.

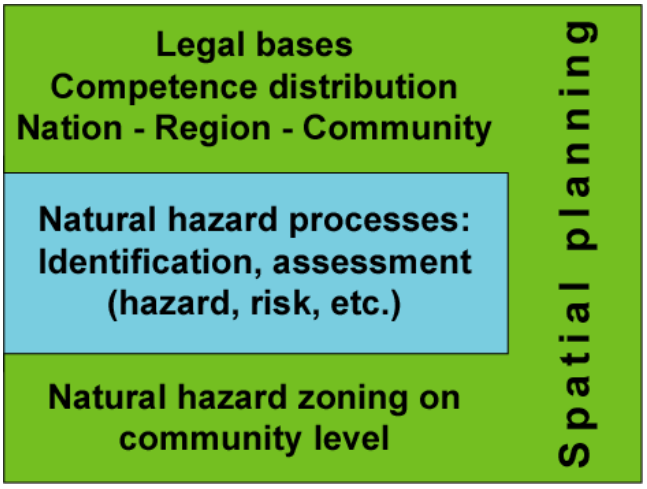

Figure 3.1: Structured procedure for an integral treatment of natural hazards.

- Identification of natural hazards.
- Assessment of natural hazards.
- Risk analysis and risk management.

The following text discusses a model procedure and confronts it with the ac-

tual situations in the regions of ARGE ALP.

Protection of the population by spatial planning

The central idea behind a modern treatment of natural hazards is the recognition of the necessity to protect the population and values not only by direct interventions in the field (e. g. by rockfall barriers), but rather by a systematic regulation of land use. The easiest way to do this is by integrating natural hazards into the generally already existing concepts of spatial planning, establishing the corresponding legal formulation. The clear assignment of the executive competences to implement the legal prescription, defined in a democratic process, favors a rapid proceeding.

Generally existing situations of concurrence between nation, region and community have to be accounted for. A homogenous solution can be attained by a distributed approach, formulating a legal framework on the top-level (nation), which leaves the control to the regions and delegates the implementation to the communities (e. g. Swiss approach: legal framework laws on federal level – execution to the cantons, implementation on community level; Lombardia – regional law 41/1997; Austrian approach – legal framework on national level, implementation on community level).

The community level is the most appropriate for the concrete implementation of hazard zoning for two practical reasons: The communities form the administrative units, where the conflict between land use and the protection of the population has to be resolved. This level also offers the platform, where the identification and assessment of natural hazards can be done on the appropriate scale.

Elaboration of hazard zone plans

In order to attain the envisaged target, i. e. the regulation of land use with respect to natural hazards, a sequence of base information has to be elaborated. Homogenous solutions regarding the identification and assessment of natural hazards, and also for the consecutive steps of risk analysis can be reached by defining them on a (inter-) national level. A possible procedure is defined in [15, 17].

In order not to a-priori exclude parts of the territory or certain hazard processes, it is best to define a general procedure on the complete territory, which includes the different hazards in a modular way. Some approaches (e. g. Italy or Austria concentrate mainly on catchment areas - Italian law 183/1989, or torrential or avalanche activities - Austrian forest law, 1975), which a-posteriori neglect parts of the territory or certain hazard processes.

Identification of natural hazards. A well balanced approach integrates the whole spectrum of natural hazards, e. g. due to fall processes (rockfall, ice fall) sliding processes (landslides), flow processes (debris flows, mud flows), flooding and avalanche hazards and earthquakes, etc. A modular set-up allows the exclusion of hazards which proof to be not important for a certain area, or the integration of non-geological hazards, such as wind hazards or anthropogenic hazards.

The natural hazard processes should be identified using homogenous criteria, in order to guarantee their comparability and continuity across regional, national borders, i. e. language and cultural borders (e. g. [33]).

Hazard assessment. A very promising approach is given by the two-step procedure for hazard assessment, proposed by the Swiss federal authorities, which distinguishes two levels of as-

sessment (see Switzerland, federal level):

In a first step, hazard-index maps on the regional level are created, which identify areas, where a general threat is given by natural hazards.

In a next step, the level of hazard due to a process is determined, typically on the community level. Special characteristics of natural hazards e. g. their intensity allow a better description of the situation. Also in this step, methods and parameters should be chosen, which facilitate the comparison across national and cultural borders (e. g. Austrian approach, Table 2.1; Italian approach of Autorità di Bacino; or Swiss system of hazard assessment, Table 2.2).

The procedure of assessment can be shortened by concentrating on restricted areas, i. e. the assessment is only conducted in inhabited areas of a community, where a considerable damage potential is present (e. g. Austrian procedure, Swiss procedure, Figure 2.6, Figure 2.7).

The results of these evaluations are hazard maps, which have, in comparison to the hazard-index maps, an internal structure regarding the degree of hazard. These hazard zone maps can be integrated into the mostly already existing land use planning of the communities and give a high resolution view on the situation regarding existing hazardous situations.

Working on the two levels of hazard-index and hazard maps has the advantage of shortening the elaboration and focusing on areas of interest. Outside of the restricted areas, the hazard-index map serves for the identification of a dangerous situation, which successively is analyzed in a case-by-case assessment (Figure 2.8).

Risk analysis. Successively, the damage, which can result from a dangerous situation, must be analyzed and the necessary planificatory consequences must be defined. This is done by the superposition of the results of the hazard assessment and the actual or planned land use. Based on the resulting protection deficits (i. e. in a particular situation, the existing hazard exceeds a pre-defined safety level), the necessary measures of spatial planning must be worked out [17], either by limiting the land use or by increasing the safety by protective works in the field.

The risk management has to define which level of safety is wanted at what price and expresses the importance a society wants to dedicate to this topic, with all its consequences on spatial planning, land use and the financial expenditures.

Natural hazard zones as a part of spatial planning

The step-wise elaboration of the above-cited map information leads to documents, which serve as the base for the integration of natural hazards in the concepts of spatial planning.

The elaboration leads, with continuous depth, from the cartographic documentation of events, to hazard-index maps and hazard maps to the envisaged risk maps. In parallel to the depth of elaboration, the scale of elaboration grows: An impact on spatial planning can only be reached on a detailed scale.

The elaboration of risk maps offers the possibility of an objective treatment of the consequences of spatial planning, in the problematic field of the mitigation of the natural hazard threat versus economic interests of land use.

3.2 Topics of interregional cooperation

The analysis of the regional situations indicates the possibilities for cooperations and know-how exchange in the procedures of natural hazard zoning, and its various components of terminology, identification and assessment of hazards, and the consecutive risk analysis and risk management.

Interregional and international cooperations can help especially less advanced regions to speed up their development and to avoid errors which have been done by other regions, or generally work into the direction of a homogenization of the situations regarding natural hazards, a topic which has a strong interregional and international aspect.

Even though the same targets are envisaged, the whole process of natural hazard zoning lacks of coherence between the various regions. The different actual state of development offers the opportunity to tune the different approaches, respectively to exchange experiences in the following areas:

- The **identification of natural hazards** displays divergences and incompatibilities of terminology across language and cultural borders.
- The whole process of solution finding in the **zoning of natural hazards** shows divergences, not only in an international comparison, but often also from one region to another within the same nation. Here, an international or interregional knowledge exchange could be of help for the regions which are less advanced.
- The most reasonable topic for cooperations and knowledge exchange is in the basis of the whole process of **hazard assessment**, which presents an actual research topic. The schemes for hazard assessment applied by the Austrian, Italian and Swiss procedures are largely different.
- Today, well-founded **risk assessment** and risk management are widely ignored, but in the near future might gain a lot of importance as a tool for the minimization of the conflict of land use, territorial safety and its respective cost.

4. Cartographic information

What map data is available in the regions of ARGE ALP?
Is it possible to compile a common map of natural hazards?

4.1 Map data of the regions of ARGE ALP

The map data of Bayern, Bozen-Südtirol, Lombardia, Salzburg, St. Gallen, Ticino and Vorarlberg, which is appended in the following pages, has the purpose to illustrate the variety of the available data, and does not document the state of the art of hazard zoning in the various regions.

4.2 Common map of natural hazards

The initial project targets included the collection of the available map information in the regions of ARGE ALP, in order to compile a common map of natural hazards for ARGE ALP. The analysis of the different situations in the regions, however, has shown a widely diverging situation, with regards to quality, intention, state of realization and availability of map data.

A common map of natural hazards of all the regions of ARGE ALP does not appear meaningful – at least in this moment – for the following reasons:

Type and purpose of the available map information. Even though the base motivation is generally the same, i. e. to guarantee a safe territory, the concrete solution procedures are very different. The procedures for hazard assessment diverge from region to region and nation to nation and vary from a process-based (what hazard process is it?) to a hazard-based (how dangerous is it?) approach or a historical approach (what has happened?). The geological, topographical and meteorological conditions together with a historical record define which hazards are treated and what importance is given to the subject.

Common legend. A common map needs a common legend. The map data, collected in the different regions serves different purposes and so different are the legends which are used in the various ARGE ALP regions.

The most striking argument against a common map of natural hazard is probably this last one: Most regions do not have a complete natural hazard map for their own region, much less possible is it to create a common map of all the regions.

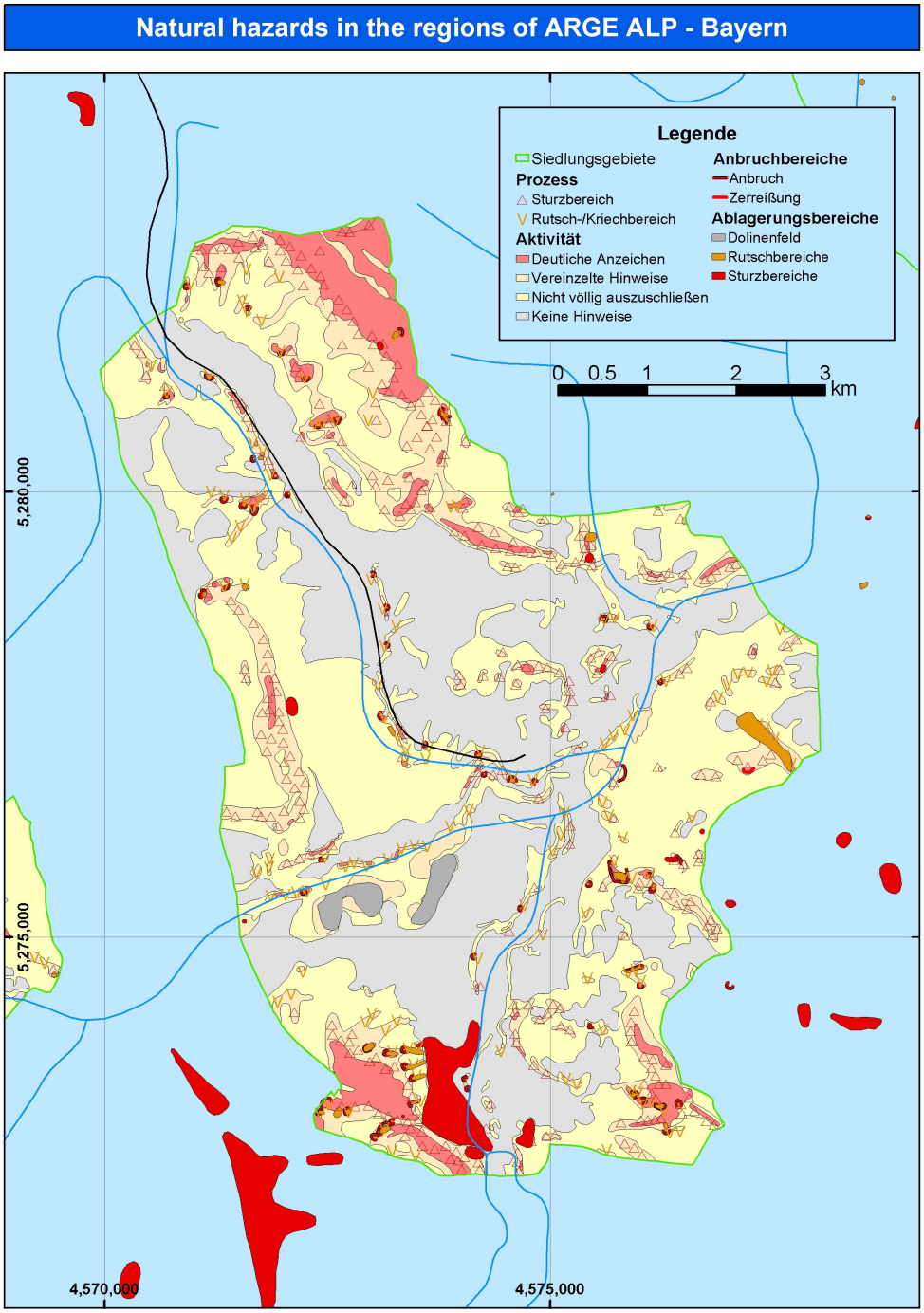

Figure 4.1: Extract of Georisk by the Geological Survey of Bavaria. The displayed data has the character of a hazard-index map.

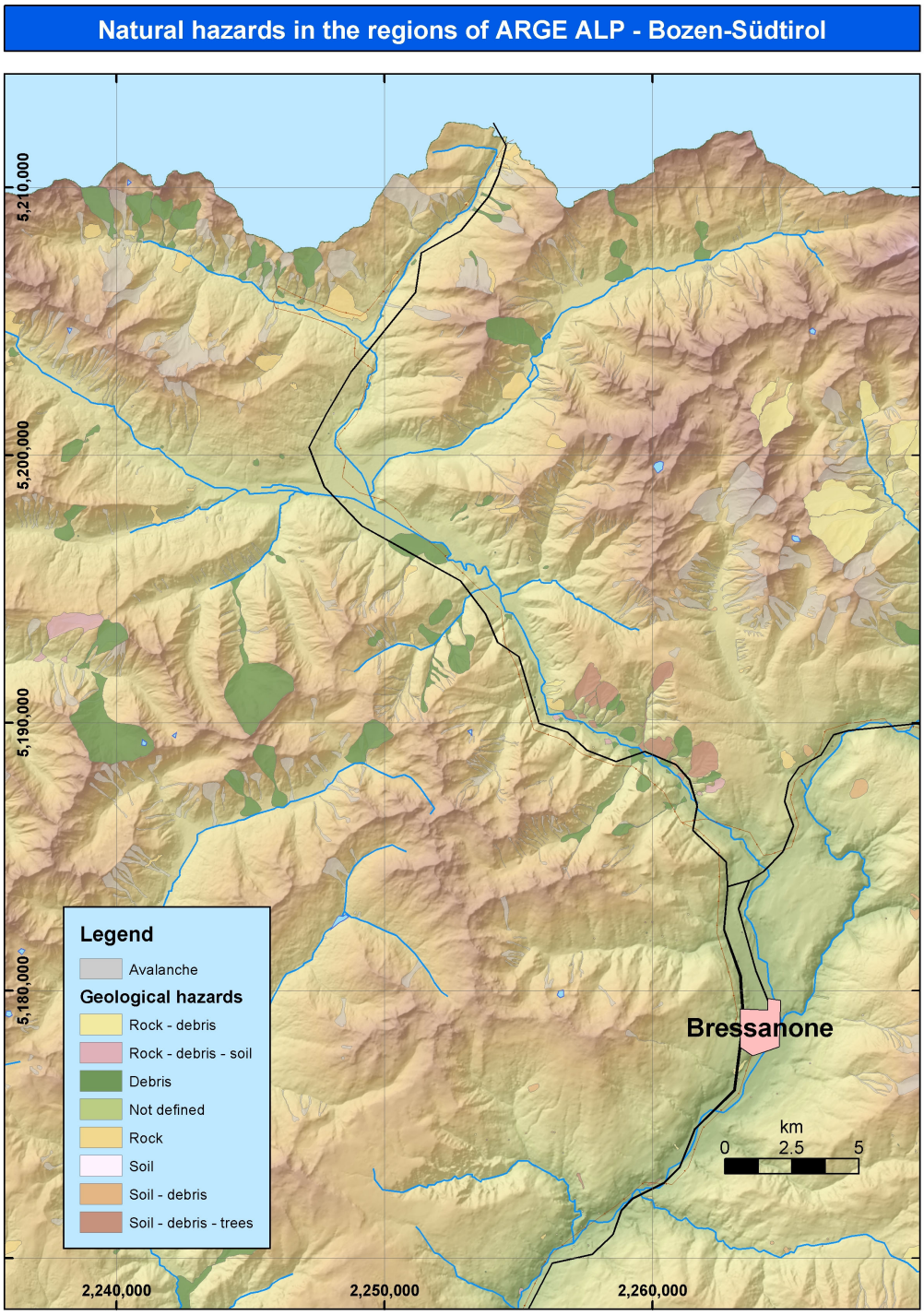

Figure 4.2: Natural hazard map data of Bozen-Südirol. Extract of the area Bressanone. The displayed data has the character of a hazard-index map.

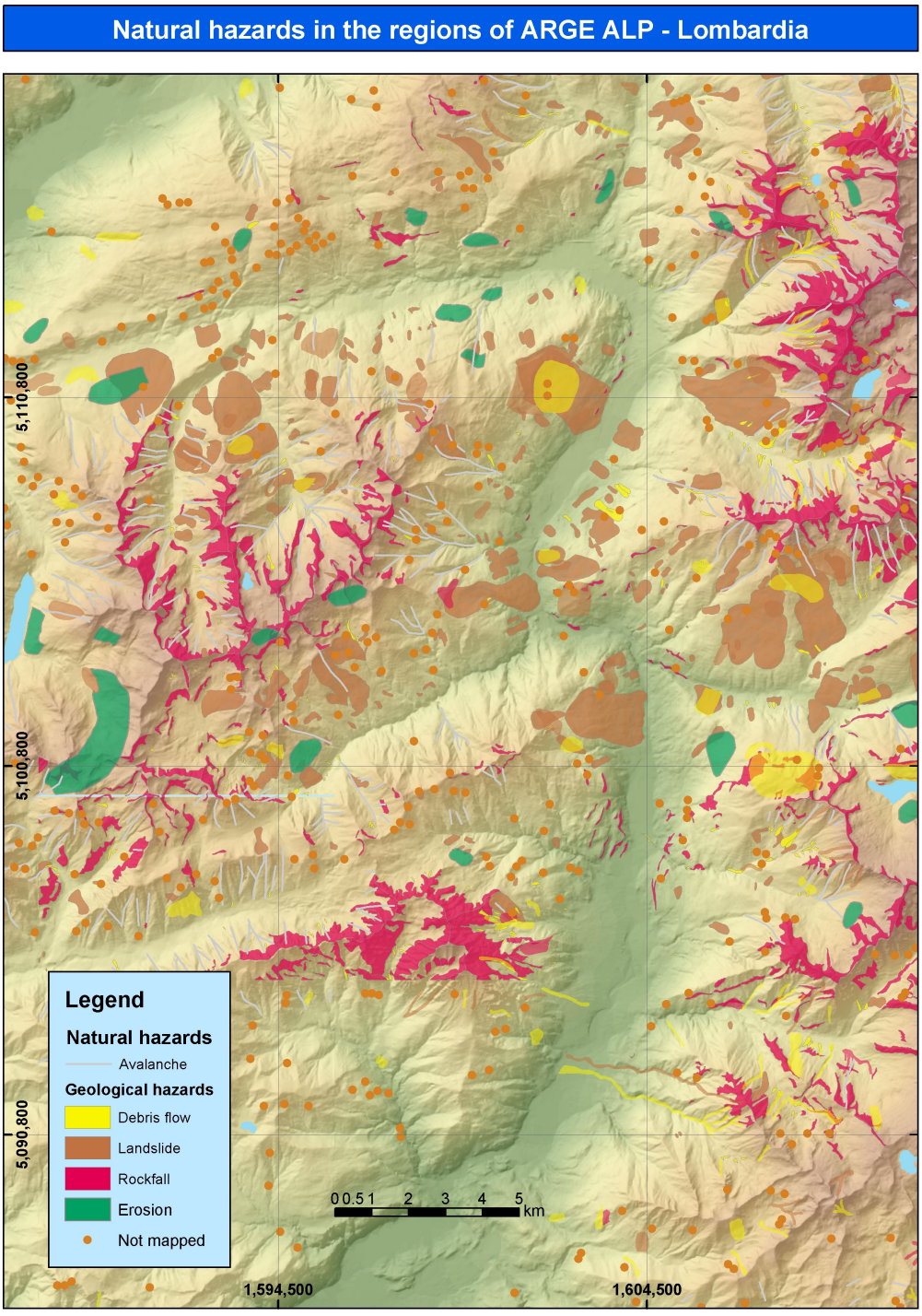

Figure 4.3: Natural hazard map data of Lombardia (region of Valcamonica). The displayed data has the character of a hazard-index map.

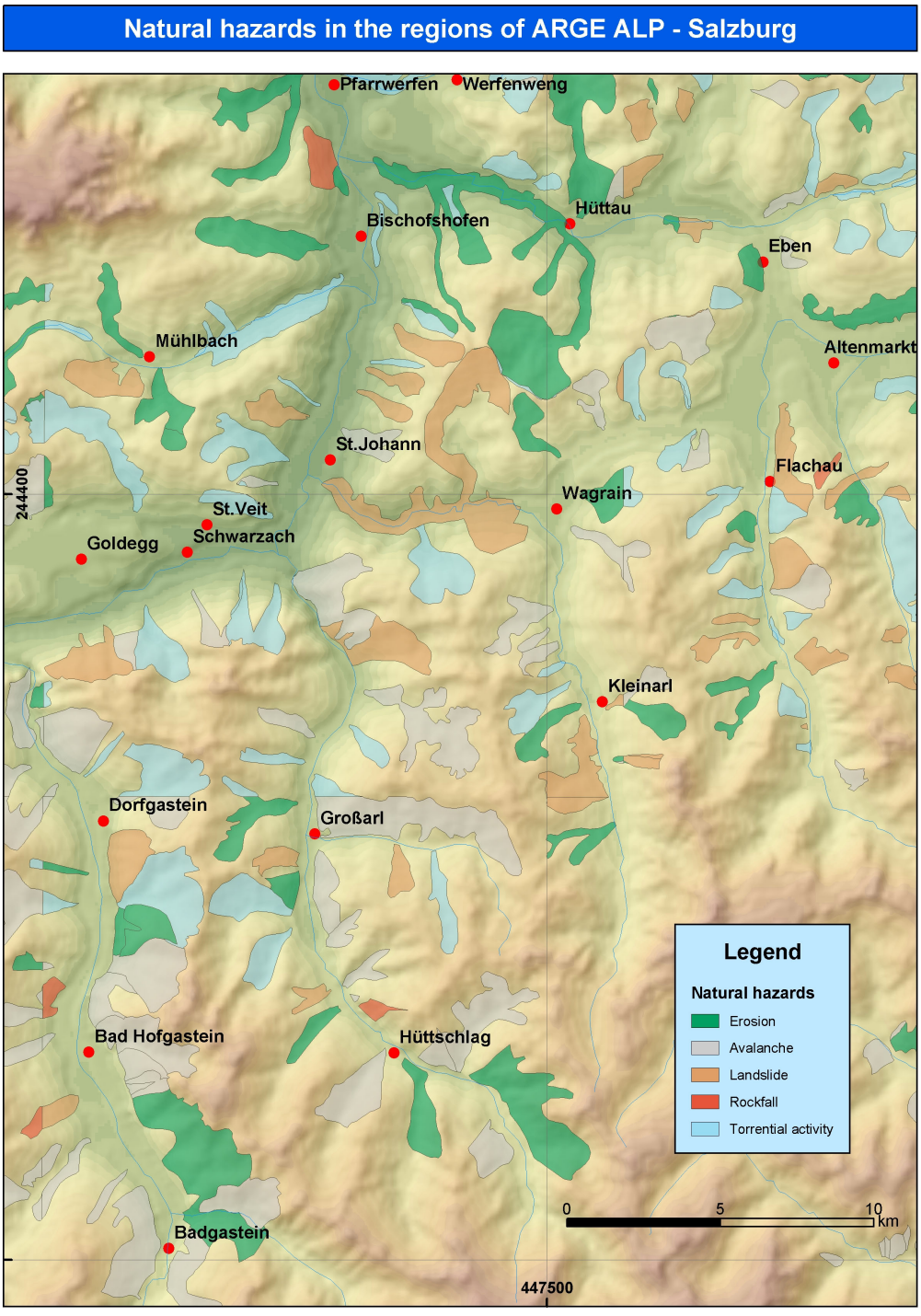

Figure 4.4: Natural hazard map data of Salzburg. The displayed data has the character of a hazard-index map.

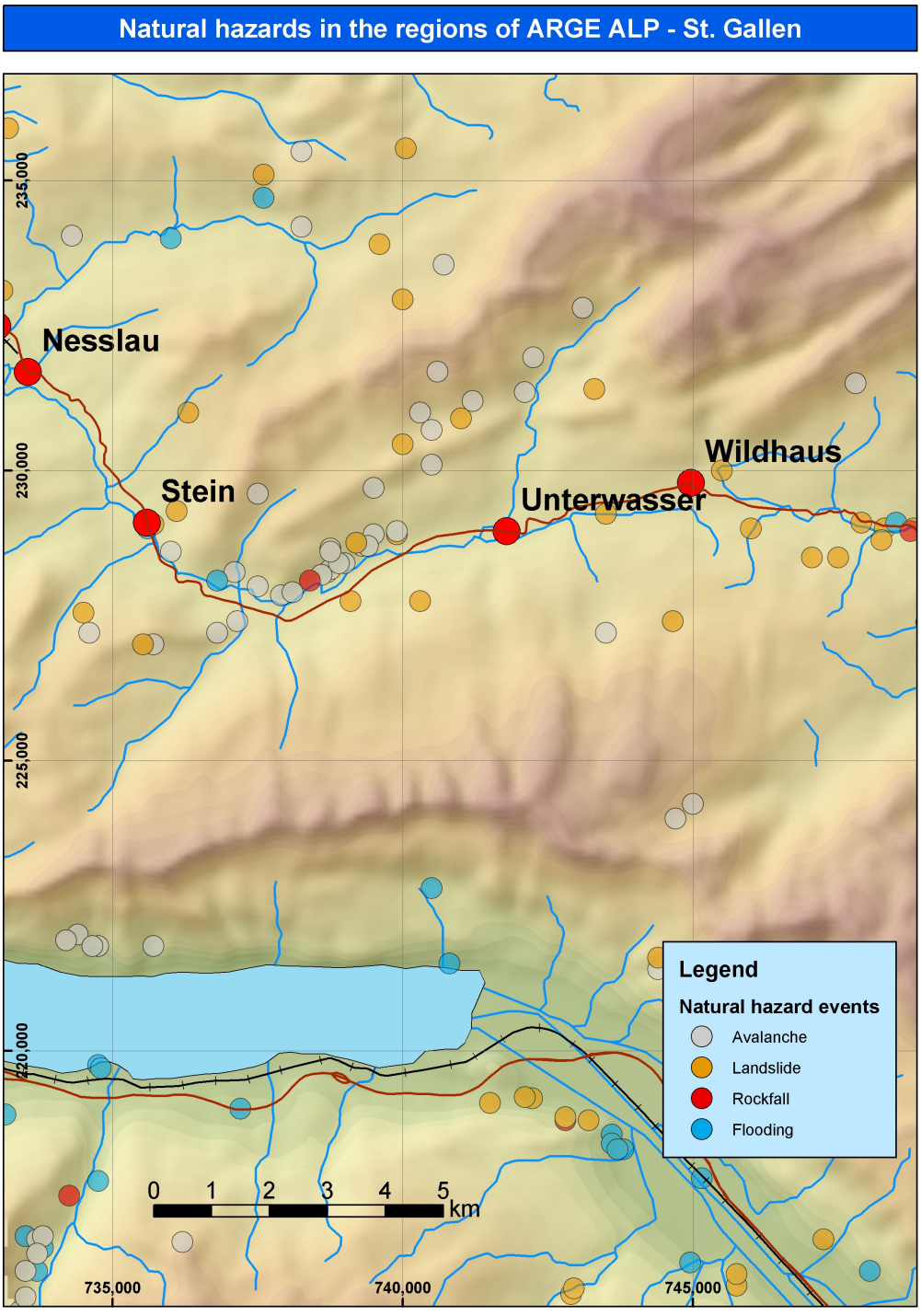

Figure 4.5: Swiss federal inventory of past events StorMe for Canton St. Gallen, in the area of lake Walensee.

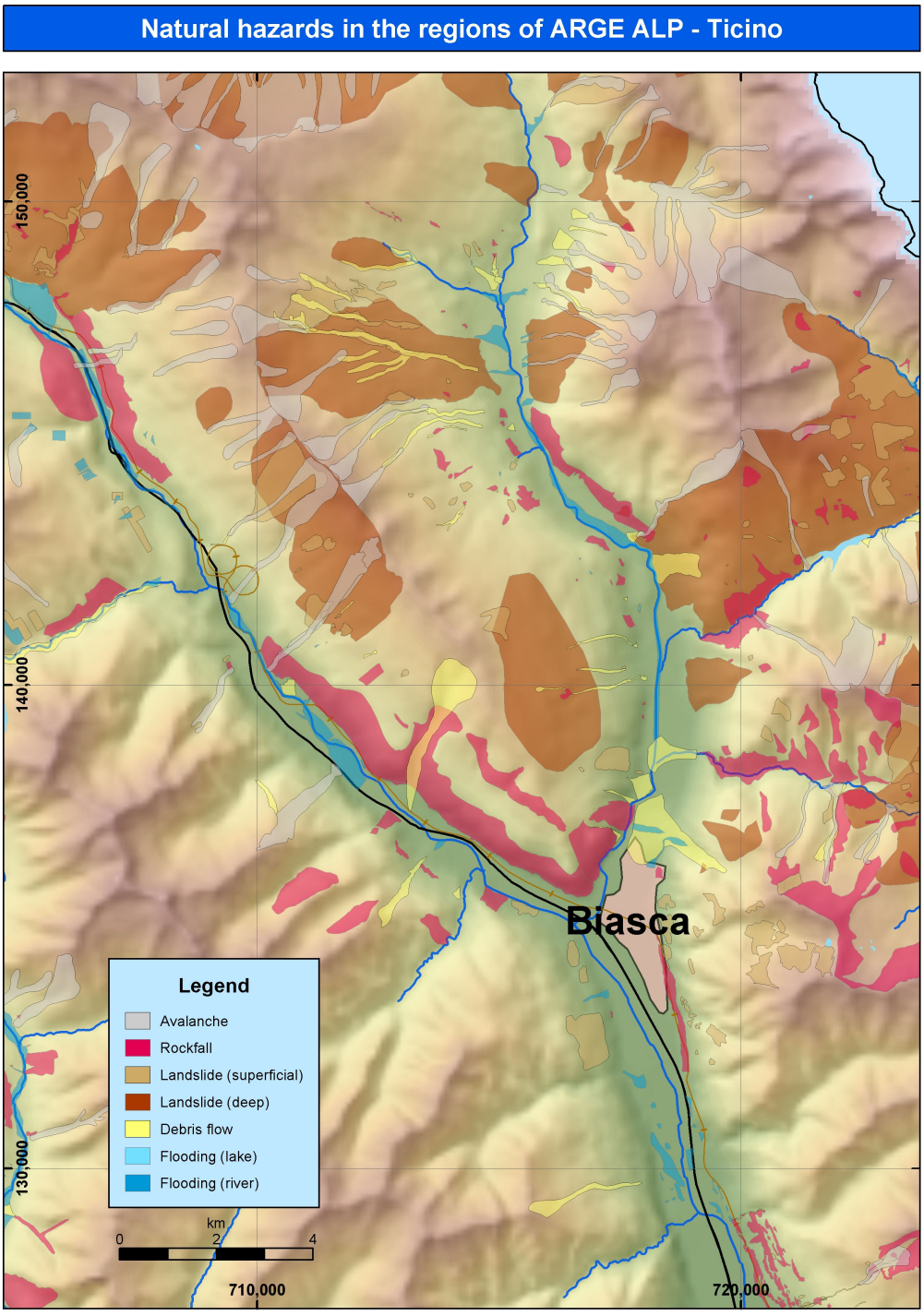

Figure 4.6: Natural hazard map data of Ticino. Extract around the village of Biasca, Leventina valley. The displayed data has the character of hazard-index map.

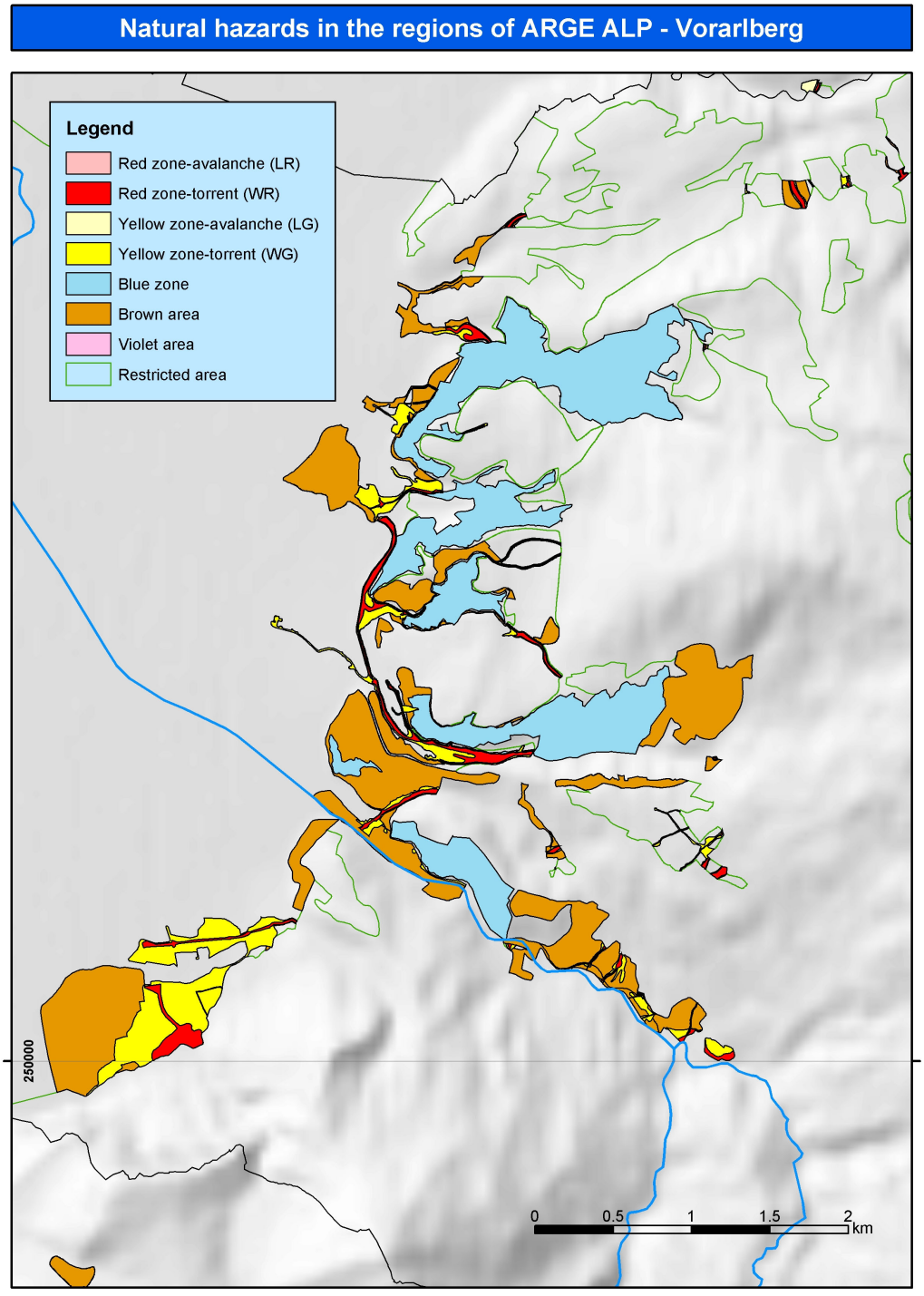

Figure 4.7: Natural hazard map data of Vorarlberg, area of Dornbirn. Displayed are the natural hazard zones according to the federal Austrian forest law of 1975.

Glossary

Explanation of terms used in the text. Based on [16,21,28].

Catastrophe	*dt. Katastrophe, ital. catastrofe* – A sudden and unexpected event that causes widespread human, material or environmental losses. E. g. the criteria used by Swiss Re is more than 20 dead or more than 10 Mio CHF of material losses.
Damage	*dt. Schaden, ital. danno* – Negative consequence of an event or process. Can be expressed as the product of the value of an object and its → vulnerability.
Geological hazard	*dt. Geologische Gefahr, ital. pericolo geologico* – Direct danger for people and values, which result from geological processes. Includes besides mass hazards also dangers due to earthquakes and volcanism.
Hazard	*dt. Gefahr, ital. pericolo* – State, condition, or process, from which damage can result. Possibility of realization of a damaging, dangerous process.
Hazard analysis, assessment	*dt. Gefahrenanalyse, Gefahrenbeurteilung, ital. analisi, valutazione del pericolo* – Study, investigation and diagnosis of → natural hazards.
Hazard-index map	*dt. Gefahrenhinweiskarte, ital. carta indicativa dei pericoli* – Map, which has been produced according to objective scientific criteria, which identifies and localizes, but does not analyze and assess in detail, natural hazards.
Hazard map	*dt. Gefahrenkarte, ital. carta dei pericoli* – Detailed map, produced using scientific criteria, which identifies for the whole area of a perimeter, existing hazards, type of hazard, expected intensity and frequency for each process.
Hazard zone	*dt. Gefahrenzone, ital. zona di pericolo* – Area subject to hazards, on which, based on the → hazard map, usage restrictions have to be employed.
Hazard zone map	*dt. Gefahrenzonenplan, ital. piano delle zone di pericolo* – Based on the → hazard map. Planning instrument, based on a detailed hazard assessment, that is approved by the political instances and binding on landowners.
Inventory of past events	*dt. Ereigniskataster, ital. catasto degli eventi pregressi* – Index of past natural hazard events. Most important base for retrospective part of the → hazard analysis.

Map of past events	*dt. Ereigniskarte, ital. carta degli eventi pregressi* – The data, which is collected in an → inventory of past events is displayed on a map. The historical analysis is of fundamental importance, delivering an important base for the further analysis.
Map of phenomena	*dt. Karte der Phänomene, ital. carta dei fenomeni* – A map showing the features of geomorphologic processes and serving as a basis for hazard assessment and hazard mapping.
Map of protection deficit	*dt. Schutzdefizitkarte, ital. carta del deficit di protezione* – Superposition of a → hazard map and a land use plan.
Mass hazard	*dt. Massengefahr, ital. pericolo di massa* – Natural hazards which transport material due to gravity.
Natural hazard	*dt. Naturgefahr, ital. pericolo naturale* – All natural processes, which for people or values can be hazardous.
Return period	*dt. Wiederkehrdauer, ital. periodo di ritorno* – The long term average interval of the time within which an event will be equaled or exceeded.
Risk	*dt. Risiko, ital. rischio* – The probability and extent of damage due to a particular hazard. Can be expressed as the product of the value of an object, its → vulnerability and → hazard.
Risk assessment	*dt. Risikobewertung, ital. valutazione del rischio* – Judgement about the acceptability of the outcome of the risk analysis, using individual and collective criteria. Answers the question "what *may* happen?"
Risk analysis	*dt. Risikoanalyse, ital. analisi del rischio* – A procedure used to assess a risk on the basis of the probability of occurrence and the extent of damage.
Risk map	*dt. Risikokarte, ital. carta del rischio* – Map which informs about the risk (persons and values) caused by different natural hazard processes.
Risk management	*dt. Risikomanagement, ital. gestione del rischio* – The way how → natural hazards and → risks are dealt with, based on the results of a → risk analysis and risk judgement.
Spatial planning	*dt. Raumplanung, ital. pianificazione territoriale* – The coordination and long term control of spatially effective activities.
Threat	*dt. Gefährdung, ital. pericolosità, minaccia* – Danger referring to a concrete situation or object.
Vulnerability	*dt. Schadenempfindlichkeit, ital. vulnerabilità* – The degree of loss of an object resulting from a damaging phenomenon. Can be expressed on a scale of 0 (no damage) to 1 (destruction).

Addresses

Bayern	Internet: www.bayern.de
Bayerisches Geologisches Landesamt Hess-Strasse 128 D-80797 München	Tel.: +49 (0)89 / 9214 2600 Fax: +49 (0)89 / 9214 2647 E-Mail: poststelle@gla.bayern.de Internet: www.geologie.bayern.de
Bayerisches Landesamt für Wasserwirtschaft Lazarettstrasse 67 D-80636 München	Tel.: +49 (0)89 / 9214 01 Fax: +49 (0)89 / 9214 1435 E-Mail: poststelle@lfw.bayern.de Internet: www.bayern.de/lfw
Bozen-Südtirol	Internet: www.provinz.bz.it
Autonome Provinz Bozen-Südtirol Wasserschutzbauten Cesare-Battisti-Strasse 23 I-39100Bozen	Tel.: +39 0471 / 414 550 Fax: +39 0471 / 414 599 E-Mail: wasserschutzbauten @provinz.bz.it
Autonome Provinz Bozen-Südtirol Hydrographisches Amt Mendelstrasse 33 I-39100 Bozen	Tel.: +39 0471 / 414 740 Fax: +39 0471 / 414 779 E-Mail: hydro@provinz.bz.it
Autonome Provinz Bozen-Südtirol Amt für Geologie und Baustoffprüfung I-39053 Kardaun	Tel.: +39 0471 / 361 510 Fax: +39 0471 / 361 512 E-Mail: geologie@provinz.bz.it
Graubünden	Internet: www.gr.ch
Amt für Wald Graubünden Loestrasse 14 CH-7000 Chur	Tel.: +41 (0)81 / 257 38 61 Fax: +41 (0)81 / 257 21 59 E-Mail: info@afw.gr.ch Internet: www.wald.gr.ch

Lombardia	Internet: www.regione.lombardia.it
Regione Lombardia Struttura Rischi idrogeologici e sismici Via Sassetti 32/2 I-20124 Milano	Tel.: +39 02 6765 46 90 Fax: +39 02 6765 72 51
Salzburg	Internet: www.salzburg.gv.at
Landesforstdirektion Salzburg Fanny-von-Lehnert-Straße 1 A-5020 Salzburg	Tel.: +43 (0)662 / 8042 36 82 Fax: +43 (0)662 / 8042 38 87 E-Mail: post@ forstdirektion.land-sbg.gv.at
Forsttechnischer Dienst für Wildbach- und Lawinenverbauung Sektion Salzburg Bergheimerstrasse 57, PF 162 A-5021 Salzburg	Tel.: +43 (0)662 / 87 81 530 Fax: +43 (0)662 / 87 02 15 E-Mail: sektion.salzburg@wlv.bmlf.gv.at
St. Gallen	Internet: www.sg.ch
Kantonsforstamt St. Gallen Davidstrasse 35 CH-9001 St. Gallen	Tel.: +41 (0)71 / 229 35 02 Fax: +41 (0)71 / 229 48 00 E-Mail info@vd-kfa.sg.ch Internet: www.afu.sg.ch
Ticino	Internet: www.ti.ch
Istituto Scienze della Terra-SUPSI Trevano, C.P. 72 CH-6952 Canobbio	Tel.: +41 (0)91 / 935 12 11 Fax: +41 (0)91 / 935 12 09 E-Mail: admin@ist.supsi.ch Internet: www.ist.supsi.ch
Canton Ticino, Sezione forestale Viale S. Franscini 17 CH-6500 Bellinzona	Tel.: +41 (0)91 / 814 36 62 Fax: +41 (0)91 / 814 44 38 E-Mail:dt-sf@ti.ch Internet: www.ti.ch/DT/DA/SF

Tirol	Internet: www.tirol.gv.at
Forsttechnischer Dienst für Wildbach- und Lawinenverbauung, Sektion Tirol Liebeneggstrasse 11 A-6010 Innsbruck	Tel.: +43 (0)512 / 596 120 Fax: +43 (0)512 / 581 216 E-mail: sektion.tirol@wlv.bmlf.gv.at
Trentino	Internet: www.provincia.tn.it
Provincia autonoma di Trento Servizio prevenzione calamità pubbliche Via Vannetti, 41 I-38100 Trento	Tel.: +39 0461 / 497 444 Fax: +39 0461 / 497 445 E-mail: serv.prevcal@provincia.tn.it
Provincia autonoma di Trento Ufficio neve, valanghe e meteorologia Galleria Legionari Trentini 5 I-38100 Trento	Tel.: +39 0461 / 494 870 Fax: +39 0461 / 238 305 E-mail: meteotrentino@provincia.tn.it
Provincia autonoma di Trento Servizio geologico Via Roma, 50 I-38100 Trento	Tel.: +39 0461 / 495 200 Fax: +39 0461 / 495 201
Vorarlberg	Internet: www.vorarlberg.at
Amt der Vorarlberger Landesregierung Raumplanung und Baurecht Landhaus A-6901 Bregenz	Tel.: +43 (0)5574 / 511 271 05 Fax: +43 (0)5574 / 511 927 195 E-Mail: viia@vorarlberg.at
Amt der Vorarlberger Landesregierung Landeswasserbauamt Jahnstraße 13 A-6900 Bregenz	Tel.: +43 (0)5574 / 511 430 05 Fax: +43 (0)5574 / 511 943 095 E-Mail: lwba@vorarlberg.at
Forsttechnischer Dienst für Wildbach- und Lawinenverbauung Sektion Vorarlberg Rheinstrasse 32/A A-6900 Bregenz	Tel.: +43 (0)5574 / 749 950 Fax: +43 (0)5574 / 749 956 E-Mail: sektion.vorarlberg@wlv.bmlf.gv.at

Bibliography

[1] *Regione Lombardia: 1° Programma regionale di previsione e prevenzione di protezione civile*. Regione Lombardia, Direzione Generale Opere Pubbliche e Protezione Civile, Servizio Protezione Civile.

[2] *Alpenkonvention: Protokoll zur Durchführung der Alpenkonvention von 1991 im Bereich Raumplanung und nachhaltige Entwicklung, Protokoll zur Durchführung der Alpenkonvention von 1998 im Bereich Bodenschutz, Protokoll zur Durchführung der Alpenkonvention von 2000 im Bereich Verkehr*.

[3] *EM-DAT: The OFDA/CRED International Disaster Database*, Brussels: Université Catholique de Louvain (www.cred.be/emdat).

[4] *Richtlinien Hinderungsgründe (BMLF, 52.240/03-VC7/80, vom 7. 4. 1980)*. 1980, Bundesministerium für Land- und Forstwirtschaft.

[5] *Richtlinien zur Beurteilung der Lawinengefahr bei raumwirksamen Tätigkeiten*. 1984, Bundesamt für Forstwesen, Eidgenössisches Institut für Schnee- und Lawinenforschung, Davos.

[6] *Gefahrenzonenpläne und Gefahrenzonenrevision; Richtlinien (52.240/06-VB7/84 vom 31. 1. 1984)*. 1984, Bundesministerium für Land- und Forstwirtschaft.

[7] *SIA Norm 160: Einwirkung auf Tragwerke*. 1989, Schweizerischer Ingenieur- und Architekten-Verein: Zürich.

[8] *NFP-31: Klimaänderung und Naturkatastrophen, Zielsetzungen des Nationalen Forschungsprogramms 31*. 1991, Schweizerischer Nationalfonds zur Förderung der wissenschaftlichen Forschung.

[9] *A suggested method for a landslide summary.* Bulletin International Association for Engineering Geology, 1991. 43: p. 101-110.

[10] *Hinderungsgründe-Richtlinien, Überarbeitung und neue Regelung (BMLF, 52.240/21-VC8a/91, vom 30. 7. 1991)*. 1991, Bundesministerium für Land- und Forstwirtschaft.

[11] *Richtlinien für die Abgrenzung von Gefahrenzonen, Übermittlung des Konzepts; Weisung (52.240/08-VC8a vom 24. 2. 1994)*. 1994, Bundesministerium für Land- und Forstwirtschaft.

[12] *Abgrenzungskriterien für Gefahrenzonen; vorläufige Richtlinien; Anpassung, Mitteilung vom 24. 11. 1994*. 1995, Bundesministerium für Land- und Forstwirtschaft.

[13] *Berücksichtigung der Massenbewegungsgefahren bei raumwirksamen Tätigkeiten, Empfehlungen*. 1997, Bundesamt für Raumplanung, Bundesamt für Umwelt, Wald und Landschaft.

[14] *Berücksichtigung der Hochwassergefahren bei raumwirksamen Tätigkeiten, Empfehlungen*. 1997, Bundesamt für Wasserwirtschaft, Bundesamt für Raumplanung, Bundesamt für Umwelt, Wald und Landschaft.

[15] *Methoden zur Analyse und Bewertung von Naturgefahren, Umwelt-Materialien Naturgefahren*. 1998, Bundesamt für Umwelt, Wald und Landschaft.

[16] *Begriffsdefinitionen zu den Themen: Geomorphologie, Naturgefahren, Forstwesen, Sicherheit, Risiko, Arbeitspapier*. 1998, Bundesamt für Umwelt, Wald und Landschaft, Eidgenössische Forstdirektion.
[17] *Risikoanalyse bei gravitativen Naturgefahren. Teil I - Methoden, Teil II - Fallbeispiele und Daten, Umwelt-Materialien Naturgefahren*. 1999, Bundesamt für Umwelt, Wald und Landschaft.
[18] *Wegleitung Naturgefahrenanalyse im Kanton St. Gallen*. 1999, Naturgefahrenkommission St. Gallen.
[19] *Richtlinien für die Abgrenzung von Gefahrenzonen (52.240/10-VC6a/99 vom 1. Juli 1999)*. 1999, Bundesministerium für Land- und Forstwirtschaft.
[20] *Annual Review of North American Catastrophes*. 2001, American Re.
[21] *Valutazione della pericolosità e del rischio da frana*. 2001, Regione Lombardia, Territorio e Urbanistica; CNR-IRPI Perugia; CNR CSITE Bologna; Università Bicocca.
[22] Arbeitsgemeinschaft-Geotest and GlueData, *Informatikgestützter Ereigniskataster, Schlussbericht. Projektphasen 1 und 2*. 1996, BUWAL, Eidgenössische Forstdirektion, Sektion Naturgefahren: Bern.
[23] Brabb, E.E. *Proposal for world-wide hazard maps*. in *7th international conference and field workshop on landslides*. 1993: Balkema.
[24] Brunsden, D. and M.-L. Ibsen, eds. *The nature of the European archive of historical landslide data, with specific reference to the United Kingdom*. Ref. EUR 15805 EN ed. Temporal occurrence and forecasting of landslides in the European Community, Final Report EPOCH EC Programme, ed. R. Casale, R. Fantechi, and J.-C. Flageollet. Vol. 1. 1994, Europäische Kommission, Science Research Development. 21-70.
[25] Bunza, G., et al., *Abfluss und Abtragungsprozesse in Wildbacheinzugsgebieten.* Grundlagen zum integralen Wildbachschutz, 1996. 72.
[26] Casadio, M. and C. Elmi, *Il manuale del geologo*. 1995, Bologna: Pittagora Editrice.
[27] Egli, T., *Richtlinie Objektschutz gegen Naturgefahren*. 1999: Gebäudeversicherungsanstalt des Kantons St. Gallen.
[28] Eurodicatom., Internet: europa.eu.int/eurodicatom/Controller.
[29] Knoepfel, I., *Klimarisiken aus der Sicht der Versicherungsgesellschaft*, in *Klimarisiken - Herausforderung für die Schweizer Wirtschaft*, P. NFP-31, Editor. 1996, vdf, Hochschulverlag: Zürich.
[30] Petrascheck, A., *Klimaänderungen und Naturkatastrophen*, in *NFP-NR 31 Info*. 1996.
[31] Plate, J.P. and B. Merz, eds. *Naturkatastrophen - Ursachen, Auswirkungen, Vorsorge.* 2001, Schweizerbart'sche Verlagsbuchhandlung.
[32] Stötter, J., et al., *Konzeptvorschlag zum Umgang mit Naturgefahren in der Gefahrenzonenplanung - Herausforderung an Praxis und Wissenschaft zur interdisziplinären Zusammenarbeit.* Innsbrucker Jahresbericht. 1997.
[33] Varnes, D., *Slope movement, types and processes*, in *National Academy of Sciences, Special Report*. 1978: Washington.

[34] Regione Lombardia, Territorio. Inventario delle frane e dei dissesti idrogeologici della Regione Lombardia, Note illustrative. 2002. Bollettino Ufficiale, Regione Lombardia. No. 31. Edizione speciale del 31 luglio 2002. Con CD-ROM.
[35] Regione Lombardia. Sistema informativo territoriale, Sit. Schede descrittive delle banche dati – Edizione 2002.
[36] Canton Ticino, Dipartimento del territorio, Istituto Geologico e Idrologico Cantonale. 1995. Raccomandazioni per la pianificazione dei territori soggetti a pericoli naturali. Cadenazzo, Marzo 1995.