

Beyond the Expected: Dealing with the Case of Overload and Residual Risk of Natural Hazards in the Alpine Region

	Study on dealing with the case of overload and residual risk
Contracting authority:	Bavarian State Ministry of the Environment and Consumer Protection
Contractor:	EURAC Research
Duration:	April 2017 until March 2018
Supplement:	12 page policy paper in English and German

Objectives

The study's concrete objective is to collect the status quo of dealing with cases of overload in the different Alpine countries and states regarding the natural hazards floods, torrential hazards, avalanches, rockfall and landslides. In addition, it collects examples of good practices developed to deal with and manage related risks. Finally, some recommendations are formulated for possible future activities with the aim to improve the governance of residual risk and cases of overload in the Alps.

Approach

Four main methodological working steps were pursued to collect relevant information and to analyse them, namely (I) a literature review, (II) an online questionnaire, (III) expert interviews and (IV) the analysis of the collected data as well as the development of recommendations.

Results

Main outcomes presented in this report reveal that the understanding of the concept and terminology of residual risk and the case of overload varies significantly amongst the countries of Austria, Italy, Switzerland, Slovenia, Germany, France and Liechtenstein. The ways, in which (residual) risks are managed, the methods to determine protection goals as well as the amount and type of actor groups participating in the risk governance process display a large range of possible procedures. Despite those differences, the majority of interviewed experts underlined the fact that the transfer from a traditional hazard control approach towards an integrated risk management (IRM) is a requirement, which is recognised and accounted for in their countries. Moreover, there was a general agreement that mutually accepted definitions and understandings of the concepts of 'case of overload' and 'residual risk' would foster harmonised and mainstreamed related risk governance across the Alpine region.



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Beyond the Expected: Dealing with the Case of Overload and Residual Risk of Natural Hazards in the Alpine Region

Final Report

Schneiderbauer, S., Hartmann, S., Dalla Torre, C., Dinkelaker, N., Sankowsky, A., Hoffmann, C., Pedoth, L., Streifeneder, T.

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Institute for Earth Observation

Institute for Regional Development

Bavarian State Ministry of the
Environment and Consumer Protection



This project is co-financed by the European Regional Development Fund through the Interreg Alpine Space Program.

EUSALP Action Group 8

Please cite this publication as:

Schneiderbauer, S., Hartmann, S., Dalla Torre, C., Dinkelaker, N., Sankowsky, A., Hoffmann, C., Pedoth, L., Streifeneder, T. (2018): Beyond the Expected: Dealing with the Case of Overload and Residual Risk of Natural Hazards in the Alpine Region. Final Report. Bolzano, Italy.

Executive Summary

This is the final report of a study analysing risk governance in the EUSALP region in the context of residual risk. The study's concrete objective is to collect the status quo of dealing with cases of overload in the different Alpine countries and states regarding the natural hazards floods, torrential hazards, avalanches, rockfall and landslides. In addition, it collects examples of good practices developed to deal with and manage related risks. Finally, some recommendations are formulated for possible future activities with the aim to improve the governance of residual risk and cases of overload in the Alps.

Four main methodological working steps were pursued to collect relevant information and to analyse them, namely (I) a literature review, (II) an online questionnaire, (III) expert interviews and (IV) the analysis of the collected data as well as the development of recommendations.

Main outcomes presented in this report reveal that the understanding of the concept and terminology of residual risk and the case of overload varies significantly amongst the countries of Austria, Italy, Switzerland, Slovenia, Germany, France and Liechtenstein. The ways, in which (residual) risks are managed, the methods to determine protection goals as well as the amount and type of actor groups participating in the risk governance process display a large range of possible procedures. Despite those differences, the majority of interviewed experts underlined the fact that the transfer from a traditional hazard control approach towards an integrated risk management (IRM) is a requirement, which is recognised and accounted for in their countries. Moreover, there was a general agreement that mutually accepted definitions and understandings of the concepts of 'case of overload' and 'residual risk' would foster harmonised and mainstreamed related risk governance across the Alpine region.

A number of good practice examples could be found in the literature and were suggested by experts in the questionnaire or the interviews. They cover technical, legal, governance-related and communication-related aspects. Technical good practices include constructions that were designed with special consideration of cases of overload as well as specific warning and altering systems or emergency plans. Examples of legal and governance-related practices mainly comprise measures using spatial planning tools, implementing the European Flood Directive and building capacities amongst practitioners handling emergency situations. Communication-related practices embrace improved hazard and risk maps as well as innovative awareness raising activities.

The formulated recommendations are addressed to both stakeholders and the interested public. They were developed by first analysing the collected expert information and opinions. The results of these analyses were in a second step sharpened and prioritised during a workshop event with help of EUSALP 'Action Group 8' members. The recommendations are grouped in 4 classes covering issues of risk assessment, residual risk management, actors' involvement and residual risk communication. Key aspects of the recommendations contain the development of holistic risk assessments possibly across administrative borders, the consideration of residual risk and eco-system based approaches in spatial planning procedures, the explicit involvement of actors in assessing and dealing with residual risk as well as the increase of general awareness about the limitations of constructional protection measures and the importance that a certain residual risk can never be avoided.

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List of abbreviations

Action Group 8	AG8
AlpGov	Implementing Alpine Governance Mechanisms of the European Strategy for the Alpine Region
BAFU	Federal Office for the Environment, Switzerland
BMLFUW	Federal Ministry of Agriculture, Forestry, Environment and Water Management, Austria
ERDF	European Regional Development Fund
EUSALP	EU Strategy for the Alpine Region
FOCP	Federal Office for Civil Protection, Switzerland
IRGC	International Risk Governance Council
IRM	Integrated Risk Management
MCA	Multi Criteria Analysis
NGO	Non-governmental Organisation
PLANALP	Platform on Natural Hazards of the Alpine Convention
PLANAT	National Platform for Natural Hazards, Switzerland
PPR	Plan de Prévention des Risques, France [French risk prevention plan]
STMUV	Bavarian State Ministry of the Environment and Consumer Protection, Germany
VGI	Volunteered Geographic Information

Acknowledgements

The authors of this document would like to thank all people contributing to this study for their support throughout the past year.

First and foremost, we would like to express our gratitude to Hannah Berger from the Bavarian State Ministry of the Environment and Consumer Protection and Andreas Rimböck from the Bavarian Environment Agency for guiding us through the stages of this project, for their willingness to always provide us with helpful comments and for their availability to fruitfully discuss the content of this report whenever needed.

Next, we would like to express our thanks to all experts who contributed to this project. All type of contributions - responding to the questionnaire, participating in the interviews, providing background material, and organising site inspections – represent essential components of this report. We would also like to thank the members of the EUSALP Action Group 8 for having given us the opportunity to discuss definitions and recommendations of this study during their meeting in Innsbruck on September 19, 2017.

Finally, we would like to say thank you to our colleagues at Eurac Research for supporting us in writing and revising this report.

Preface

An integrated and interdisciplinary management of the risks associated with Alpine natural hazards has become most widely standard in the Alpine region. Integrated risk management can be seen as crucial part of the overarching concept of risk governance, which is understood as the comprehensive process necessary to identify as well as incorporate relevant actors to find the most efficient combinations of measures and solutions that address prevention and mitigation but also response and recovery.

The activities and measures carried out by an integrated risk management usually protect the territory and particularly the population against potential hazardous events up to a certain magnitude or intensity. Events that exceed this intensity are called 'cases of overload'. These events are typically characterised by a low probability of occurrence combined with a great potential for damages and losses. Hence, they should be explicitly taken into account when planning structural protective measures, in order to keep the extent of harm as small as possible by means of suitable non-structural measures. An appropriate consideration of cases of overload has become more important due to changing climate conditions and the associated increase in uncertainty of future risks related to geo-hydrological hazard events.

Cases of overload fall into the category of deliberately accepted residual risk. The technical term 'residual risk' is hereby understood as the part of the (natural hazard-related) risk that remains after the realisation of a protection strategy, which is usually based on a reference design event. So far, scientific reflections and risk management practitioners amongst the Alpine countries and regions have rarely addressed the concepts and definitions of *case of overload* and *residual risk*. In fact, the various definitions applied to these terms in the Alpine region differ substantially. To a similar extent the risk governance approaches vary, which are in place to deal with cases of overload and residual risks. Therefore, this study can be considered as an early contribution to shed light on the difference, accordance, conformity and existing gaps in governing cases of overload and residual risk in the Alpine region.

1. Introduction

1.1 Project introduction

This document represents the final report of the study “Risk governance dealing with the case of overload: Status quo and possible improvement in the EUSALP”. The study has been carried out within the scope of the project ‘AlpGov’ (Implementing Alpine Governance Mechanism of the European Strategy for the Alpine Region), a project financed through the Alpine Space Program of the European Regional Development Fund (ERDF). The overall objective of the study is the inquiry of the status quo regarding risk governance in the case of overload and residual risk in the Alps. It thereby contributes to the AlpGov’s main objective to support an effective and efficient implementation of the EU Strategy for the Alpine Region (EUSALP) in a systematic and transnational approach. The present study is supporting this activity by looking particularly into risk governance of the case of overload and residual risk related to natural events.

The findings of this study will contribute to an overall analysis concerning the risk governance in the field of alpine natural hazards. They will support further work within EUSALP, particularly of the Action Group 8 (AG8), and will back the formulation of recommendations to improve the current situation concerning risk governance in the Alps. The EUSALP AG8 has the specific task to improve risk management and to manage climate change, including major natural risks prevention better. This is backed by the fact that, despite considerable progress made in the last years, there is still a pressing need for more integrated risk management (IRM) approaches as well as for a change in risk culture and for the consideration of residual risks related to natural hazards in the Alps (EINHORN and PEISSER 2011).

1.2 Study introduction

The concrete objective of this study is to collect and present the status quo of risk governance in dealing with overload events and residual risk in the Alpine region regarding the natural hazards floods, torrential hazards, avalanches, rockfall and landslides. In addition, it intends to collect examples of good practices developed to deal with and manage related risks. Finally, based on the findings of various working steps, the study formulates recommendations for possible future activities with the aim to improve the governance of residual risk and cases of overload. The target groups of this study are on one-hand experts in the field of risk governance. On the other hand, the study addresses decision-makers at different governmental levels as well as the wider interested public. More in detail, the study objectives can be summarised as:

- delivering a compendium of the different existing definitions of residual risk and the case of overload in the EUSALP area,
- presenting the status quo of risk governance in the context of residual risk and overload events in the EUSALP area, taking into account legal, technical and political aspects,
- presenting the variety of approaches to risk management in the EUSALP area – giving particular attention to the phases of the risk management cycle, communication and the consideration of climate change,
- providing a collection of 'good practice' examples dealing with overload events concerning the above-mentioned natural hazards,
- and elaborating shared recommendations for improving the existing status quo.

The main outputs of the study are 2 reports. First, an intermediate report, which contains the quantitative findings and preliminary analyses derived from the literature review and the online questionnaire. Second, the final report, which summarises the analysis of the most relevant quantitative as well as qualitative findings of the study. It provides insights in similarities and differences in risk governance of residual risk and cases of overload in the Alpine region and presents a collection of 'good practices' as well as a set of elaborated recommendations. Together with the final report, also a brief summary for policy- and decision-makers is delivered.

1.3 Thematic introduction

Large areas of the Alpine region are characterised by a steep topography with narrow valleys surrounded by mountains confined by pronounced slopes. Consequently, its territories and communities are exposed to gravitational geo-hydrological hazards of which the most relevant are torrential floods (including debris flows), rockfalls, landslides and avalanches. The main drivers of the mountain hazards are the high potential energy related to steep terrains and the hydro-climatological conditions (AUER et al. 2007, FUCHS et al. 2017).

Currently, the risk of loss and damage triggered by natural hazards in the Alps is increasing due to potentially adverse impacts of changing climate conditions but also due to growing population density and the accumulation of human assets and settlements in risk prone areas. Moreover, between the late 20th and the early 21st century, the Alpine region faced a temperature increase of approximately 2°C. This is more than twice the global average warming rate (EEA 2010). Changes in precipitation schemes have been explicit but a slight trend towards increasing precipitation in the northern Alpine region and a decrease in the south has been detected (EEA 2009). Particularly the warming of the mountain areas has already triggered modifications in the ecological systems observable through changes in the hydrological cycle, thawing of permafrost, and glacier retreat (APCC 2014, KNIGHT et al. 2013, STOFFEL et al. 2014, CROZIER 2010). Against this background, it is likely that frequency and magnitude of natural hazards will grow as consequences of climate change (PLANALP 2012). However, the factors influencing natural hazardous processes are manifold and climate is only one of them. Taking further into consideration the given limitations of climate modelling and knowledge gaps about potential impacts as well as vulnerabilities, it is unmistakable that the effects of climate change on natural hazard risks are uncertain. Nevertheless, because of the variety and severity of the potential adverse impacts, the EC's White Paper on the adaptation to climate change mentions mountain areas and particularly the Alps, as the areas that are most vulnerable to climate change in Europe (EC 2009).

Another factor that is of great importance for the risk of being impacted by natural hazards in the Alps is the spatial concentration of settlements and infrastructure in endangered areas. Due to the topography, particularly in the central parts of the Alps, the areas available for spatial development are limited and – additionally – spatial planning is often not sufficiently aligned with risk management. FUCHS et al. (2017) have looked into these issues and have mapped the exposure rate of residential buildings to hydrological hazards in Austria and Switzerland (Figure 1). The results reveal that an overall average of about 14% of residential buildings are exposed to hydrological hazards. Spatially, low exposure is predominant in the Alpine foreland whilst high exposure occurs particularly in municipalities located in the high mountain areas around the main crest.

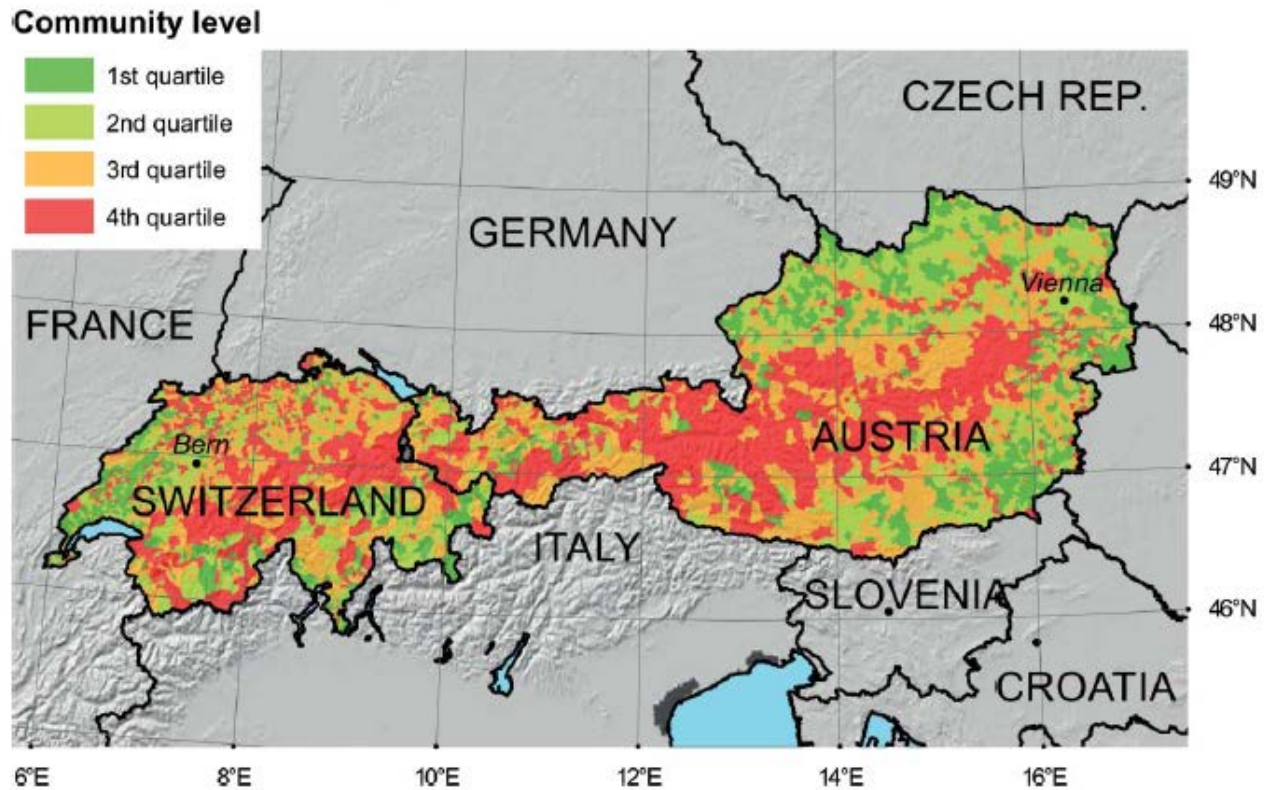


Figure 1: Exposure rate of residential buildings to hydrological hazards in Austria and Switzerland (proportion of exposed buildings over all buildings within a local authority, shown in terms of quartiles) (Source: Fuchs et al. 2017).

The construction in risk prone areas leads on one hand to an increase of potential damage and loss of the exposed elements. On the other hand, the soil sealing that is linked with economic development and the extension of built-up areas, hinders infiltration, increases direct run-off and hence aggravates flood risks.

However, Alpine communities have always faced risks to natural hazards and have developed strategies to protect themselves from impacts and to avoid damage. For many years, since the end of the 19thth century, respective measures to reduce risks were predominantly of structural engineering type (HOLUB and FUCHS 2009). In the second half of the 20th century, additional spatial planning measures were put in place with a stronger focus on reducing the exposure. Yet, in the late 20th century due to the continuously increasing values at risk and associated costs to protect them, it became evident that alternative strategies are needed. Within this context, the attempt to achieve total control has paved the way to the approach of 'living with risks' and to accept a certain level of residual risk (CAMENZIND and LOAT 2014). This approach is nowadays being addressed by means of IRM. Recently, the awareness of the importance of risk governance issues in connection with IRM has grown. Against this background, the present study intends to provide a contribution to the discussion of the concept of residual risk and to an improved risk governance in the Alpine region.

Within this study we refer to a selection of hazard processes, namely flood, torrential hazard, rockfall, landslide as well as avalanche. Based on the Swiss National Platform for Natural Hazards (PLANAT) knowledge base (<http://www.planat.ch/en/knowledge-base/>), these terms are understood as follows:

Flood: Flood is the state of a waterbody where the water level or discharge reaches or exceeds a certain threshold value. Floods in plain areas are called static floods.

Torrential hazard/debris flow: Torrential hazards are dynamic floods. They are characterized by a high flow velocity and appear in slope areas in torrents and mountain rivers. They usually carry a certain amount of sediment (sand, gravel, rocks, wood).

Avalanches: An avalanche is a process that incorporates snow or ice from a release area and transports it along an avalanche track as a sliding mass or as a turbulent snow and air mixture down to an accumulation area.

Rockfall and landslide: Landslides and rockfall are mass movements. Mass movements are processes in which the solid material (stone or loose rock) is set in downward motion mainly by gravity, and without the assistance of a transport medium (e.g. snow, water, wind).

2. Methodology

Four different methodological steps have been pursued to collect information required for the description and analysis of the current situation regarding risk governance in the context of residual risk and cases of overload in the Alps. The first 3 steps are predominantly related to data acquisition whilst the last step concentrates on analysing the obtained information and on formulating recommendations:

1. A review of existing relevant literature including academic papers, grey literature as well as laws and regulations.
2. An online questionnaire addressed to experts in the field of risk governance that was developed with a focus on the acquisition of quantitative data.
3. A set of in-depth discussions through semi-structured interviews with key stakeholders and professionals to obtain additional qualitative data.
4. An analysis of collected data and elaboration of recommendations.

These working steps were carried out subsequently and have revealed complementary results. The results have clarified the various approaches to risk governance in the Alpine region, yielded examples of good practices, and supported the formulation of recommendations to improve the existing status quo.

Figure 2 provides an overview how the various working steps within the study are connected to and relying on each other.

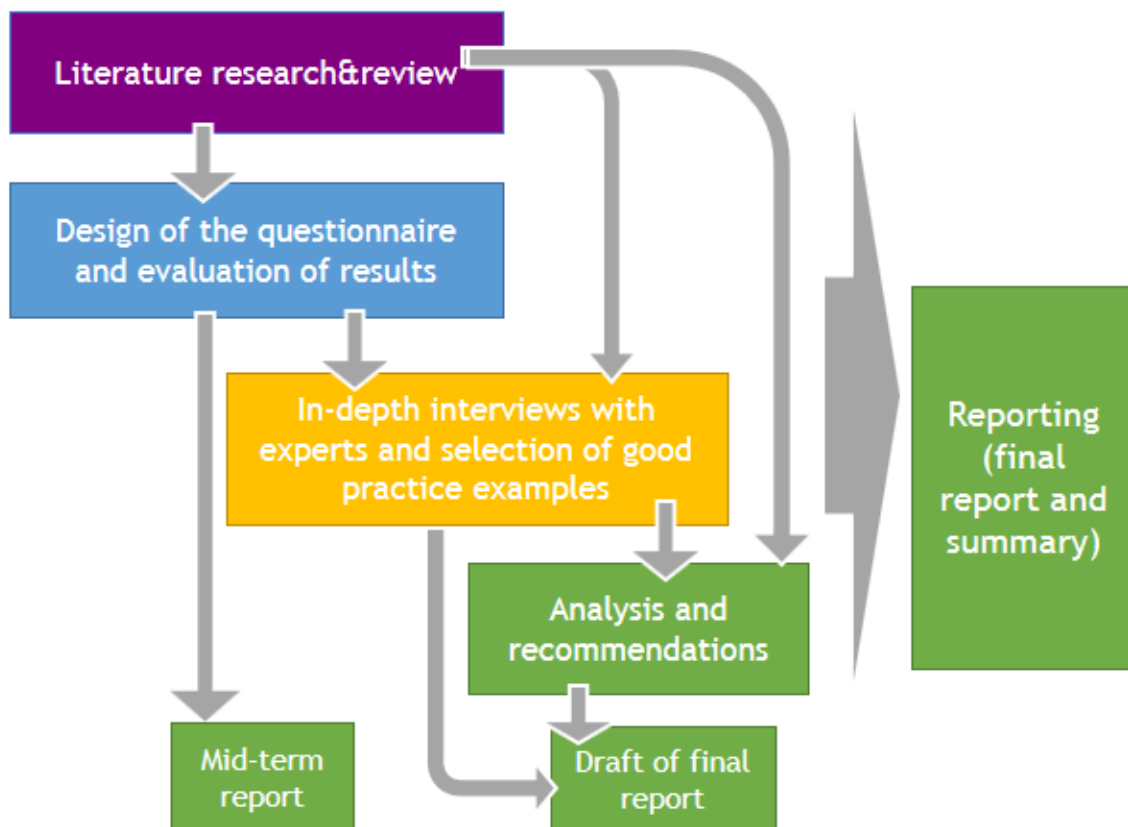


Figure 2: Overview of working steps of the study (Source: Authors).

2.1 Literature review

The literary research includes a review of scientific publications, grey literature as well as laws and regulations that have been selected in order to assess transnational, national, regional as well as local strategies of dealing with natural hazards in the context of residual risk and the case of overload. A matrix for the analysis of the literature was developed, which has allowed carrying out a structured comparison of the documents. For further information, an extract of the matrix is attached to this report as Annex 1: Literature selected for the review.

The criteria used to select articles for the literature review were:

- Literature mentioning the concept of residual risk or remaining risk and/or
- Literature mentioning the case of overload or extreme events.

Based on these criteria, more than 70 documents were analysed. The findings were exploited according to their country-specific content. This resulted in 7 factsheets for the 6 countries Austria, France, Germany, Italy, Switzerland, Slovenia and 1 for the EU. These sheets contain an overview of the type of reviewed documents, the collected information about natural hazards in the EUSALP region, definitions for residual risk and the case of overload, the status quo of risk governance and risk management including possible considerations of climate change as well as a description of good practices taken from the literature. Finally, the results of all factsheets were compared with each other and analysed looking at cross-country issues.

2.2 Questionnaire

The survey “Dealing with the case of overload” was developed to collect primary data about the status quo of risk governance in the context of cases of overload and residual risk in the Alpine region. The questionnaire focused on the collection of information to describe and analyse:

- similarities and differences among definitions for the case of overload and residual risk as well as protection goals in the Alpine countries and regions,
- the status quo of risk governance and management measures related to these cases, as well as
- personal considerations and recommendations aiming at an improvement of the current situation.

The purpose of the questionnaire was to provide an overview of definitions of the case of overload as well as residual risk and information on the status quo of dealing with such cases in the EUSALP area. In this context, it aimed at covering all geographical areas of the Alpine Region at national, regional, and, where possible, at local level.

The survey was conducted using online questionnaires. It consisted of 54 questions divided into 7 parts and was developed based on a draft version used for previous activities of the Bavarian State Ministry of the Environment and Consumer Protection (STMUV) and Interpraevent. The draft version has been intensively re-elaborated in order to align the content and structure with the specific objectives of this study. The 1st part of the elaborated questionnaire included questions about general data of the interviewed person, with attention to the country and region of origin and the experience related to the topic. The 2nd part was dedicated to information about protection goals set in the respective country or region. The 3rd part focused on existing and missing definitions of the case of overload and residual risk, while the 4th part aimed at receiving information about risk governance procedures and actors in

each country or region dealing with the case of overload and residual risk. The 5th part was dedicated to collecting data about the status quo of the approaches to risk management. This part was structured according to the phases of the IRM cycle used by the Swiss Federal Office for Civil Protection (FOCP). The 6th part used questions in Likert scale format aimed at obtaining personal considerations and recommendations focusing on possible measures that may lead to an improvement of the current situation. Finally, the 7th part was dedicated to the collection of good practice examples. For further reading, the questionnaire can be found at the end of this document as Annex 2: Questionnaire.

In order to collect quantitative and qualitative data, the questions asked in the questionnaire were of different type: closed questions, semi-open questions, questions using a Likert scale and open questions. The open source software *Opinio* was used for data query and data insertion. Data analysis was carried out using the software for statistical analysis *SPSS*.

An important aim of the study was to investigate differences within the Alpine countries and regions concerning definitions, protection goals, governance procedures, and management measures in dealing with overload events and residual risk. Therefore, the questions were analysed by country level, by regional level and by hazard type.

Overall, 42 experts from 6 Alpine countries completed the questionnaire. Fifteen of these 42 respondents came from Austria, 10 from Italy, 6 from Switzerland, 5 each from Slovenia and Germany, as well as 1 from Liechtenstein. Experts from France filled in no questionnaire.

Due to the relatively small number of respondents, the results of the questionnaire can by no means be seen as representative. Moreover, the amount of respondent per country is random and imbalanced. This data limitation has to be kept in consideration when interpreting the questionnaire outcomes quantitatively. Consequently, the expert interviews presented in the following chapter addressed resulting gaps in information.

2.3 In-depth expert interviews

The in-depth expert interviews are to be understood as surveys, which allowed addressing remaining open questions in more detail. The interviews were also used to clarify issues of mismatch or misunderstanding resulting from the analysis of the questionnaire. Furthermore, they aimed at covering thematic areas, where answers to the questionnaire were not able to give exhaustive results.

Thus, the expert interviews represent a qualitative approach to complement the quantitative data gained through the online questionnaire. Based on the interviewee's expertise, tailored interview guidelines were prepared for each of the interviews. To understand approaches to risk governance in the context of residual risk and cases of overload in the whole Alpine region, at least 1 interview with a relevant actor from each of the 7 Alpine countries was carried out. In this context, particular attention was given to collect information about France, as it is the only country from which no data was received through the online questionnaires.

Based on these priorities, 20 interviews were carried out. They were conducted in a semi-structured format, which allowed the interviewer both to guide the discussion towards previously chosen issues and to address spontaneously upcoming topics. The data collected via the expert interviews contribute significantly to the present report. For further information, an example of interview guidelines can be found in Annex 3: Example of Interview guideline.

2.4 Analysis and elaboration of recommendations

The final steps of the study were the analysis of collected data and the elaboration of recommendations, with the aim to contribute to an improved risk governance of natural hazards in the context of the case of overload and residual risk.

The data and information obtained by means of the first 3 methodological working steps were analysed according to their content and quality with respect to the targeted objectives. The results of this analytical step were summarised with particular focus on similarities and differences amongst the Alpine countries. They also represented a fundamental input for the recommendations, which were subsequently collected, reformulated and classified into 4 groups:

- (I) risk assessment,
- (II) residual risk management,
- (III) residual risk communication, as well as
- (IV) involvement of actors and processes for assessing and dealing with residual risk.

In addition to the elaboration of recommendations, possible common definitions for the terms *residual risk* and *case of overload* were proposed by the authors and discussed with experts. Further input for both, definitions and recommendations, was provided by the participants of the 4th EUSALP AG8 meeting in Innsbruck on September 19, 2017. The discussion during this meeting supported the refinement of the proposed definitions as well as the selection and prioritisation of recommendations presented in this report.

3. Concept and terminology of residual risk and the case of overload

In the Alps, the responsibilities for risk governance and thus the management of residual risk and the case of overload are allocated to national or sub-national authorities as well as to municipalities. Therefore, it is not surprising that the understanding and the definitions of 'residual risk' and 'case of overload' vary significantly.

A wealth of information concerning the definition of these 2 terms could be collected through the online questionnaire. The majority of experts stated that a definition for these terms does exist within the context of their field of activities. This response was slightly more often given for the term 'residual risk' than for the term 'case of overload'. The analysis of the responses shows that there are differences in the interpretation of the terms 'residual risk' and 'case of overload' over the Alpine region. Namely, they differ between countries but partly also differ between administrative levels of the same country. Several experts expressed the demand for and the potential benefit of a common definition of these key terms and a shared understanding of the underlying concepts.

Chapter 3 presents an overview of all collected data related to the status quo of existing definitions for residual risk and the case of overload as well as approaches to determine protection goals for natural hazards in the Alpine region. It attempts to summarize the common conceptual understanding in a figure, which visualizes the connections between protection goals, the case of overload and residual risk (Figure 3). Additionally, in response to a lacking common definition for 'residual risk' and 'case of overload', this chapter proposes a terminology to be commonly used in the Alpine region.

3.1 General description of the concepts

There is a strong connection between the determination of protection goals and the definition of what cases of overload and residual risks are. One could say that the first determines the latter two. The risk related to events that exceed the magnitude of protection goals falls into the category of deliberately accepted, sometimes also ignored risk and constitutes a crucial part of residual risk. In this context, cases of overload represent the realization of residual risks.

A protection goal is the determination of a threshold in relation to safety measures. As stated by the PLANAT, it is the "level of security that particular responsible actors aim to achieve in their area of responsibility. In practice, the protection goal is also used as a criterion for assessing the need for action to reach the recommended security level" (PLANAT 2014: 4). PLANAT further specifies that the determination of a protection goal needs to take into consideration economic, environmental and societal aspects. Protection goals provide a frame for dealing with natural hazards and are an indispensable prerequisite for risk management.

In general, the cost-effectiveness of protection measures is a decisive factor when determining protection goals. Planning, constructing and maintaining structural protection measures are cost-intensive tasks. Financial investments need to be reasonable in respect to the extent of risk reduction they can achieve. Hence, the determination of protection goals does not primarily reflect the technical possibilities but the financial capacity and the willingness of the society to bear expenses for residual risk.

Independent of the extent of any determined protection goal, there is always a certain probability that hazardous events or their impacts exceed these goals, generate a case of overload and constitute an event that is part of residual risk. However, residual risk comprises also those risks, which are related to unawareness and/or ignorance, an incorrect assessment of risks or inappropriate measures to control them. Therefore, dealing with residual risk is a question of accepting uncertainties. It requires the consideration of unknown risks as well as risks wrongly assessed during planning and implementation processes. Consequently, despite a common protection goal for a certain area, the residual risk may be perceived differently amongst individuals.

Figure 3 attempts to visualise the concept of residual risk and the case of overload. The overall risk is represented by the figure's rectangle. The arrow at the bottom of the figure represents an increase of risk towards the right-hand side, which is usually correlated with an increase of the events' intensities, their damage potential as well as a decrease of their probabilities. In this concept, the overall risk is divided into 2 main parts. First, the controlled risk to the left, which is known and intolerable. Second, the residual risk (including the cases of overload) to the right, which cannot be fully controlled and which is to a certain degree unknown as well as tolerated. These 2 parts are marked out by the determined protection goals and the respective structural protection measures in place to reach these goals. A change in protection goals and related protection structures can reduce or increase the residual risk. However, even if protection goals are clearly determined and respective protection measures have been put in place, the extent of the risk reduction achieved is not unambiguous due to possible uncertainty and errors.

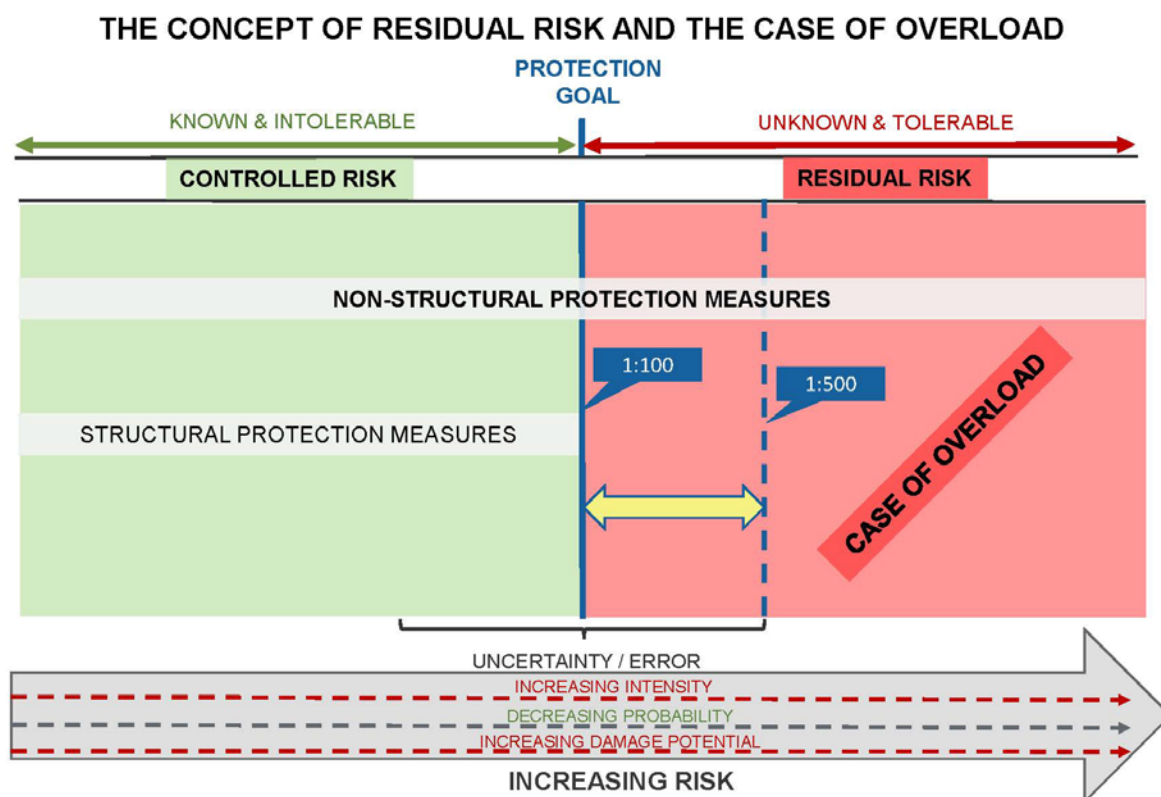


Figure 3: Conceptual framework with respect to natural hazard risks clarifying the notions of protection goals, residual risk and the case of overload (Source: Authors).

Figure 3 also illustrates that *structural* protection measures in the first place deal with and affect the controlled risks. Only if specifically designed for cases of overload they also contribute to a decrease of residual risks. To date, in the Alps, only few structural protection measures are constructed to fulfil this purpose. Some of them are listed as ‘Good Practices’ in Chapter 5.1. On the contrary, *non-structural* measures such as spatial planning or ecosystem services may have an important protecting effect when protection goals are exceeded. They may support the management of cases of overload and reduce connected damages and losses. By including different non-technical measures into risk governance activities, residual risk may eventually be reduced. Amongst other authors, STEINMAN et al. (2008) support this approach by identifying the need for measures beyond the implementation of protection structures. According to these authors, amongst others rescue activities are needed to address residual risk and the case of overload successfully.

The here represented concept goes beyond the engineering interpretation of risk. Addressing and managing risks in an integrated way implies the recognition that *risk* to natural hazards is a mental construction resulting from people’s subjective perceptions of uncertain phenomena and their acceptance of residual risk (LUHMANN 1993; OECD 2003; IRGC 2005). This perception of risk and also the ability and willingness to carry out precautionary measures may be influenced by various factors such as

- economic factors or prerequisites (e.g. income, savings, insurance),
- environmental factors or prerequisites (e.g. exposure to hazards, topography, distance to rivers, torrents or slopes),
- social factors or prerequisites (e.g. neighbourhood and community support, contacts to the mayor, fire brigades etc.),
- technical and logistical factors (e.g. precautionary measures, building protection, elevated light wells, arrangement of doors and windows, flood barriers, etc.), as well as
- personal factors (e.g. awareness and knowledge about potential impacts during the case of overload, hazard maps, risk zones, emergency planning etc.).

The risk perception of individuals is strongly normative and is closely related to the question which level of residual risk is accepted at individual or community level. As a consequence, for all these points, the understanding and acceptance of residual risk and the case of overload may vary strongly amongst the numerous individual actors who are involved in risk management. For this reason, risk governance activities, which recognize this variance in risk perception and strive for commonly agreed measures to manage them, are very important.

3.2 Status quo of concepts and definitions in the Alpine region

The concept of cases of overloads and residual risks as illustrated in Figure 3 reflects a largely common understanding of the experts involved in this study. The commonalities are substantially less when looking at the more detailed interpretation of the terms across the Alpine region. There is a particularly large variety in how protection goals are determined and for which size of events. Consequently, respective protection measures for different types of hazards differ in the countries investigated for this study.

The variety of existing interpretations for residual risk in Alpine countries is reflected in the answers received from the online questionnaire. As shown in Figure 4, most but not all experts stated that a definition for residual risk exists in their country. However, when filling in the questionnaire, the experts referred to different administrative levels in the Alpine countries.

Therefore, they also refer to many different documents in which the concept of residual risk is considered. In addition to this variety, not every expert knew about an existing definition for residual risk.

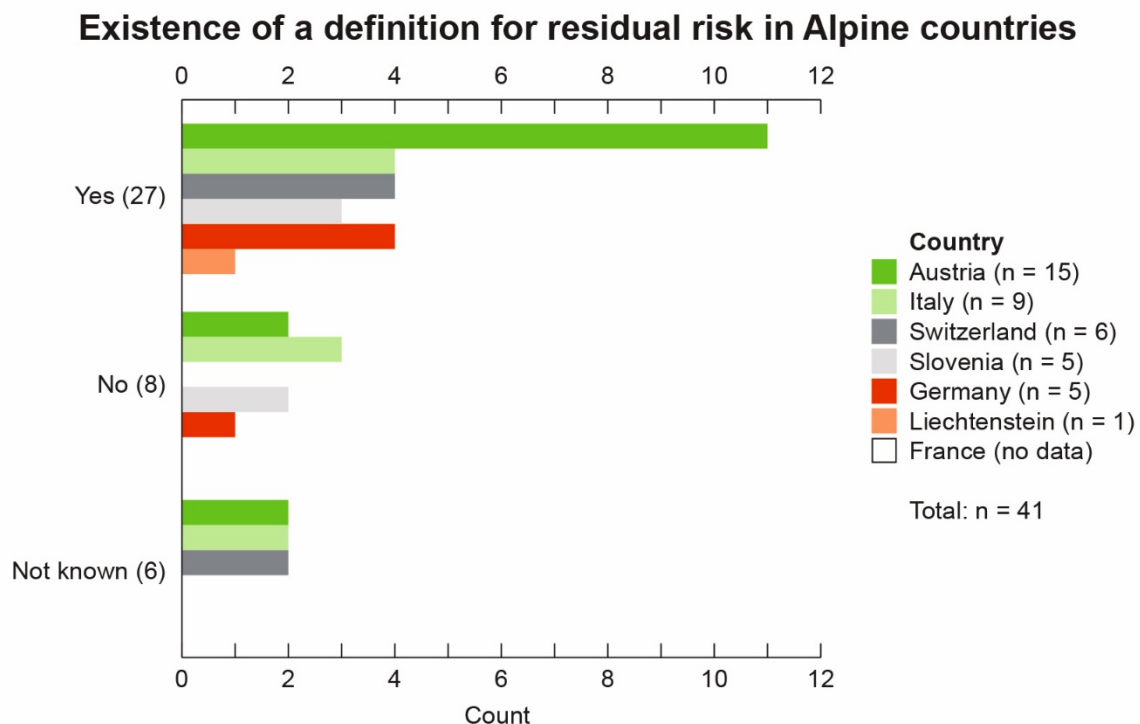


Figure 4: Existence of a definition for residual risk in Alpine countries according to experts (Source: Authors).

As shown in Figure 5, also most experts stated that a definition for the term 'case of overload' exists in their country or region. As for residual risk, the experts refer to different documents as well as norms, which address the concept of the case of overload. Comparing Figure 4 and Figure 5 clarifies that more experts know about a definition of residual risk than about a definition of the case of overload.

Existence of a definition for the case of overload in Alpine countries

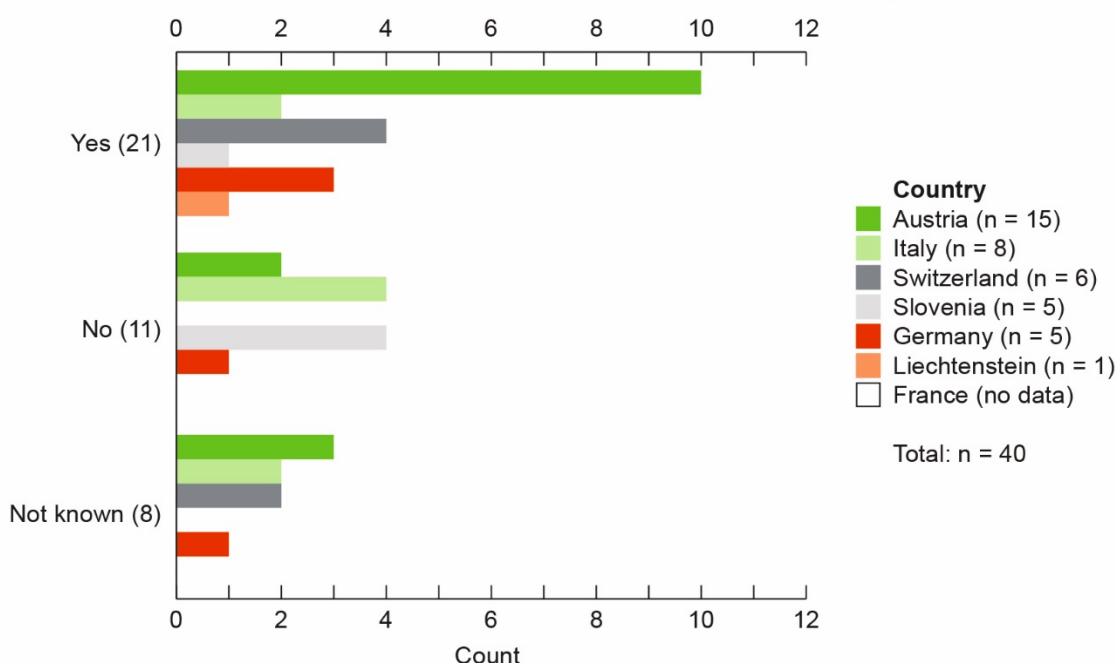


Figure 5: Existence of a definition for the case of overload in Alpine countries according to experts (Source: Authors).

The different understandings of the terms ‘residual risk’ and ‘case of overload’ imply a number of challenges. First, the lack of a common understanding of these terms limits the efficiency of risk governance activities across the administrative borders of the Alpine region. Second, differences in interpreting the terms hinder the public and affected individuals to grasp the respective concepts, which may consequently impede their active involvement in risk governance. Therefore, many experts see the need to find a common and precise definition for the terms amongst practitioners as pre-requirement to explain them to the public.

Experts interviewed for this study also point out the difficulty to communicate such technical terms. They underline the need to explain both terms ‘residual risk’ and ‘case of overload’ repeatedly to the public. The experts further state that there is a wider understanding of these terms in the context of water-related hazards, whilst the recognition for other types of hazards such as rockfall, landslides or avalanches, is much smaller.

The following chapters present the status quo and definitions of both terms as well as the role of protection goals when dealing with different natural hazards in the Alpine space in more detail.

3.2.1 Residual risk – status quo and definitions

The analysis of Alpine-wide literature revealed that in about 15 reviewed articles, residual risk is described as a risk that remains after adopting all foreseen structural measures (e.g. BMLFUW 2016, BAFU 2016a, STEINMAN et al. 2008, BÜCHELE et al. 2006). However, after having scrutinised the various definitions for residual risk in detail, a number of small but essential differences become apparent. These differences can be allocated to the following conceptual aspects:

- definitions considering the relation between risk and the implemented protection measures,

- definitions considering the relation between risk and the design event of reference for determining protection goals,
- definitions considering the relation between risk and the probability as well as the intensity of the related natural hazard events, as well as
- definitions considering the relation between risk and the overflowing, exceeding or failure of protection measures.

This chapter elaborates on these small differences in the definitions. Additionally, it provides an overview of the status quo of the concept of residual risk in each of the Alpine countries.

In **France**, residual risk is understood as the risk that remains after implementing protection measures but the term residual risk does not imply the notion of acceptable risk. In this context, residual risk is described as the risk of a natural event to exceed a protection measure. **French** experts stated that phenomena with a higher return period than the reference scenario of a protection measure have to be considered within risk governance. The reviewed **French** literature did not include a precise definition for residual risk.

Also in **Austria**, experts understand the term ‘residual risk’ as the risk, which remains after realising or despite the implementation of a protection measure against a natural event. In many cases in Austria, the interpretation of the term focuses on technical aspects, which are related to the determination of protection goals. Non-technical aspects such as individual perception of residual risks are often not taken into account. However, few **Austrian** experts consulted for this study also consider residual risks to be the result of a combination of the extent of acceptable risk, the unknown risks as well as those risks that exist due to inappropriate measures, which may have been taken based on false calculations. The Austrian Federal Ministry of Agriculture, Forestry, Environment and Water Management (BMLFUW) as well as other authors elaborate on the linkages of residual risk and the case of overload in a number of publications. In addition to the understanding of the term residual risk as explained by the experts, the failure of existing protection measures as an influencing factor for residual risk is explicitly mentioned (BMLFUW 2016; NEUHOLD et al. 2016). In this context, the BMLFUW further specifies residual risk as the risk that is accepted after protection structures have been dimensioned (BMLFUW 2015). Finally, HOLUB and FUCHS (2009), refer to residual risk as the risk that remains despite the implementation of technical protection measures.

The **Slovenian** experts see residual risk as the risk remaining after the implementation of protection measures, too. They also state that no official definition for the term exists in the Slovenian legislation. STEINMAN et al. (2008), however, identify the need for other measures beyond the implementation of protection structures. They point out the need for residual risk to be handled by interventions and rescue activities.

German experts describe residual risk as the risk that remains after carrying out measures towards a protection goal. Within **German** literature, the interpretation of the term residual risk varies. For example, LOCHNER (2011) refers to residual risk as the remaining risk related to events of high intensity and low occurrence probability. Other publications also consider existing emergency planning as factor that may influence residual risk (RIMBÖCK and OBERACKER 2015, Rimböck et al. 2016; BORNSTEIN 2010; BÜCHELE et al. 2006). Mentioning emergency planning within this context of residual risk is particularly interesting since it goes beyond the usually primarily technical interpretation.

No literature was reviewed from **Liechtenstein**. An interviewed expert stated that residual risk is defined as the remaining risk following the realization of protection measures.

The **Italian** documents reviewed for this study present residual risk as a particular risk that becomes reality after the overflowing and/or failure of structural protection measures. In this context, residual risk is not only seen as the risk associated with failures caused by low probability events, but also the risk of medium and high probability events that could lead to piping, erosion and structural instability of protection structures without overflowing them (AUTORITÀ DI BACINO DEL FIUME PO 2012; RANZI et al. 2013). Another document describes residual risk as events related to natural hazards that exceed the design event and that have the potential to cause social and economic damages (AUTORITÀ DI BACINO DEL FIUME PO 2005).

Interviewed **Swiss** experts have a similar view on the term 'residual risk'. They describe it as the remaining risk after the implementation of protection measures. According to 1 expert, the term has originally arisen in the context of nuclear energy and possible major damages related to it. The **Swiss** literature confirms the experts' affirmation, as the same experts who had been interviewed afterwards published many of the reviewed documents. Within the literature, the understanding of residual risk as the remaining risk after the implementation of protection measures had already been mentioned by LOAT and WILLI (1995) more than 20 years ago. The understanding of residual risk has not changed much in recently published documents, in which the term is described as the risk remaining despite all protection measures (BAFU 2016a; PROBST et al. 2012; PLANALP 2009; PLANAT 2012). Another author describes residual risk as the risk remaining if the design event is exceeded (LATELTIN et al. 2005). Furthermore, one way of defining residual risk is to describe it as 'risk still remaining after the realization of all necessary measures (regarding a specific scenario)' (translated from BAFU 2016a: 88).

Non-technical aspects of residual risk are recognized as important factor by the Platform on Natural Hazards of the Alpine Convention (PLANALP). They relate the determination of residual risk not only to implemented protective measures but also to the question of risk acceptance by the individual and by the society. According to PLANALP, residual risk therefore is composed of a) unknown or unpredictable risks, b) unrecognized risks, and c) deliberately accepted risks (PLANALP 2009, 2012). The Swiss PLANAT pursues a similar approach, which sees residual risk as the risk that remains after adopting all safety measures. According to PLANAT, residual risk consists of a) risks consciously accepted, b) risks wrongly assessed, and c) unrecognized risks (PLANAT 2012).

3.2.2 The case of overload – status quo and definitions

Similar to residual risk, there are different definitions available for the case of overload. The definitions collected for the case of overload within this study are less consistent compared to those for residual risk. This chapter presents an overview of the information acquired on the term 'case of overload' and its role in risk governance processes in the Alpine region.

In many of the documents reviewed for this study, the case of overload was mentioned in the context of hydrological events including river floods and torrential hazards. Only few documents reviewed for this study address the cases of overload triggered by other hazards such as avalanches, rockfall and landslides. In line with this finding is the fact that the majority of the interviewed experts refer primarily to water-related events, too.

Across the Alps, the case of overload refers to events, which exceed a design event and have the potential to cause damage despite the implemented protection measures (e.g. HOHERMUTH et al. 2016) or as an extreme event that overtops existing structural measures (e.g. PLANALP 2009). In 7 reviewed documents, the case of overload is considered as both the overtopping and/or the failure of a dam or other structural measures.

From a societal perspective, it is important to be aware that by determining a certain protection goal, one decides up to which level a community is protected and from which level onwards one accepts the possible adverse impact of potential cases of overload. This decision is an essential part of risk governance and closely related to cost-benefit calculations: measures are only implemented if their costs do not exceed the potential damage that a case of overload is estimated to cause.

In **France**, experts understand the case of overload as a scenario during which the theoretical nominal capacity of protection measures is exceeded. Consequently, the intensity of an event leading to the case of overload needs to be superior to the maximum intensity, which can be absorbed by existing protective structures. Moreover, non-structural measures such as the organisation of emergency planning are needed to deal with those situations during which the structural measures are overloaded. Interviewed experts point out that a functional failure of a protection measure is not per se considered as a case of overload because it may have been caused by an event with an intensity below that of a reference design event. Within **French** literature, GENDREAU et al. (2003) describe the term 'case of overload' as the overtopping of protection measures.

Altogether, **Austrian** experts named 4 different documents as important reference material and only 2 out of 15 experts provide exactly the same definition for the case of overload. Some experts from **Austria** describe the case of overload as the consequence of a process that is above the expected design event. In **Austrian** literature, the case of overload is described as an event that exceeds the magnitude of the design event (usually referring to the return period of natural events, the so-called threshold 'HQ100') (BMLFUW 2015, 2016). LÖSCHNER et al. (2017) refer to the case of overload as extreme events with a low probability of occurrence or with a magnitude greater than a reference scenario.

Only for **Slovenia**, all except 1 expert stated that a *legally binding* definition for the case of overload exists. According to these experts, the definition describes the case of overload as an exceptional or extreme event, or a situation, when a failure of certain protection measures occurs. The experts also name the amount of material transported during an event and the related damage as decisive parameters when referring to the case of overload.

Amongst **German** experts and within the **German** documents reviewed for this study, the case of overload is described as an event that exceeds the threshold of a design event. (RIMBÖCK et al. 2016; BORNSTEIN 2010; SIEBER 2004, BÜCHELE et al. 2006, SIEKMANN and PINNEKAMP 2011). Two authors also mention the possibility that the case of overload may lead to a failure or collapse of protection measures (RIMBÖCK and OBERACKER 2015; BORNSTEIN 2010).

Amongst **Italian** experts, the case of overload is described as a hazardous event with the potential to cause damages, which are part of residual risk. The case of overload is seen as a phenomenon that exceeds the calculations used for the design of structural protection measures. Within **Italian** literature reviewed for this study, the case of overload exclusively refers to floods. In this context, it is defined as a residual flood hazard and as the probability that events of a greater magnitude than the protection measures are designed for may occur

(AUTORITÀ DI BACINO DEL FIUME PO 2012). The Italian experts consulted for this study propose to distinguish between events leading to the case of overload due to the intensity of the hazard itself and those events that lead to the case of overload due to other factors including structural failure of the protection structure.

In contrast to the experts from other countries, the **Swiss** experts did not provide specific definitions for the case of overload but rather describe it in conceptual terms. This concept embraces the permanently existing possibility of an overload case to take place since it is part of non-avoidable residual risk. Within **Swiss** literature, events that lead to cases of overload are typically described as an event or discharge scenario clearly exceeding the design event (MINOR 2004, BAFU 2016a) or as an event leading to the collapse of existing protection structures (PLANAT 2012; DOHMEN et al. 2014).

Across **the Alps**, almost all interviewed experts refer to the case of overload in the context of river floods. More than 3 quarters of the experts contacted for this study consider the overflowing of protection measures, a higher volume of an event and depleted retention space as a case of overload. More so, most experts consider greater intensities and higher frequencies of heavy precipitation events as parameters that may cause more cases of overload in the future. The majority of experts does not consider events as cases of overload when they are triggered by silting up or sedimentation processes, when they are caused by technical failure or a lack of maintenance or when a design event has been based on incorrect statistics. Finally, the experts point out that in many cases the calculations of design events do not consider a possible multitude of triggering (natural) factors. Thus, relevant actors in the Alpine region must not necessarily consider events that are larger than reference scenarios as cases of overload.

3.2.3 Protection goals – status quo and definitions

In the Alpine region, before all, protection measures have the task to provide a certain safety for potentially exposed citizens and for infrastructure, particularly when of critical type. In general, however, protection goals are determined with respect to the frequency or intensity of the hazardous processes themselves and not with respect to any damage parameters.

There are specific procedures and distinct protection goals for different types of natural hazards and for different land use types. Moreover, the determination of protection goals depends on local conditions and requires the consideration of all potential hazards in a region. Consequently, the determination of protection goals across the Alpine region is manifold and results in a variety of protection goals.

In Switzerland for example, a matrix for protection goals for different object categories developed by the Swiss Federal Office for the Environment (BAFU) is used to distinguish between acceptable and non-acceptable intensities for all type of natural hazards (CAMENZIND-WILDI et al. 2005). In Austria, Germany and other European countries, technical rules or norms (e.g. ONR; DIN; EUROCODE) are used to ensure certain standards of protection structures. In Italy and Slovenia, provincial regulations or national laws (e.g. Water Act) are the fundament for deciding on protection goals.

In the online questionnaire conducted for this study, experts were asked to provide information about existing protection goals in their countries. They were requested to specify differences between types of natural hazards and - if possible - for various land use types (in particular for built-up areas in comparison to other land use types). Moreover, they were asked to indicate

if specific protection goals were set considering hazards or hazardous processes themselves or if they were determined according to hazard related risks and potential impacts. Finally, experts were asked if protection goals were adjustable or not in order to take into account possible future changes such as climatic or demographic conditions.

The majority of experts stated that, in the Alps, protection goals are in most cases defined with respect to hazards and hazardous processes, namely by specifying an event's return period. This is particularly true for water-related hazards. Protection goals related to avalanches and rockfall are more often based on risk parameters. When protection goals for avalanches or rockfall are based on return periods, the specified thresholds vary greater than for water-related hazards, as they may use values of 50, 100, or 150 years.

The answers of experts with respect to protection goals for different land use types were very heterogeneous across the Alpine countries. Particularly those goals for areas with a high damage potential (e.g. critical infrastructure, settlements or transport networks) are set higher than areas with less damage potential (e.g. forests and land used for agriculture).

Regarding a possible adjustment of protection goals, most of the experts stated that once protection goals are set, they are not easily modifiable, as this would require going through a complicated legislative process.

Protection goals for river floods

According to experts who participated in the online questionnaire, in most of the Alpine countries protection goals for river floods are solely based on the hazard's return period (see Figure 6). This is the case in Austria, Slovenia and Germany, where the most often applied protection goal is to provide measures up to the size of an event that statistically occurs once in 100 years. In Italy, Switzerland and Liechtenstein, protection goals for river floods may also be based on the risk that is associated with a hazard.

In this context, it is worth mentioning the role of the EU Floods Directive (EC 2007), which entered into force in 2007. This directive supports a structured approach to flood risk management across Europe. Though developed in view of the flood impact in European plains, the directive is also in the Alpine region perceived as a central document to support the determination of protection goals for flood events.

Type of protection goal for river floods in Alpine countries

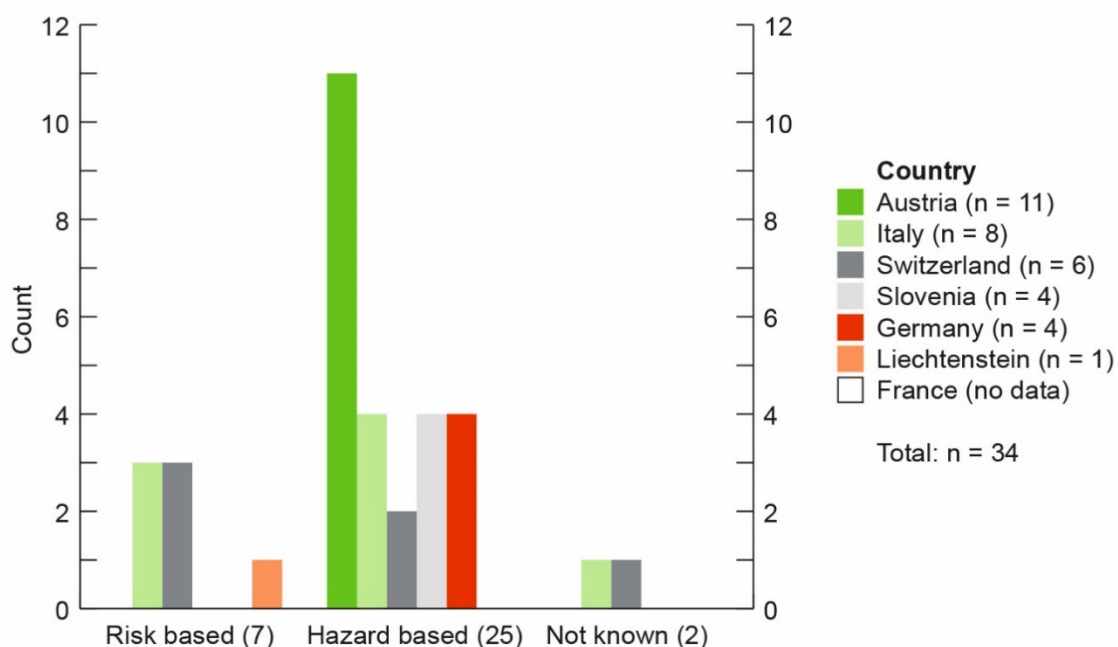


Figure 6: Protection goals for river floods in Alpine countries (Source: Authors).

Protection goals for torrential hazards

According to experts, also protection goals for torrential hazards in the Alps are predominantly hazard based. Again, Austria, Slovenia and Germany are the countries in which the return period of 100 or 150 years is taken as base for the design event according to which the protection measures are implemented for torrential hazards. While in Italy, both hazard and risk based protection goals exist, in Switzerland and Liechtenstein there is a focus on the application of risk based protection goals. In these 2 countries, the experts mention the consideration of cost-benefit calculations as basis for decisions on protection measures and hazard zone planning, which finally specifies the level up to which people and infrastructure are protected (see Figure 7).

Type of protection goal for torrential hazards in Alpine countries

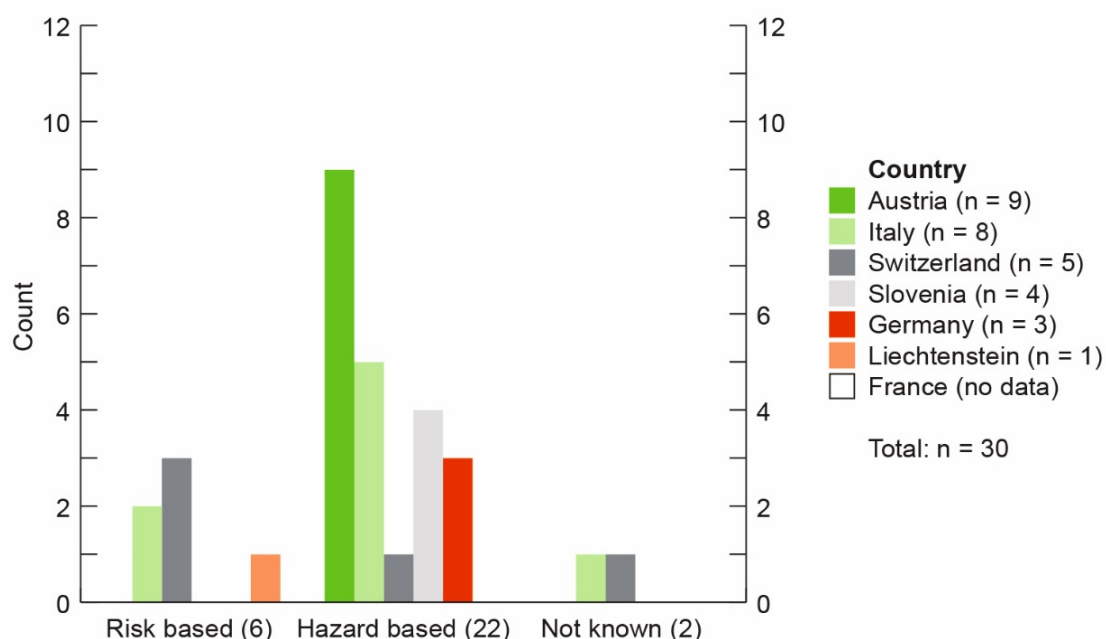


Figure 7: Protection goals for torrential hazards in Alpine countries (Source: Authors).

Protection goals for avalanches

For avalanches, the situation is different. While also the majority of protection goals for avalanches are based on a return period of 100 to 300 years, they differ essentially at different administrative levels (see Figure 8). In none of the Alpine countries, protection goals for avalanches do exist at the national level. At sub-national level, they are based on physical parameters such as impact pressure or the sum of snowfall. In contrast to river floods, there is neither a European directive nor national laws, which define up to which level citizens and infrastructure are to be protected against avalanches. Another reason for the heterogeneous situation of protection goals against avalanches is the large variety of avalanche intensities and frequencies that occur across the Alps.

Type of protection goal for avalanches in Alpine countries

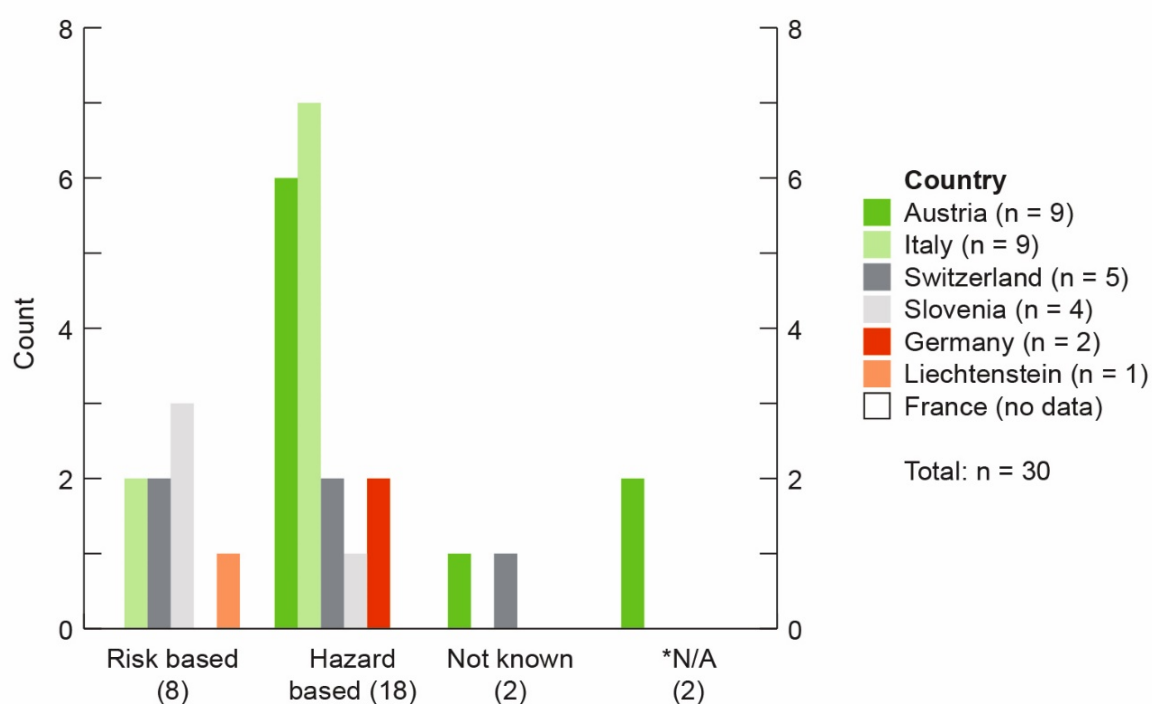


Figure 8: Protection goals for avalanches in Alpine countries (*not applicable) (Source: Authors).

Protection goals for rockfalls and landslides

As indicated by Figure 9, for rockfalls and landslides the situation is different in contrast to water-related hazards and avalanches. The distribution of answers received from experts varies greatly. This implies that there is no general rule of thumb on how to define protection goals for rockfalls and landslides. In Austria, Italy and Slovenia both hazard- and risk-based approaches for the determination of protection goals for these hazards exist, while in Liechtenstein and Switzerland there are exclusively risk-based approaches. Experts from Germany and Austria stated that, in contrast to other hazard types, the return period of an event would not be an adequate way to define protection goals for rockfalls and landslides.

Type of protection goal for rockfall and landslides in Alpine countries

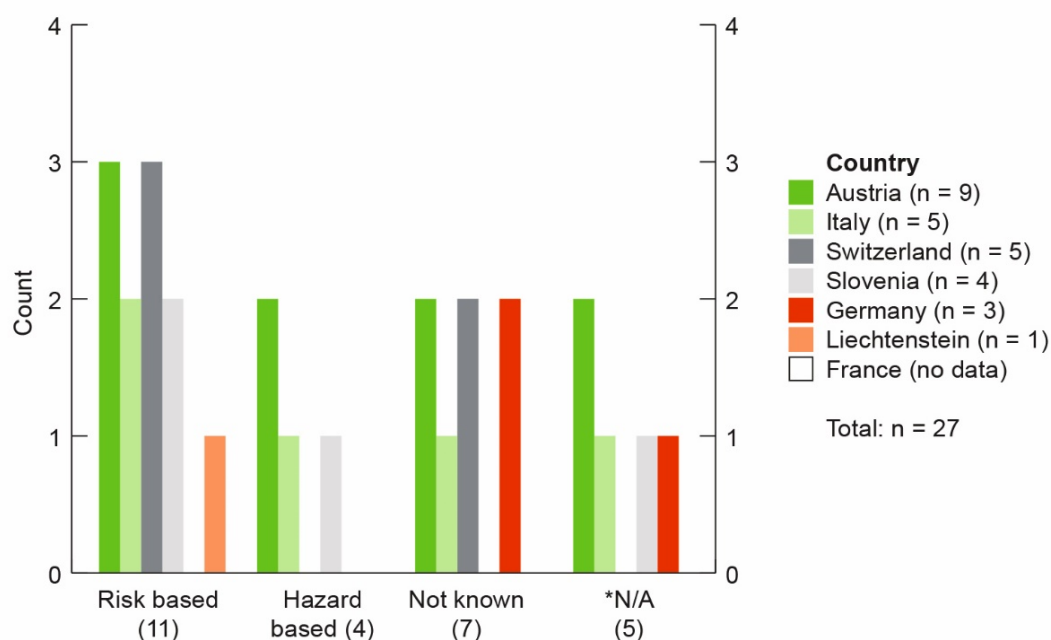


Figure 9: Protection goals for rockfall and landslides in Alpine countries (*not applicable) (Source: Author).

Protection goals for different land use types

As mentioned before, it is common to determine different protection goals for different land use types in the Alpine countries. Depending on the potential negative consequences that natural hazard induced impacts could cause, suitable protection goals are elaborated for different land use types.

In general, the prioritization of protection goals for different land use types is very similar in the Alpine region: They are highest for critical infrastructure (up to HQ1000 in Liechtenstein), usually high for built-up areas and transport networks and lowest for agriculture and forest areas. However, beyond this homogenous generic picture there are significant differences in determining these goals in the various Alpine countries. Respective information received by the experts is patchy and includes the following examples:

- In Austria, there are different protection goals for 'highly sensitive' areas in major cities such as Vienna
- In Upper Austria, the operating companies of critical infrastructure are in charge of determining protection goals

- In Italy, provincial regulations are relevant for determining protection goals
- In Liechtenstein, it is aimed to protect residential, industrial and commercial areas as well as public buildings up to an event's return period of 300 years – in most other Alpine countries, this is currently set at HQ100
- In Switzerland, the revised strategy on how to deal with natural hazards ('Strategie Naturgefahren') will be published in 2018 – it will contain information about how to address recent climatic developments and changing societal conditions when determining protection goals for different land-use types
- In parts of Switzerland, even hiking trails are considered as land-use types that are worth protecting – in parts of Italy this is the case for ski resorts

3.2.4 Critical issues and way forward with respect to protection goals

Residual risk and the case of overload are important notions of IRM. As seen in the previous chapters, they are strongly related to the determination of protection goals. Hence, protection goals are at central focus in the conceptualisation of residual risk and the case of overload. Determining these goals marks the threshold between controlled risk and residual risk. Their existence allows communities to develop and implement protection structures. It provides a frame up to which level of safety citizens can be protected. However, the process of determining protection goals is all but trivial. It shows a number of weaknesses and limitations, which will be addressed in this chapter.

Based on the data collected in each working step of this study, 3 types of limitations within the current use of protection goals have been identified.

1. Adjustment of protection goals to a changing climate and natural phenomena

The first limitation refers to the difficulty to adjust existing protection goals to climate change and natural phenomena. Such adjustments may be necessary in order to react to potentially changing climate conditions and the influence these effects may have on natural phenomena. This issue is currently being addressed in different ways in the Alpine countries. In Switzerland and Liechtenstein, all protection measures must be designed and implemented considering potential climate change effects. This is similar in France, where it is intended to refer to and protect against hazards of greater size when determining protection goals. Experts see this approach as a 'security margin' that allows to address natural phenomena with a certain increase in magnitude and intensity compared to those occurring so far. Consequently, implemented protection structures will be technically able to face a case of overload caused by the effects of climate change up to a certain degree without losing functionality or even collapsing.

In Bavaria, where river floods correspond to the type of hazards with the greatest damage potential, since 2004 a generic 15% surcharge in runoff is projected and used as base for the calculation of flood protection measures. This 15% buffer is applied with the intention to cope with the potential but uncertain impacts from future climate change. This measure received both support and criticism from international experts as it is seen to be very pragmatic and straightforward by some, while others underline the importance of location-specific assessments of protection goals. In any case, it presents a way of dealing with an expected increase in extreme weather events and intensified natural hazards.

2. Return periods and uncertainties

The currently applied concept of using an event's return period to determine a protection goal is used for most types of hazards and in most Alpine countries except for Switzerland and Liechtenstein. This approach relies on the availability and quality of existing event databases, which are often the only base available for determining such return periods. The respective statistical analysis to calculate return periods face problems of incompleteness, inconsistency of data and an imbalanced focus on certain type of hazards in those event databases (GRAF 2016).

Determining protection goals for water related hazards, avalanches, rockfall and landslides is complex because of the uncertainty of each of the phenomena's dynamics and the scarce availability of data. Often physical models are used as a calculation base for protection goals as an alternative to the statistical analysis of past events. The errors and uncertainties associated with such calculations are obvious limitations of resulting protection goals.

Another general limitation of using an event's return period as a base for determining protection goals is the fact that the methods used to establish it presume stationary occurrence of natural phenomena. Overall, this is not in accordance with the dynamics of real world processes. For instance, it does not consider the fact that the boundary conditions for Alpine ecosystems are already changing due to modified climate parameters. These changes contribute to the uncertainty of future event characteristics, which are not represented in the definition of the return periods yet. For this reason, the EU floods directive requires all local flood risk strategies to include the revision of hydrological regimes in order to incorporate potential changes in rainfall intensities and flow parameters.

Additionally, some experts argue that the potential local consequences of natural hazards often remain unknown and therefore unquantifiable for decision-makers. In their opinion, protection goals and the technical structures need to be able to protect the society against a range of possible scenarios. Since most current protection goals do not fulfil this requirement yet, the management of uncertainties remains a key challenge in risk governance. It represents another crucial limitation of the way in which protection goals are defined and how challenging it is to adjust them. Furthermore, these uncertainties create a range of possible errors and further ambiguity between risk that can be controlled and residual risk as illustrated in Figure 3.

3. Political and legal issues

A number of limitations are related to political and legal situations. Even if a protection goal has been set based on calculations using one or the other method, the implementation of measures to achieve them, only takes place when there is sufficient political support. Experts point out that there are many factors, which influence this support and finally the political decisions required for actions. Issues about the cost-benefits of measures, differing opinions concerning the prioritization of protection goals and the tendency of politicians to act in response to an event rather than prior to it are only some of the factors that hinder an efficient risk governance.

Finally, the complicated legislative process for reviewing protection goals has been identified as a constraint in the current conceptualization of residual risk and the case

of overload. Against the background of changing climatic conditions and the current demographic developments, this constraint represents a challenge for the Alpine region. The processes, which are in place to adjust existing protection goals, vary between the Alpine countries. In Italy, this is based on land use planning as well as on provincial laws. In other countries such as Austria, Germany, and France, it is based on an inspection of individual projects. According to Slovenian experts, no legal regulation exists for the adjustment of protection goals at national level in their country.

Within this context, it is noteworthy that a number of interviewed experts have mentioned the possibility to reduce uncertainties through a variety of activities. Amongst others, they identified the need to be prepared to work with the uncertainty that data sets comprise and to take into account the non-stationarity of natural phenomena. This requires close monitoring of developments and evolutions at different scales. Thus, experts suggest to base protection goals on reference scenarios instead of an event's return period. This approach could be used to show the dynamics of different natural phenomena and their response to changing climate conditions of various intensities. In this perspective, scenarios could be analysed and integrated in a decision process by means of multi criteria analysis (MCA) methodologies, which would support a structured and transparent way of taking decisions on protection goals within uncertain framing conditions.

This approach could also foster the establishment of common thresholds for larger areas, which has been desired by some interviewed experts, particularly those engaged with hydrological hazards. At present, it is a difficult task to agree on common goals. In most cases, for historical reasons, there are differences in protection goals for the upper and the lower parts of river and torrent catchment areas. This makes an efficient risk management in the context of residual risk and the case of overload particular challenging. Additionally, the responsibilities of actors may differ for various water bodies, which adds complexity to successfully carrying out risk management across administrative borders in the Alpine region. Some experts suggest making protection measures compulsory in high-risk areas as well as to foster the involvement of insurances to cover potential damages caused by cases of overload.

Despite their limitations, the use of protection goals is inevitable for the management of natural hazards. They help to distinguish between risk that a community attempts to control through technical protection structures and those risks that require to be addressed by non-structural measures focusing on the reduction of potential negative consequences. Amongst experts, there is a growing awareness that both residual risk and the case of overload must be accounted for when determining protection goals. Since the reduction of damages caused by events that fall into the category of residual risk is related to non-structural measures (see chapter 3.1), many experts have identified the need for the incorporation of non-structural measures when deciding upon protection goals.

3.3 Towards common definitions in the Alpine region

The study results reveal that the definitions for the terms of *residual risk* and the *case of overload* at present vary significantly within the Alpine region. Throughout the investigations, many experts stress the potential benefit of a common terminology to address jointly the challenges related to these points and independent of administrative borders. The need for experts to use a common language is seen as a crucial prerequisite for other stakeholders and the public to be able to follow the discussions on residual risk and the case of overload.

A clear view of the general concept and the meaning of both terms within risk governance may contribute towards raising the awareness and acceptance of the presence of residual risk and the case of overload amongst the public.

Backed by the expert opinions the authors of this study consider a commonly agreed terminology for residual risk and the case of overload as a crucial step towards an improved risk governance of natural hazards in the Alps and possibly beyond. The process of seeking an agreement on such a common terminology may be hampered by the fact that there are already a number of existing definitions in the Alpine regions on the base of which various documents and regulations have been formulated. Notwithstanding, a definition for each of the 2 terms is here proposed, which may serve as a starting point for following discussions.

Defining the 2 terms residual risk and the case of overload requires to take into account that the concepts behind both terms are strongly connected with each other (see Chapter 3). In the realm of engineering, they are commonly used and defined exclusively in relation to technical protection measures. In the context of natural hazard risk management, the case of overload is similarly solely determined by the extent of structural protection measures. Within IRM at least the definition of the term of 'residual risk', however, requires to consider non-technical and non-structural aspects and measures as well.

Against this background and by incorporating the results of this study, the authors propose the following definitions:

The case of overload

“A (natural hazard) event that exceeds the threshold value of an expected design event and the capacity of structural protective measures implemented in this regard. The surpassing of these protection measures, possibly aggravated by their additionally reduced functionality, represents a case of overload with the potential to cause damage and loss”.

Residual risk

“The risk that remains after all protective measures – be it structural and non-structural (technical, legal, planning, organisational and communication-related etc), have been implemented. The residual risk is influenced by intrinsic factors such as the capacity to appropriately assess risk and cope with it as well as the acceptance and awareness of risks at individual or community level. It is also influenced by external factors leading to uncertain or unknown risks such as the consequences of changing climate conditions.”

One of the fruitful outcomes of commonly shared and used definitions could be a mutually agreed framework for IRM, which explicitly incorporates dealing with residual risk and the case of overload. It does not serve as - and it cannot provide - a precise technical definition on the base of which legally binding documents are generated. Therefore, the proposed definitions are intended solely to contribute to a common understanding of the complex concept of cases of overload and residual risk with regard to natural hazards.

4. Risk Governance – dealing with residual risk and the case of overload

Risk governance refers to the institutions, rules, conventions, processes and mechanisms by which decisions about risks are taken and implemented. It goes beyond traditional risk management and includes the involvement and participation of various stakeholders as well as considerations of the broader legal, political, economic and social contexts in which risk is evaluated and managed. Thus, it addresses the complex whole of what traditionally has been called and treated as separate activities - "risk assessment", "risk management" and "risk communication" (RENN 2008, RENN and SELLKE 2011). One motivation for an improved risk governance is to decrease the economic costs of the natural hazards' consequences by closing gaps in risk policy. Figure 10 illustrates the concept of risk governance, as the International Risk Governance Council (IRGC 2012) delineates it.

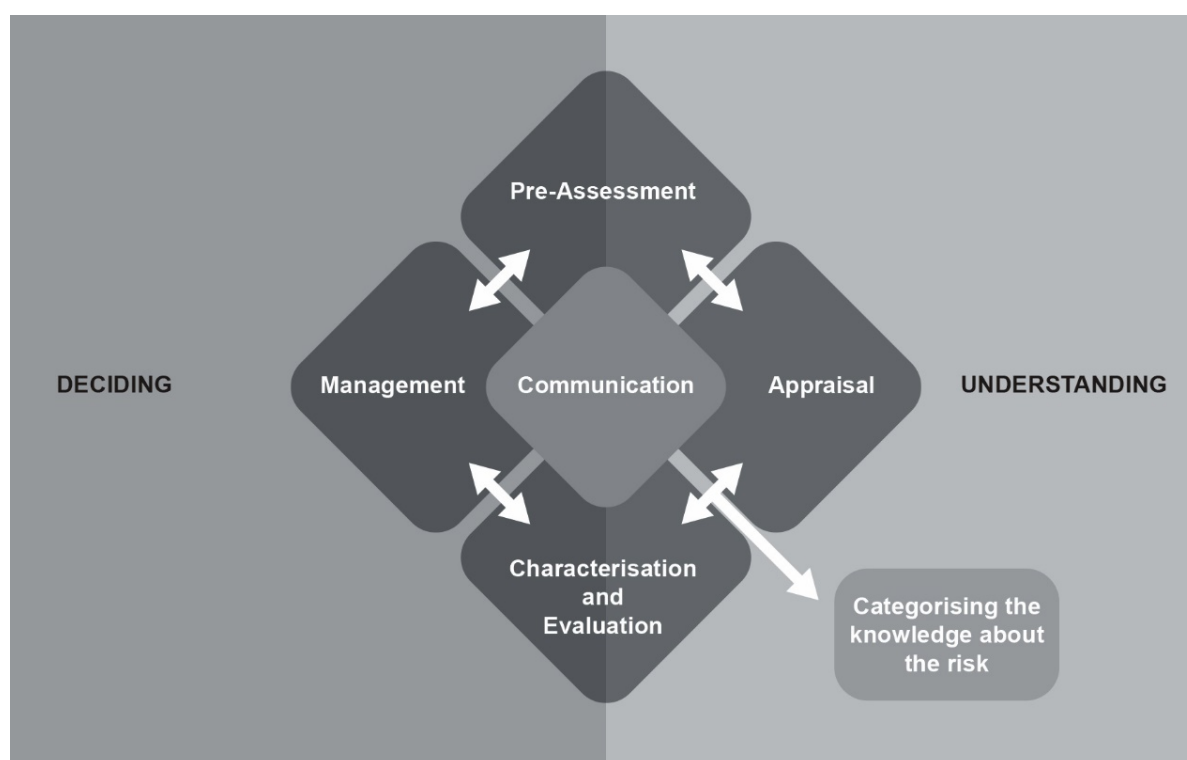


Figure 10: The concept of risk governance (Source: adapted from IRGC 2012).

The AG8 of the EUSALP states that sustainable risk governance amongst other things “encompasses the involvement and cooperation of people affected by natural hazard risk in safety planning and implementation of mitigation measures” (EUSALP AG8 2017). Furthermore, risk governance is described as an appropriate approach to foster regional adaptation to the consequences of natural hazards in which cooperation and communication are essentially needed to increase resilience. Risk governance aims to enhance the participation of different actors in the decision-making process, as well as the creation of public knowledge and awareness of hazards. It further aims to increase the acceptance for imminent risks and to support the development of a ‘risk culture’ within potentially affected communities. It strives for establishing a public discourse and negotiation process on protection goals and the level of safety accepted by the society (IRGC 2005).

In order to strengthen the integration of residual risk and the case of overload within risk governance, this chapter addresses all components of risk governance including risk management (Chapter 4.1), risk communication as well as the involvement and role of actors (Chapter 4.2).

4.1 Managing risk

According to the IRGC, “risk management involves the design and implementation of the actions and remedies required to avoid, reduce, transfer or retain the risks” (IRGC 2012: 19). It includes the generation, assessment, evaluation and selection of appropriate risk-reduction options as well as implementing the selected measures, monitoring their effectiveness and reviewing the decision” (Ibid: 19). Finally, risk management “is confronted with the challenges of complexity, uncertainty and ambiguity” (Ibid: 20). Within the IRGC risk governance framework, risk management is considered the key activity. It helps to distinguish between analysing and understanding risks and the decision how to approach risks.

Based on these thoughts, this chapter presents the concept of risk management and its tools, the status quo of measures applied in the Alpine countries, existing limitations thereof as well as recommendations towards an improved risk management.

4.1.1 Understanding risk management and its tools

This study was carried out with the awareness that an integrated and interdisciplinary management of the risks associated with Alpine natural hazards has become most widely standard in the Alpine region. Hereby, IRM is understood as the comprehensive process necessary to find the most efficient solutions and combinations of measures that address all principles of risk management. IRM is an approved methodology for treating hazards and their related risks with appropriate actions in a systematic and comprehensive way that complies with the principles of sustainability. A thematic box at the end of this chapter is dedicated to IRM practices common in Switzerland.

As shown in Figure 11, IRM also expresses a certain mind-set to address the challenges posed by the wide range of hazards and their risks in a comprehensive, transparent, and comprehensible manner, as well as in cooperation with all relevant decision-makers and those who are affected (FOCP 2014).

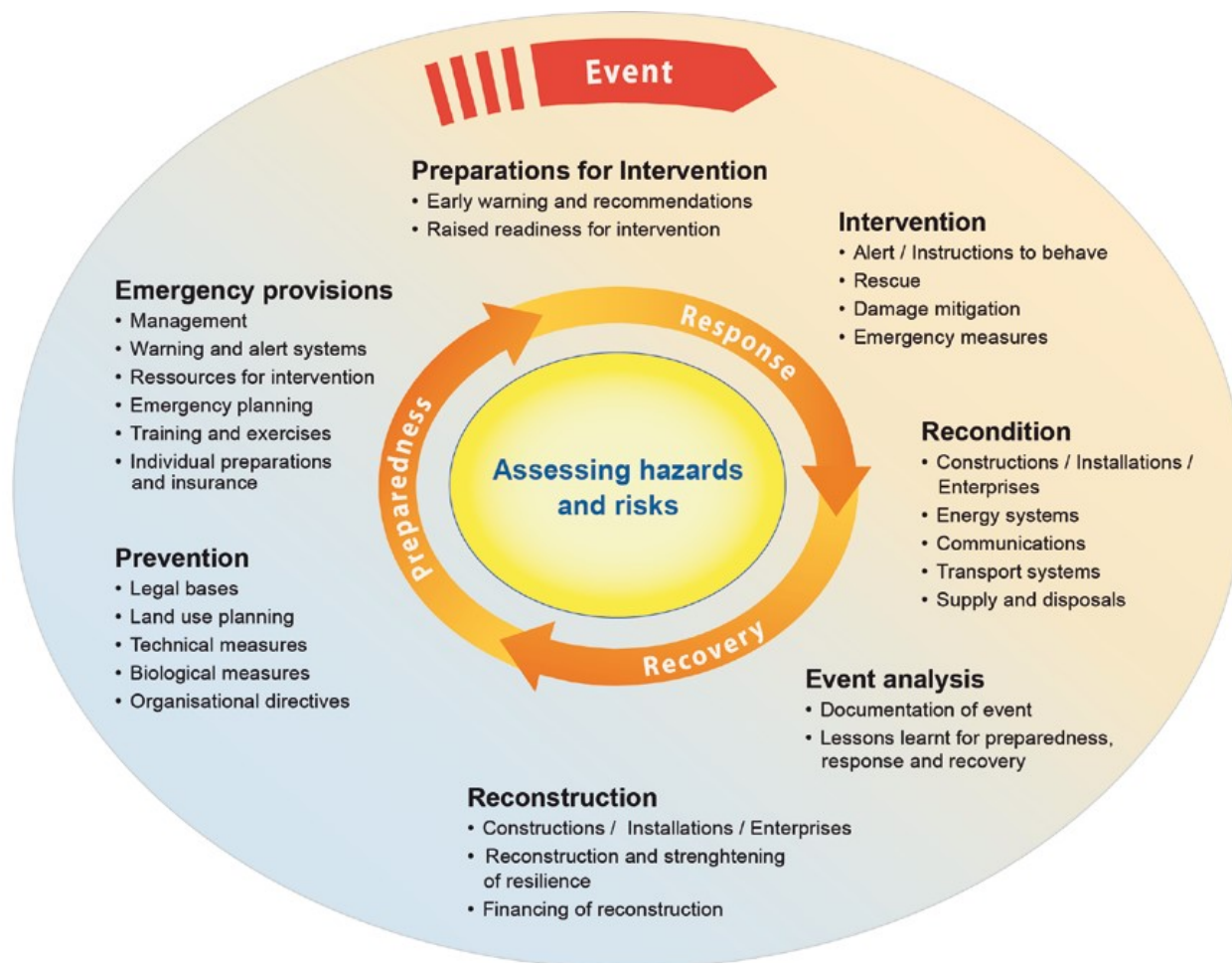


Figure 11: The different phases of IRM (Source: adapted from FOCP 2014).

The EUSALP AG8 has the specific task to improve risk management and to better manage climate change, including major natural risks prevention in the Alpine region. This is backed by the fact that despite considerable progress made in the last years, there is still a pressing need for stronger consideration of IRM approaches. Overall, it is intended to foster a change in risk culture and to raise awareness of residual risks related to natural hazards in the Alps (EINHORN and PEISSER 2011).

Many authors from the Alpine region have identified prevention, preparedness and response, mitigation as well as recovery as essential parts of risk management (e.g. STREITEL and PROBST 2009; GOMBÁS et al. 2015; LISKA and MAJOR 2014; ERHARD-CASSEGRAIN et al. 2006). The FOCP (2014 and Figure 11) suggests a further division of the risk management components as phases of the risk cycle particularly within and beyond the design event for a given protection structure. There is a clear difference between the measures carried out before a case of overload and the measures necessary to be taken during and after the case of overload. Many experts consider the prevention stage as the main phase to implement strategies for coping with the case of overload and residual risk. According to them, a complete protection from natural hazards is neither possible nor economically feasible. Thus, an improved prevention through non-structural measures such as the distribution of information, constant monitoring of potential hazards, communication and training are considered as essential parts of risk management. Consequently, those risk management approaches that are solely relying on structural protection measures are seen as an outdated strategy.

Thematic Box #1: IRM in Switzerland – role model for the Alps?

Integrated Risk Management (IRM) complies with the 3 principles of sustainability (environment, economy, and society) and it aims to address the challenges posed by a wide range of hazards and their risks. The way in which the IRM concept is realised in Switzerland may serve as an example for this study. The Swiss have pursued the idea of IRM since approximately 20+ years. It is now acknowledged as a comprehensive and approved approach to treat hazards and their related risks with appropriate actions in a systematic and integrated way.

Severe damages caused by multiple extreme weather events in 1987 had led the Swiss authorities to re-evaluate their traditional hazard protection concepts. These events can hence be considered as a starting point for the orientation towards IRM in the Alps. Facing the losses of 1987, the Swiss recognized that the existing hazard information was insufficient. As an alternative, a basic concept of IRM was introduced, which was further developed and successfully implemented by Swiss experts during the following years. Nowadays, IRM explicitly includes the task to address situations during which the capacities of protection structures are exceeded by means of spatial planning and organisational measures (see Box #2). As a basic principle, the Swiss IRM approach strives for being transparent and integrates all stakeholders relevant for decision-making (FOCP 2014). Fundamental notions of IRM in Switzerland are risk analysis, spatial planning, awareness raising, emergency planning, as well as the risk dialogue between responsible authorities, (affected) citizens and other actors involved (e.g. insurances, private companies). The Swiss approach towards IRM is based on 3 underlying questions: (I) 'What can happen?', (II) 'What is allowed to happen?', and (III) 'What has to be done?' (Figure 12). They are essential to assess and to evaluate risks and help to determine protection goals against natural hazards. In respect thereof, spatial planning is used as a powerful tool to prevent damages from occurring wherever possible by means of land use regulations, development of retention areas and discharge corridors (see Chapter 5.1) (BAFU 2016b).

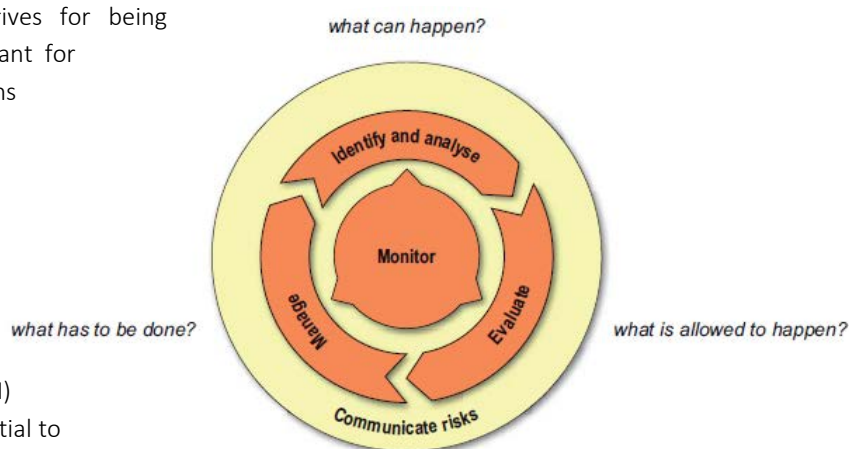


Figure 12: Risk management cycle (Source: Swiss National Platform for Natural Hazards).

According to Swiss experts consulted for this study, the highest priority of IRM in Switzerland (and most likely elsewhere, too) is to save the lives of citizens. To accomplish this goal, massive investments in warning and alarming systems as well as in monitoring and forecasting activities were made in the past 2 decades. Another highlight of the implementation of IRM in Switzerland is the expressed objective to achieve a nationally comparable handling of risks for all types of hazards, which is ecologically justifiable, economically proportionate, and socially acceptable. In contrast to other countries, in Switzerland a transparent communication of and raising awareness about residual risk are considered as mandatory measures to build a proactive and self-providing society (BAFU 2016b). Swiss experts point out that the awareness of residual risk and potential cases of overload has been growing in recent years due to transparent communication and involvement of the public. Nowadays, hazard and risk maps as well as emergency plans are available in almost every Swiss municipality (WILLI 2015). The range of measures used in IRM and phases in which they are implemented are shown in Figure 12 in Chapter 3.4.

PLANALP (2012) states that the recent challenges of IRM exist in preparing for changing climatic as well as societal conditions and in developing solutions that – despite growing uncertainties - are able to maintain the existing level of protection at the least. Switzerland takes into account these emerging and potentially adverse issues by “imagining the unthinkable” (Ibid: 8) and hence pays more attention to residual risks than other countries in the Alps.

4.1.2 Status quo of protection measures applied in the Alps

According to experts who contributed to this study, protection measures to reduce the potential negative impacts of the case of overload are available for the majority of natural events in all Alpine countries. Many of these measures are of generic type and not specifically designed to cope with cases of overload or to deal with residual risk.

Table 1 shows those measures that were mentioned by the limited number of experts in the online questionnaire. Hence, it is not exhaustive and it is in the following complemented by measures found in the literature.

Table 1: Protection measures to reduce negative impacts of the case of overload mentioned by experts in the questionnaire for the different type of hazards (Source: Authors).

	Selected protection measures in Alpine countries
River floods	(Multiple) dikes and dams, flood retention areas, predetermined breaking points, spillway sections, emergency and evacuation plans
Torrential hazards	Dams and dikes, retention areas, relief areas, emergency plans, spatial planning
Avalanches	Constructional measures, avalanche services, monitoring, emergency plans
Rockfall, landslides	Constructional measures, safety zones, monitoring, emergency plans

The following paragraphs provide an overview of measures that can be allocated to the phases of the risk management cycle – prevention, preparedness and response, recovery – as well as to mitigation.

Prevention measures serve primarily to reduce the hazard magnitude and related vulnerabilities. They aim to avoid events or – if this is not possible - to reduce their adverse impacts. Prevention measures therefore come into play before an event may occur. Commonly used tools in the prevention phase are an appropriate design of the regulatory framework, adequate land use planning as well as organisational directives (FOCP 2014). Hereby, the use of maps helps to delineate those zones potentially affected by hazardous processes or to show the spatial distribution of different risk levels. More than half of the experts who participated in the online questionnaire state that information about natural hazards in maps do not only include areas that are protected by means of protection structures, but also information on areas potentially affected by cases of overload.

Within prevention, spatial planning plays an important role as a process for assessing risk and delineating hazard zones. However, there are different framing concepts and existing regulations related to spatial planning across the Alps and the modalities of spatial planning activities vary accordingly.

One problem of spatial planning in the Alps is the limited space for human activities. As a result, many constructions in Alpine countries are located in areas that are likely to be affected in cases of overload. Mostly, these constructions were built before spatial planning and hazard zones were used as tools for risk management and to restrict developments in high-risk areas. Nowadays, the consideration of relocating these constructions – be it houses or critical infrastructures - is indispensable. For this reasons in Switzerland, resettlement has recently

received greater attention as a spatial planning tool and as an alternative to deal with risks associated to natural hazards.

Preparedness and response measures for intervention are put into action shortly before an event occurs. Their purpose is to warn the persons in charge and those who are potentially affected, to put them on alert, and where necessary, to issue guidance on appropriate conduct. Intervention measures are deployed once an event has occurred. Their primary aim is to protect and to rescue individuals, tangible as well as intangible assets, and to limit damage to the environment as much as possible (FOCP 2014). Many experts have pointed out that the highest priority during emergencies is to save lives.

Unfortunately, emergency plans for cases of overload are not yet everywhere publicly available. Only 2 thirds of the experts who contributed to this study stated that emergency plans for the case of overload are provided in their region. These plans vary in many aspects and are prepared at different spatial scales as it is the case for other elements of risk governance as well. They are designed to fulfil different tasks and to prepare for and response to only selected types of hazards.

Recovery or reconstruction measures are designed to restore facilities, supply and disposal, transport and energy systems as well as the communication network to their previous functional levels. Ideally, recovery efforts lead to an increased level of resilience, improved functionality, and lessons learnt (FOCP 2014).

An important aspect with regard to the recovery phase is the financing of reconstruction for damages caused by a case of overload. Almost half of the experts who participated in the online questionnaire have stated that legal regulations foresee a partial compensation, while less than 1 third of experts have explained that a full compensation is foreseen. Particularly, all experts from Germany indicated that no compensation at all is foreseen. Insurances may present a useful tool to avoid conflicts on this matter. In Switzerland for example, a compulsory insurance against all types of natural events guarantees a full compensation and contributes to a speedy recovery.

Structural **mitigation** measures play a role in all risk cycle phases. They intend to protect valuable assets and to contain or prevent the spread of damage (FOCP 2014). There are passive and active mitigation measures against natural hazards. While the latter are influencing the hazard itself (e.g. through dams, nets, barriers, protection forest) mainly in order to decrease its intensity, the former aim to reduce a hazard's impact (e.g. through resettlement of buildings, spatial planning, hazard zoning, construction bans, closure of roads and hiking paths etc.). According to the experts, both types of measures need to be combined in order to achieve a successful prevention against and recovery from natural hazards.

Additional protection measures were found in the literature. For example within Austrian literature it is asserted that for almost all hazards multiple active and passive protection measures are already in place. In order to be prepared for torrential hazards, a variety of dams are used to address different processes in torrential catchment areas. Further measures are discharge sections, constructional stabilization of torrent banks and the development of natural inundation and sedimentation areas in the valley. Deflecting dams and catchment basins in the runout zones are other useful tools to protect infrastructure and settlements in Austria to reduce the potential negative impacts of the case of overload (BMLFUW 2016).

In order to prepare for potential rockfall, steel nets and catching dams are built to “ensure the safe deposit” (BMLFUW 2016: 17) of loose material. Debris flow barriers, steel posts and

anchors as well as the drainage of slopes are measures used to prevent landslides from happening and to reduce their potential damages. Transverse felling of trees as well as the creation of preventive avalanches are seen as another option for a possible bioengineering measure against the potential impacts of avalanches. In addition to the abovementioned structural protection measures, individual object measures may be installed in order to reduce the damage at household level (BMLFUW 2015).

The study results reveal that several points need to be considered when implementing protection structures. First, the ecological compatibility has to be taken into account for each structural measure. The ecosystem services provided by forests and vegetation need to be preserved and restored if affected by structural measures. The overall goal must be to limit any impact on ecosystems as far as possible during all phases of the construction of structural measures. Second, due to the technical and economical limitations of structural measures, an absolute safety will never exist. Even after the implementation of structural measures, additional measures are required to address the remaining residual risk. For this reason, the case of overload may occur despite the most advanced technical precaution measures. If the implementation of a technical protection measure is not possible (e.g. due to logistical or topographical circumstances) or not cost-effective, non-structural measures become even more important. In this case, also a shift of residential areas as well as infrastructure through the means of resettlement or expropriation are measures worth considering. In any case, for risk governance to be effective, precautionary spatial planning is an essential task to be done now in order to avoid conflicts in the future (BMLFUW 2016).

To be able to cope with residual risk and the case of overload in the future, a permanent maintenance, development and adaptation of structural protection measures is required. The consideration of climate change and changing socioeconomic conditions are challenges identified by experts that may require an adjustment of existing measures and approaches towards risk governance. In any case, the functionality of protection structures must be guaranteed and the documentation of ongoing developments carried out. More than ever, experts consider the education of the public and decision-makers about such changes as a necessary task of stakeholders in order to efficiently prepare society for future natural hazard management (Ibid).

4.1.3 Limitations within risk management

Despite the fact that structural protection measures have a number of limitations, they are an essential part of risk management and have a long tradition in mountainous regions. The first control measures were installed already a few hundred years ago around the year 1500 using biological construction material to stabilize slopes and to prevent erosion. Such bioengineering measures started to be combined with technological measures and defence structures to protect residential areas as well as infrastructure in the Alpine region (BMLFUW 2016). Since the 1890s, measures to protect from natural hazards were predominantly of structural engineering type (HOLUB and FUCHS 2009). From the 1970s onward, non-structural measures supplemented these engineered structures. Hazard zoning and spatial planning started to be used to identify areas where constructions against natural hazards are needed. Over time, key strategies in natural hazard management were incapable of sufficiently addressing the magnitude of associated losses. Nowadays, institutions and respective policymakers rely on a combination of structural and non-structural measures to reduce natural hazard risk in the European Alps (HOLUB and FUCHS 2009) and beyond (KUBAL et al. 2009). In current natural hazard debates, there is a shift away from focusing on engineered solutions towards the use

of broader integrated management strategies. Such strategies include land use management and incentives to discourage developments in high-risk areas (HOLUB and FUCHS 2009). This shift has been identified as a key point of political discussions leading towards the implementation of non-structural measures (FUCHS et al. 2017).

Hand in hand with these developments, there is a growing awareness within the risk management experts and practitioners that absolute safety to natural hazards cannot be achieved and does not exist. As illustrated in Figure 3 (Chapter 3.1), structural protection measures are only able to protect the society up to a certain degree. Investing in the extension of structural protection measures may shift the line distinguishing manageable risk from residual risk. However, by doing so, the residual risk is not addressed per se, nor it is managed. This fact presents a critical issue in currently applied risk management in the Alpine region. According to experts, the communication of the limitations of structural measures becomes an increasingly important part of residual risk management. The knowledge that structural measures are limited in their protective function, (i) must be accepted by experts and the public, (ii) has to become common amongst all actors involved in risk management of natural hazards, and (iii) should encourage the implementation of non-structural measures within risk management activities such as those described in previous chapters.

Another limitation of currently applied risk management concerns the involvement of actors in decision-making. A successful approach towards a multi-stakeholder process needs to be based on participation, cooperation, transparency and sustainability. It should strive for the involvement of all potentially affected parties. Although experts from all Alpine countries have stated the implementation of a participatory and transparent approach as their goal, it is far from being fully developed in practice. In many cases, crucial steps of risk management are still exclusively in the hands of engineers, technicians as well as policy- or decision-makers and related decisions are taken without participation of the public.

Italian experts have pointed out that specific improvements should be made in the field of communication strategies. As of today, there is no common strategy on how to communicate the aspects of risk management to citizens. Some interviewed experts stress the fact that the extensive use of complicated scientific and technical terms as well as a traditional communication approach followed by technical staff members of the public administrations are only a few of many reasons hindering a more efficient information flows. Even though some actors such as local fire departments have created innovative communication campaigns, at present these activities are based on voluntary and personal initiatives instead of being compulsory embedded in strategies and supported by institutional setting and competences.

Many experts contributing to this study have addressed the important role of spatial planning within risk prevention. It is seen as very powerful and necessary tool to reduce loss and damage associated with natural hazards. In this context, Swiss experts state that spatial planning measures have by law a higher priority than structural measures (CAMENZIND-WILDI et al. 2005; CAMENZIND and LOAT 2014). Nevertheless, also spatial planning faces a number of limitations. According to Bavarian experts, spatial planning does not include rules for constructions in areas beyond the HQ100. Consequently, areas affected by natural events that occur less than every 100 years do not succumb any limitations in land use rights. Thus, no restriction of building in an area that is potentially affected by a case of overload is legally possible.

In Italy, according to an expert, hazard zone plans are elaborated to delineate areas of potential natural threats and to provide information about possible hazard intensities. If designed in this way, the hazard zone plans could be a useful method to limit the extension of built-up areas. However, the enforcement of these hazard zone plans and their related regulations is often lacking in practice.

One expert from France stated that plans should not be based on existing protective measures due to the temporal limitations in their protective functions. Moreover, the red zones, in which building is not allowed, should be extended to areas of residual risk in order to protect the society from the potential occurring of the case of overload.

Finally, as seen in previous chapters, climate change is not comprehensively taken into consideration when it comes to practical risk management across the Alpine region. This constitutes another limitation of currently applied risk management in the Alps.

4.2 Actors, processes, decisions and potential conflicts

This chapter aims to illustrate the role of actors, the processes of cooperation within risk governance and potential conflicts, pitfalls as well as solutions that could emerge when improvements are strived for. It presents results of the analyses how the involvement of actors (cooperation, decision-making, policy making, consultation, communication, awareness raising) currently takes place in the Alpine region. This is done by investigating the type of actors involved and the instruments used to support engagement. The chapter's last part is dedicated to a critical review of present risk governance approaches.

In the last decades, the way to deal with collectively relevant risk problems has shifted from traditional state-centric approaches with hierarchically organized governmental agencies to multi-level governance systems, in which the political authority for handling risk problems is distributed among different public bodies (RENN et al. 2011 quoting ROSENAU 1992). These bodies are characterized by overlapping jurisdictions (RENN et al. 2011 quoting SKELCHER 2005) and multi-actor alliances. As a result, the socio-political arena relevant for risk management is multi-layered, diversified and based on diverse backgrounds of knowledge, values and political interests (RENN et al. 2011 quoting IRWIN 2008).

The literature suggests that the involvement of actors and the design of inclusion processes are important parts of risk management processes. Participation is understood as a means for integration of all relevant knowledge and concerns. First, it is argued from a democratic perspective that actors affected by the risks and/or the ways in which the risks are governed have a right to participate in deciding about those risks. Second, it is suggested that the more actors are involved in evaluating the advantages and constraints of the various options to address risk management, the more socially robust the outcome will be (RENN et al. 2011).

Based on this study's findings, it is essential to develop an understanding of the following 4 points regarding the establishment of participatory processes:

1. Knowledge of risks: How is the society involved in generating and sharing risk knowledge, how is risk communication addressed and which tools are used (e.g. documentation and knowledge transfer from experts to decision-makers to interested public, technical publications translated into dissemination targeted to general public, meetings and excursions to bring together the various actors involved in risk governance)?
2. Assessment of hazards and the risks associated with them: Who is involved in defining hazards and assessing risks and which methodology processes are used?

3. Determination of protection goals and decision over protection measures: Who is involved in deciding on protection goals and related thresholds? Who is responsible and liable in case of damages to assets and people? Which methodologies are used to define protection goals and to decide on protection measures?

4. Emergency response: Who is involved in taking action for preparedness? Who is responsible for which tasks during a case of overload? What are priorities for actions in a possible disaster?

4.2.1 Status quo in the Alpine countries

This chapter aims to establish an understanding of the country-specific view on involvement of actors in decision-making processes in the Alps. It investigates the responsibilities and tasks of administrative departments and actors as well as the number and types of instruments used in governance activities.

Involvement of actors in decision-making processes

Experts who participated in the online questionnaire were asked how governance processes relating to risk management are applied in their own country or region, which administrative departments are involved in policymaking and what are their responsibilities and tasks in governance activities. Departments taken into consideration were: technical departments, civil protection, spatial planning departments, and other departments. Overall, results show that a multi-department as well as a multi-actor governance and policy-making process is established in all Alpine countries for different types of hazard. Moreover, as shown in the following Figures, results also indicate differences among the countries regarding the number of actors involved and the type of instruments used.

Departments involved in dealing with natural hazards in Alpine countries

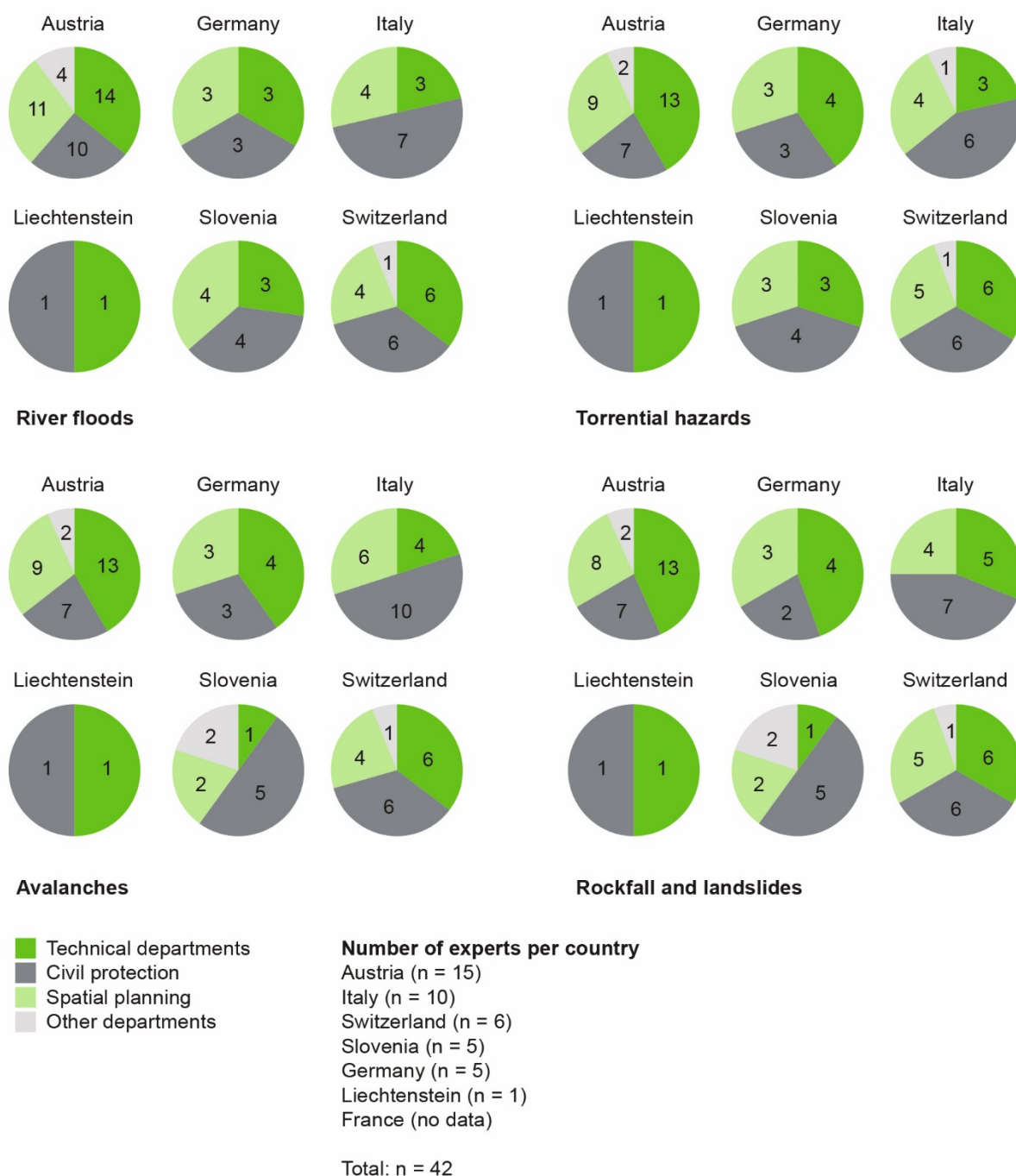


Figure 13: Departments involved in dealing with natural hazards in Alpine countries (Source: Authors).

Figure 13 shows the public authority departments, which are involved in dealing with the different natural hazards. The answers were received from experts who filled in the online questionnaire. The colours of the segments represent the various departments, the numbers in the segments show the amount of answers received. It can be observed that in Liechtenstein only spatial planning departments and civil protection are involved in dealing with natural hazards. In all other Alpine countries, also other technical departments are involved. For Austria and Switzerland at least 1 expert indicated that additional other departments are engaged in dealing with all of the investigated natural hazards.

Experts were also asked to provide information about the different actors involved in the process of policy-making for risk governance. Pre-defined possible answers were public administrations (at national, regional or municipality level), NGOs, professional as well as non-professional associations, civil society and other actors (to be specified).

According to the answers received, it can be said that Austria and Switzerland are the countries where the largest variety of actors is involved in the policy-making process, followed by Slovenia, Germany and Italy. In Liechtenstein, according to the only expert contributing to this study, only 3 departments are involved in this process (Figure 14).

Type of involvement of actors in policy making processes related to risk governance

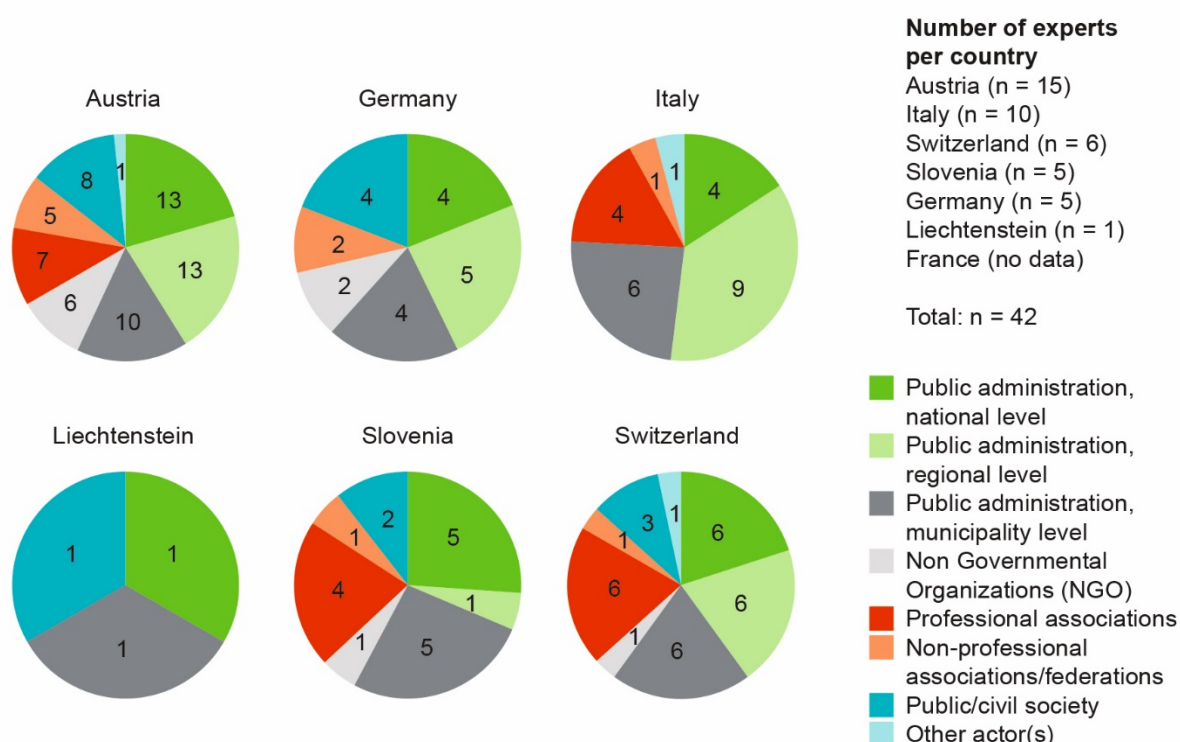


Figure 14: Type of involvement of actors in policy making of risk governance in each country (Colours of segments indicate the type of actors involved in policy-making related to risk governance. Numbers in the slices of the pie chart show the number of answers received from the questionnaire (Source: Authors).

Additionally, experts were asked to indicate which instruments are used to involve actors in the decision and policy-making processes regarding risk. The provided choices were referendums, online consultation, focus groups, public debates and other instruments. Figure 15 shows the different methods and tools for the involvement of actors in the management of each natural hazard. The numbers in the slices of each pie chart indicate the number of answers received for the respective method or tool.

Experts from all Alpine countries name public debates as a tool to involve actors into policy-making processes for risk governance, while in all countries except for Liechtenstein also focus groups were mentioned. Referendums or public consultations are instruments applied to involve actors in risk governance in Austria, Germany, Slovenia and Switzerland. The involvement of actors via online consultation is a practice only used in Germany, Italy and Slovenia (Figure 15).

Methods and tools to involve actors in policy making processes related to risk governance

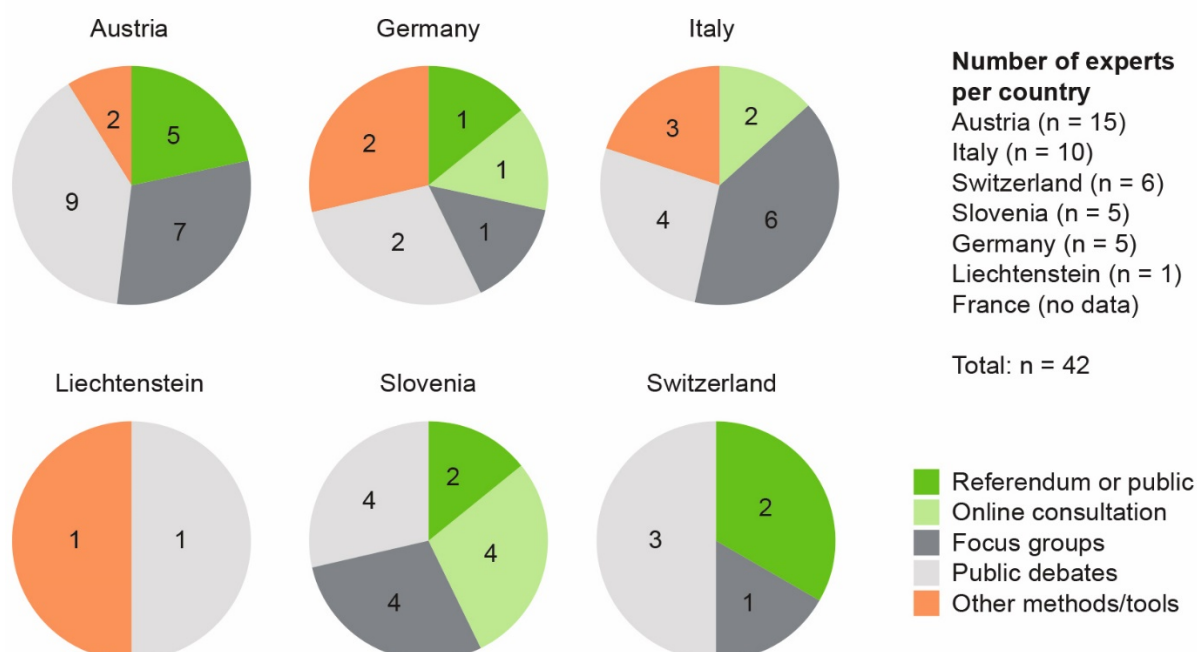


Figure 15: Methods and tools to involve actors in the policy-making for risk governance (Colours of segments indicate how actors are involved in policy-making related to risk governance. Numbers in the slices of the pie chart show the number of answers)

According to interviewed experts from France, limitations in the risk governance processes are caused by a lack of cooperation and exchange among different administrative levels and by the fact that tasks of different departments and administrative levels do overlap. Importance was also given to the fragmentation of spatial planning and risks-related tasks that are shared between state services and local communities.

Communication

According to the IRGC, “effective communication is the key to creating trust in risk management” (IRGC 2012: 22). In the context of risk governance, communication refers to the exchange of information between policy makers, experts, stakeholders and with the public. The aim of communication is to increase the knowledge level and to foster trust and social support in order to strengthen the responsible management of risks as well as the acceptance of risk management measures to be taken. Additionally, it may foster the successful involvement of the public in risk-related decisions.

In this context, experts who participated in the online questionnaire were asked to provide information about communication strategies, tools and activities applied in their own country or region not only in case of emergency, but also during the prevention phase. Furthermore, experts were asked about special communication strategies in place to reach vulnerable people (e.g. children, elderly, single or disabled persons).

The majority of answers show that there are communication strategies and concrete activities in place to communicate risk to local decision makers and the affected population.

In order to prevent severe impacts of natural hazard processes in the Alpine region a number of different communication strategies are applied. Figure 16 shows communication strategies used in the Alpine countries to communicate residual risk to local decision makers and the affected population. Most commonly, the population is informed or does participate through discussions and informative events, followed by official media channels. Training and workshops, mass media, and specific information for highly vulnerable groups are further popular types of communication. Other types of media named, which are used to communicate residual risk in different regions are emergency and hazard plans as well as local consultants. In Bavaria, the communication of residual risk is rather done in the context of a certain event or as part of the implementation of a protection measure.

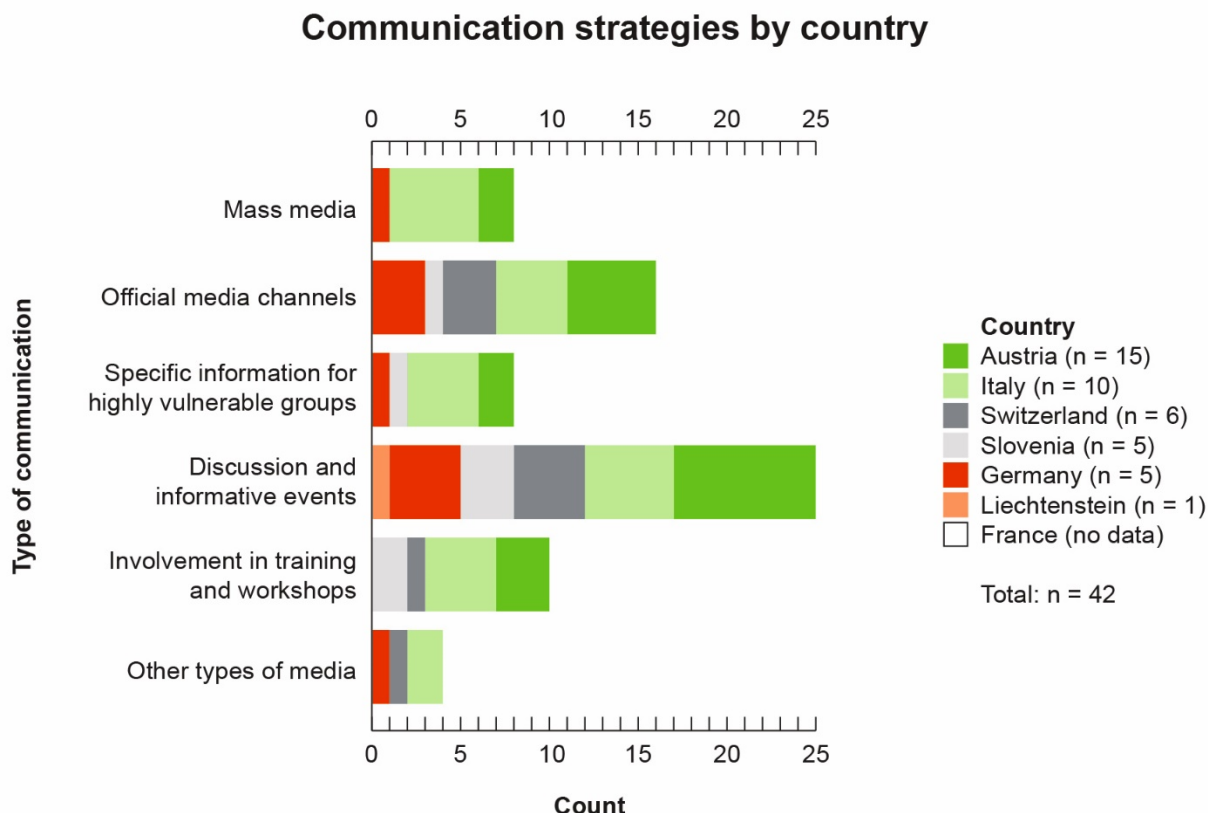


Figure 16: Existing communication strategies in the Alpine region based on the answers received from the questionnaire (multiple answers possible) (Source: Authors).

Figure 17 gives an overview of communication tools used to inform the affected population during the case of emergency. According to experts who participated in the online questionnaire, the most common communication tools for emergencies in Alpine countries are local TV channels followed by internet and specific tools (e.g. applications) for mobile phones, or megaphones. Figure 17 shows that all countries but Liechtenstein use all the tools provided as choices in the online questionnaire. Other tools mentioned by the experts but not provided within the online questionnaire were on-site information, sirens, and police patrols as well as SMS, informative e-mails, radio communications, public alarming systems and telephone hotlines.

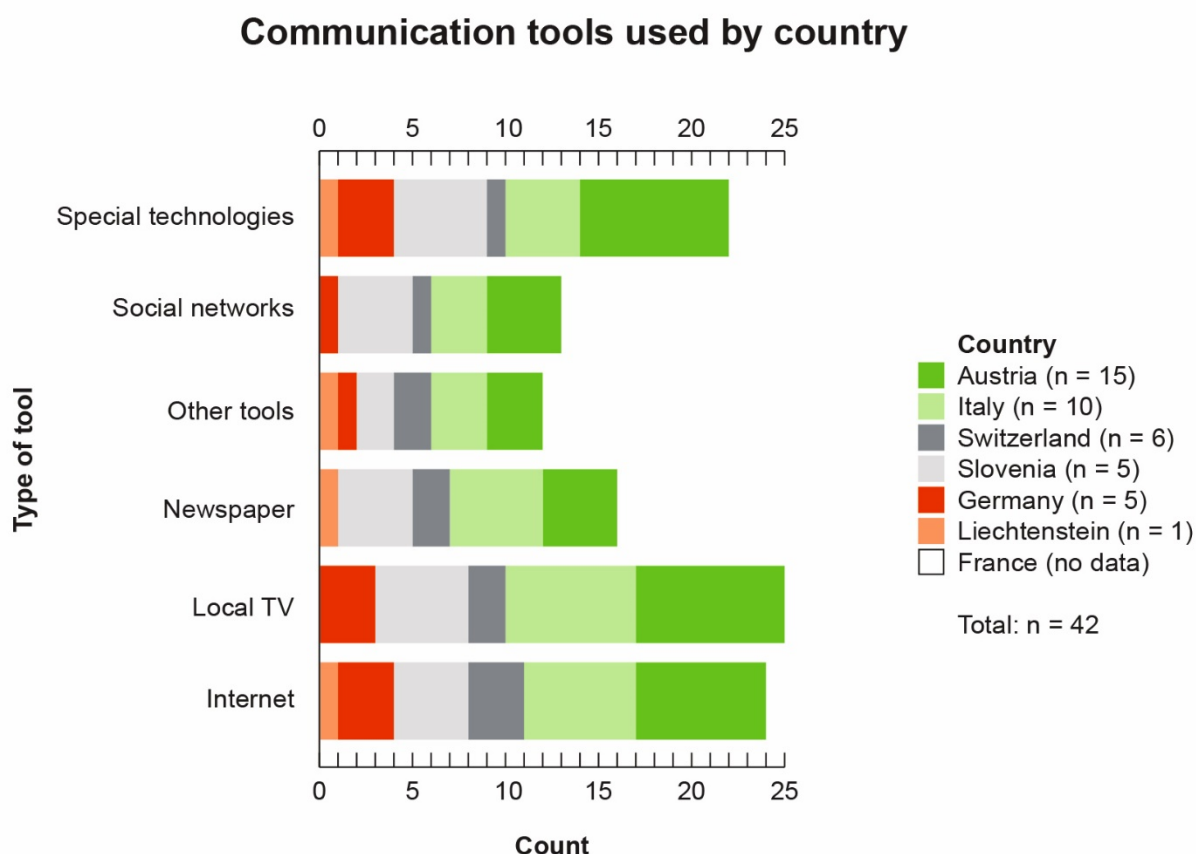


Figure 17: Communication tools applied in Alpine countries based on answers received from the questionnaire. (Source: Authors).

Besides the communication tools suggested in the online questionnaire, experts interviewed for this study named further tools applied in their countries. An Austrian expert stated that for torrents and avalanches, a cadastre is used to share information about ownership and uses of land. Through this tool, information related to spatial planning activities are provided to the public and at different administrative levels.

A **French** expert provides an example of the diversity of communication tools used and levels involved. The expert clarifies that the responsibilities of communication are clearly shared amongst various organisations. For example, in the alert phase, the French national service for meteorological data, Meteo France, provides information through television and newspapers. Additionally, the state communicates about major risks through the media, while regional and local authorities carry out crisis management. The prefect at the regional or departmental level ensures communication during emergencies. The mayor is responsible for the event communication at municipality level. Finally, departments at regional level follow the distribution of leaflets and booklets with further information for the communities.

Most interviewed experts stated that the current state of communication regarding the topic of residual risk is insufficiently addressed. According to them, the awareness of risk that remains after the implementation of protection measure is very limited. The experts further state that citizens often believe that the protective structures are sufficient to protect themselves entirely. Because of this situation, it is delicate for technicians and other actors involved in risk governance to explain to the public the existing limitations of structural protection measures and the remaining vulnerabilities of the community to residual risk.

4.2.2 Strengths and constraints of present risk governance approaches

The study results reveal both positive and negative aspects of the status quo of risk governance related to natural hazards in Alpine countries. The literature reviewed on this topic as well as the experts consulted have provided an analysis of the strengths and limitations within risk governance processes currently in place.

According to scientific literature on this topic, the present diversity of departments and administration levels dealing with risks within a country offers considerable advantages in addressing risk-related issues. This holds true because, first, risk problems with different intensities can be managed at different levels. Second, an inherent degree of overlap and redundancy makes non-hierarchical adaptive and integrative risk governance systems more resilient and therefore less vulnerable. Third, the large number of actors facilitates experimentation and learning processes (RENN 2008).

On the contrary, some authors have identified limitations related to the overlap of administration levels and different departments. In many Alpine regions, areas suitable for permanent settlements and economic activities are limited. As a result, land development and building activities are inevitably concentrated on risk-prone areas (HOLUB and FUCHS 2009). Interviewed experts have confirmed that for this reason conflicts arise between government departments, which have the mandate to protect the community against risk, and the individuals or local representatives of the municipalities. Under these circumstances, measures to reduce exposure often contradict with financial interests.

Further conflicts in spatial planning derive from a lack of cooperation and fragmentation of tasks between departments and administrative levels as well as from a lack of definitions of common goals and policies. There are great differences among the Alpine countries concerning the instruments and processes used to involve actors.

Experts interviewed for this study recognise additional constraints with respect to current risk governance approaches. Hereby, they refer to the potential fragmentation of risk governance processes pointing out that collective decision-making processes on risk-related issues can be very costly. They also state that the status quo of risk governance is characterized by a multitude of people involved, which may lead to an overlapping of tasks and a loss of clarity on the share of responsibilities that each stakeholder bears. A likely consequence of this situation is a loss of trust in those institutions that initiate such risk governance processes (RENN et al. 2011). An interviewed expert from **Austria** reported for example the existence of different protection goals due to a change in competencies within a catchment area. In this case, the torrent and avalanche control defines a protection goal of HQ150 and selects measures respectively in the upper parts of the river. The office of water control, however, uses a HQ100 as base for their protection goals and measures further downstream. Such different understandings of protection goals may hamper the cooperation amongst actors when protecting settlements and human beings.

The here mentioned numerous strengths and weaknesses of the present approaches in the Alps reflect well the complexity of the topic of risk governance. They point out the necessity to carefully evaluate possible future activities aiming to improve the current situation in order to avoid adverse effects. In any case, the results of this study may serve as a first base for the identification of most relevant fields of actions.

5. Good practices and recommendations

In the previous chapters the current situation of the various approaches to address the case of overload and residual risk in Alpine countries and regions were elaborated. This chapter presents some selected respective good examples already implemented in the Alps. It concludes with a set of recommendations on how to further improve risk governance within the context of case of overload and residual risk.

5.1 Good practice collection

The here presented selection of good practices comprises innovative methods, tools and technologies to address various aspects of IRM. There are many attempts to improve risk management and governance in the Alps, which would be worth mentioning. But only few of them specifically address the cases of overload and residual risk. In this selection, the focus is on those practices that are of particular relevance for reducing the residual risks and the negative impacts of cases of overload. They may be used as standing alone solution for a specific issue or may be applied in a combined way to deal with residual risk and cases of overload in an integrated way.

The selection of these good practice examples is based on the results of all 3 methods used for this study. That is, the identification of these examples was pursued during the literature review and throughout the questionnaire as well as the interviews.

The following selection criteria were used as a rough guidance to collect good practice examples:

- Specific focus on residual risk and/or the case of overload
- Integration of structural with non-structural or nature-based measures
- Practical implementation of measures
- Implementation produced proven positive outcome
- Transferability of measures to other regions than where applied
- Facilitation of cooperation among stakeholders or different administration levels and creation of synergies between different sectors or fields of responsibilities
- Contribution to an improved communication or an increase in risk awareness

The accordingly selected good practices were classified into 3 main types: A. Technical measures, B. Legal and institutional measures including spatial planning, and C. Communication-related measures. This allocation was not always trivial since several practices could have been categorized to more than 1 class. The examples collected for this study are listed below with a brief description and an information about where they are applied and in the context of which type of hazard they are used.

First, technical measures are listed, as they represent the majority of good practice examples presented by experts in the surveys. Secondly, good practice examples related to legal frameworks and institutional settings including spatial planning are named. Thirdly, those measures concerning communication aspects are presented. It is noteworthy that most selected practices are measures dealing with water-related hazards or are of generic type (relevant for all type of hazards).

A. Technical measures

The good practice examples collected in the context of technical measures deal with the following aspects:

- structural measures, retention areas, protection structures that consider the case of overload, reinforcement of structures in order to avoid failing of the structure,
- risk assessment, controlling, protection measures considering the case of overload in their development,
- preparation of staff, through emergency plans and alert plans.

1.

Good practice explanation	Reconstruction of cage screen for torrents in order to consider the case of overload in 2005. Situation before the reconstruction: material would flow towards the settlement during a case of overload. Situation now: higher capacities and material is led away from settlement towards a forest during the case of overload. Financing already paid off 1 year after the implementation of the measure. Full revision of existing measures have started in 2013
Type of hazard	Flood
Type of the good practice	Technical – structural measure
Location	Switzerland – Nidwalden
Source and further information	Kanton Nidwalden – upon request.

2.

Good practice explanation	Consideration of the case of overload of Swiss rivers in order to be able to handle events larger than the design event a protection goal was developed for.
Type of hazard	Flood
Type of the good practice	Technical – structural measure
Location	Switzerland
Source and further information	Swiss expert – upon request. And: https://www.baslerhofmann.ch/fileadmin/user_upload/baslerhofmann/Aktuelles/Fachartikel/16-05_FA_WasserEnergieLuft_Ausg1_Urner_Talboden.pdf

3.

Good practice explanation	Dam for protection against flood in Bad Radkersburg, has a defined section for overloading. Has been designed differently to the construction law in order to be functional.
Type of hazard	Flood
Type of the good practice	Technical – structural measure
Location	Austria – Styria
Source and further information	Austrian expert – upon request.

4.

Good practice explanation	Flood retention in the Gail river consisting of longitudinal, transverse and annular dents (uncontrolled). Transversal dams as second defensive line for overload. It is a technical protection measures with limited use of space; solidary co-financing of the measures through previously defined apportionment defined by the water law. Consideration of residual risk and overloading already took place in the general project from the 1970s.
Type of hazard	Flood
Type of the good practice	Technical – structural measure
Location	Austria – Carinthia
Source and further information	Austrian expert – upon request.

5.

Good practice explanation	Control measures implemented by "Local Avalanche Commissions" and the definition of Evacuation Operational Plans.
Type of hazard	Avalanche
Type of the good practice	Technical – controlling, Organizational
Location	Italy – Trentino
Source and further information	Italian expert – upon request.

6.

Good practice explanation	Special alert plan which explicitly planned for residual risk events and which has been exercised.
Type of hazard	Flood
Type of the good practice	Technical – organizational, communication related
Location	Austria – Lower Austria region, river March
Source and further information	Austrian expert – upon request.

7.

Good practice explanation	Protective measures were designed taken into account several scenarios of overload.
Type of hazard	Flood
Type of the good practice	Technical – risk assessment
Location	Italy – South Tyrol
Source and further information	Italian expert – upon request.

8.

Good practice explanation	This project aims at increasing runoff capacities without carrying out technical measures in built-up areas, to reduce risk zones, minimize residual risk & to prepare for potential cases of overload via nature-oriented solutions. Activities: Identification and modelling of hydraulic weak points, site inspections and measurements, participation process with universities, engineers, natural protection services and citizens. Decision-making based on a cost-effectiveness calculation and minimal usage of natural areas. Results: Higher protection goal & runoff capacities, eliminated risk zones in urban areas, overall reduced residual risk
Type of hazard	Flood
Type of the good practice	Technical – structural measure
Location	Germany – Bavaria, Oberammergau
Source and further information	German expert – upon request.

9.

Good practice explanation	The aim of this project is to prepare for possible cases of overload at the Linthwerk channel connecting the <i>Walsee</i> and <i>Züricher See</i> . To avoid a collapse of protection measures during extreme events a number of measures were realized: (I) Height differences of dikes to automatically lead water into discharge corridors away from areas with high damage potential; (II) Technical relief of water into adjacent channels to increase runoff capacities during events larger than HQ100; and (III) Withholding of water in the <i>Walsee</i> to avoid overlapping peak discharges after heavy precipitation events.
Type of hazard	River flood
Type of the good practice	Technical
Where it is located (municipality, region, country)	Switzerland
Source and further information	Linthwerk website

10.

Good practice explanation	The aim of this project is to tackle high discharges at the streams <i>Hofbach</i> and <i>Sure</i> to protect the old town in the city of <i>Sursee</i> . The integral flood protection concept aims to meet the high protection demands of the townscape as well as to realize revitalization measures. A comparison matrix and a numerical scoring system developed with local authorities were used to estimate the economic efficiency of measures. Retention areas were created to optimize and control the discharge of the <i>Sure</i> during the case of overload while local protection measures secure the old town of <i>Sursee</i> . A participatory approach included all relevant stakeholders and helped to increase the acceptance of the project. Finally, the integral implementation of measures presents a robust package that ensures sustainable flood protection and reduces overall flood risk.
Type of hazard	River flood
Type of the good practice	Technical / Communication
Where it is located (municipality, region, country)	Switzerland
Source and further information	FREIMOSER et al. (2016). Integral flood protection project for the medieval town of Sursee. In: Interpraevent 2016, 13 th Congress, Lucerne, Switzerland, pg. 204-205.

B. Legal and institutional measures including spatial planning

The good practice examples listed here deal with legal and institutional issues and comprise of the following aspects:

- spatial planning and regulation of flood retention areas, storage space for overload material, provision of zones where building is prohibited due to hazard prone situations,
- application of standards in hazard assessment that consider the case of overload.

11.

Good practice explanation	Definition of retention areas for residual risk according to a norm on planning of zones: WRG-Gefahrenzonenplanungsverordnung (WRG-GZPV), BGBl. II Nr. 145/2014
Type of hazard	Flood
Type of the good practice	Legal/governance – spatial planning
Location	Austria – national level
Source and further information	Austrian expert - upon request.

12.

Good practice explanation	The constructions law OÖ (BauTG §47; ROG §21) establishes compulsory spillways for water runoff during cases of overload in zones affected by flood. It forbids constructions in red zones
Type of hazard	Flood
Type of the good practice	Legal – spatial planning
Location	Austria – national level
Source and further information	Austrian expert – upon request.

13.

Good practice explanation	Flood polders on the Danube or other Bavarian rivers. In case of overload, additional storage space is created. Minimization of dyke break disasters etc., discharge into spaces with less damage potential (agriculture compensation)
Type of hazard	Flood
Type of the good practice	Legal/governance – spatial planning
Location	Germany – Bavaria (river basin level)
Source and further information	German expert (Bavaria) – upon request.

14.

Good practice explanation	Controlled flooding during dam failure taking into account cases of overload. Beyond HQ200 events, it is intended to flood the agricultural fields to avoid flooding the city. Implemented by the communities & financed by the state within the Plan de Prévention des Risques (PPR).
Type of hazard	Flood
Type of the good practice	Legal/governance – spatial planning
Location	France – Syndicat de l'eau d'Isère (river basin level)
Source and further information	Land use plan of Isère department Department of Savoy website

15.

Good practice explanation	All slope watercourses in Liechtenstein eventually drain in the Rhine valley and into the inland canal whose drainage capacity is very much limited due to the small size of the country. In order to tackle this issue during peak discharge, it has been recognised that retention basins and spillway edges at lower parts of the dyke are useful measures to deal with unexpected/unusual high amounts of rainfall/runoff. The controlled overflow of existing flood protection measures may thus be used to avoid an uncontrollable event, large amounts of loss and damage, to reduce the risk in downstream settlement areas and should be considered in all projects that are yet to come.
Type of hazard	Flood
Type of the good practice	Legal/governance – spatial planning
Location	Liechtenstein – Rhine valley
Source and further information	PLANALP 2012 – bibliography chapter.

16.

Good practice explanation	Application of the flood directive 2007. Study of correlated hazard must be conducted in case of a project to construct a dam. This study must include the case of overload of the reference phenomena and therefore the overload of nominal protection within the land use plans.
Type of hazard	Flood
Type of the good practice	Legal – hazard assessment
Location	France – national level
Source and further information	Legifrance website

17.

Good practice explanation	Joint training program among employees at fire brigades, civil protection, military and emergency planning in order to be able to carry out tasks associated with planning and implementation of measures.
Type of hazard	Various
Type of the good practice	Governance – training and organisational
Location	Switzerland – national level
Source and further information	More information at the BAFU website

C. Communication related

Two good practice examples address the issue of communication. One deals with communication of residual risk to the public through benchmarks in water level. It was developed at local level in Germany. The second one was developed in Liechtenstein concerning contingency planning and the transfer of knowledge in potential cases of overload. Additionally, 2 practice examples from Switzerland with focus on various aspects of risk governance activities are listed here.

18.

Good practice explanation	Information for house owners through benchmarks (so called "blaues Band") about how high the water can rise in case of a dike burst, and what to do in these cases (e.g. escape to upper floors) with the aim to raise the public awareness of possible cases of overload and the residual risk associated with them.
Type of hazard	Flood
Type of the good practice	Communication related
Location	Germany - City of Kelheim
Source and further information	German expert (Bavaria) – upon request.

19.

Good practice explanation	Aim: to establish 'water brigades' and contingency plans for torrents in order to improve disaster management during the case of overload. Key principles include: (i) development of hazard maps, which include possible cases of overload as well as contingency plans (ii) transfer of knowledge about catchment area as well as the function, capacity and limitation of protection measures to responsible people at local level; (iii) installation of 'water brigades' at community level, which are going to take the lead during all events caused by torrential hazards and triggering a case of overload; (iv) education of fire brigades and quality check of operational procedures; (v) involvement of local risk governance authorities including civil protection and foresters
Type of hazard	Torrential hazard
Type of the good practice	Communication and planning related
Location	Liechtenstein
Source and further information	RSA7 – Natural Hazard Risk Governance, Good Practice Examples (in preparation).

20.

Good practice explanation	The BAFU has carried out a number of projects in the context of climate change adaptation and management of natural hazards with potential relevance for dealing with the case of overload. Topics covered are natural processes and their influence on current risk concepts as well as measures used to prepare for potential impacts (for example risk-based spatial planning to secure flood prone corridors) .
Type of hazard	Various
Type of the good practice	Various
Location	Switzerland – national to local level
Source and further information	More information at the BAFU website

21.

Good practice explanation	The BAFU lists a number of organisational measures, which help to reduce loss and damage during the case of overload. Measures include forecasting, warning and alarming, closure of affected areas, mobile protection measures as well as evacuation and assistance of the affected population.
Type of hazard	Various
Type of the good practice	Various – education, cooperation, organization
Location	Switzerland – local level
Source and further information	More information at the BAFU website

Thematic Box #2: Good Practice Example– IRM at the Engelberger Aa

The implementation of protection measures in the Swiss canton of Nidwalden is an often praised and repeatedly cited example of how IRM can contribute towards a successful and effective risk governance of natural hazards in the context of residual risk and the case of overload. The respective project known as ‘Engelberger Aa’ has been designed to avoid the development of new, unmanageable risks, to alleviate and reduce existing risks, and to increase acceptance of those risks that cannot be eliminated.

The planning phase for the Engelberger Aa project began already in 1989; its implementation phase ran from 1998 to 2007. Therefore, the project represents one of the first in the Alps in which all aspects of the modern IRM concept were put into practice. Adapted to the specific local conditions, a combination of measures was implemented in the municipalities of Stans and Buochs comprising of:

(i) Land use regulations in risk zones; (ii) awareness raising about residual risk and potential cases of overload; (iii) structural measures (e.g. bank stabilization, (mobile) dike systems, artificial discharge corridors, tipping elements (see Figure 18), spillway edges); as well as (iv) non-structural measures such as hazard maps, emergency plans, forecast and warning systems.

In close cooperation with local actors, all combined measures helped to reduce the flood risk in the entire valley of the Engelberger Aa significantly. The case of overload has explicitly been anticipated and prepared for. Based on an extensive risk analysis, technical elements and multiple discharge corridors were developed to direct greater volumes of water or bed load towards specified retention areas with low damage potentials. In addition, a system of dams protects areas with important assets such as settlements or industrial zones from being flooded. Thanks to these measures, it is guaranteed that the maximum volume of water remaining in the channel at each discharge point corresponds to the water retention capacity of the next section. The significant decrease of high-risk areas after the implementation of measures is illustrated in the hazard map below (Figure 19).

Despite the implemented technical measures, it was possible to meet the ecological requirements for re-establishing a natural river course and to integrate the provision of local recreational amenities into the project. Additionally, the integration of joint emergency planning as well as the use of construction machinery, precise monitoring and training exercises of local authorities contribute to a further decrease of residual risk.

During several occasions in the past decade and particularly during a heavy storm in 2005, the project has undergone multiple reality tests. All structures functioned faultlessly and large-scale damages could be prevented. However, due to a construction delay of 1 protection dam, the 2005 event caused minor damage in the town of Ennetbürgen. Before the 2005 event, the construction of this dam had been subject to strong debates. After the successful damage avoidance in the entire valley in 2005, the rapid finalisation of the remaining constructions was then widely supported by the public and affected citizens. During the 2005 flood alone, the investment of CHF 30 million avoided an estimated damage of CHF 160 million (EBERLI and KLAUSER 2012; BEZZOLA and HEGG 2008; Interview with FESSLER and site inspection with KLAUSER 2017).



Figure 18: River Engelberger Aa with tipping elements (Source: Authors).

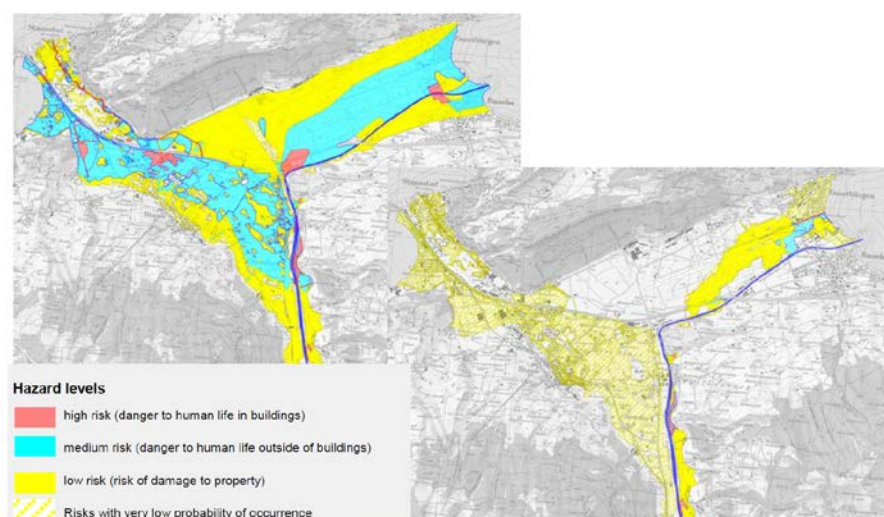


Figure 19: Hazard maps prior to (left) and after the implementation of flood protection measures at the Engelberger Aa (right) (Source: Tiefbauamt Kanton Nidwalden 2009).

5.2 Recommendations

This study results in a number of recommendations to improve the status quo of risk governance with focus on the case of overload and residual risk in the Alps. These recommendations are addressed to a variety of actors dealing with risk governance, namely those responsible at the various levels of public authority, practitioners and consultants in the private sector, scientists and researchers, as well as the interested public. A concise version of the recommendations is provided in a separate summary for policy makers.

The following recommendations are based on all working steps of the study but have been particularly derived from the answers of the questionnaires and the in-depth interviews. Within the questionnaire, the experts were asked to rate the importance of identified principles about risk management. They were requested to state their level of agreement with respect to a number of proposed recommendations for improvements of risk governance. The semi-structured interviews were also conducted in the perspective of collecting recommendations. Each topic, which was composed of specific questions, was backed with an inquiry what the interviewed expert would suggest in order to improve the current situation.

The results of the various surveys were synthesized and the proposed recommendations were clustered according to 4 main topics: (I) risk assessment, (II) residual risk management, (III) actors involvement and processes for assessing and dealing with residual risk and (IV) residual risk communication.

The obtained clusters of recommendations were presented to EUSALP AG8 members during their 4th meeting in Innsbruck, on September 19, 2017. During this meeting, it was possible to obtain feedback to the content, the wording and the clustering of the recommendations. In addition, a prioritisation exercise was carried out that allowed a ranking of those recommendations that the experts evaluated to be most important.

Each recommendation has been allocated to only 1 of the abovementioned clusters though many recommendations actually contribute to several topics. It is noteworthy, that many recommendations, which were received during the study, address risk governance and risk management issues in general and do not explicitly deal with the case of overload or the management of residual risks. In the following, only those recommendations are listed that contribute to the objectives of this specific study whilst all other provided recommendations can be found in Annex 4.

(I) Risk assessment

The first set of recommendations comprises of 3 recommendations, which aim at improving the *assessment* of risks. They also cover the process of protection goal determination as crucial input for the case of overload and delineation of residual risk.

1. Development of a common understanding of the concepts and terms of 'case of overload' and 'residual risk' – particularly for the use at the national level.

Further steps to achieve this goal would be:

- **A proposal for a possible common generic definition** for these 2 key terms to support a mutual understanding of the underlying concepts. This could follow the ideas of the 'Dictionary of Flood Protection' developed by LOAT and MEIER (2003) and would need to be discussed amongst the relevant actors in the Alpine region and other EUSALP Action Groups.
 - **A harmonization of the processes leading to protection goals** with regard to specific hazards or risks in the Alpine region, including the development of common tools to be applied for achieving these goals
2. Development of a harmonized approach for integrated risk assessments in the Alps. Risk assessments represent the base for decisions upon protection strategies and measures at the different governance levels (local, regional, national, transnational) and should follow as far as possible a common methodological and integrated approach. This approach should include technical, biophysical and social-economic / cultural aspects. It should consider possible future developments, particularly of climate change but also of other social-economic changes such as extension of built-up areas, depopulation of some rural areas and the uncertainties related to all of these issues. Moreover, the assessment should explicitly address the extent of residual risk that remains after the implementation of protection measures.

Possible improvements identified for an integrated assessment of risks are:

- **Improve and harmonize the documentation of hazardous events** and related damages as well as losses by means of accessible databases as done by HÜBL et al. (2002). This can support evidence-based decision-making and the accuracy of statistical analyses leading to probabilistic protection goals.
- **Expand traditional hazard-focused assessment** towards integrated risk evaluation, which recognizes exposure and vulnerability as equally important risk components and support the development of respective tools.
- **Consideration of uncertainty** and unknown events when defining the risk level of zones.
- **Align risk assessments** across administrative borders.
- **Develop tools for assessing multiple as well as cascading risks** and consider them in the risk assessment as the combination of events may lead to unforeseeable consequences.
- **Foster the identification and monitoring of potentially hazardous processes** and related risks with the help of new or innovative technologies (e.g. remote sensing, volunteered geographic information (VGI), etc.)

3. Establish the determination of protection goals as transparent and participatory process within risk governance.

Further considerations with respect to this aspect are:

- **A transparent and participatory process** towards the determination of protection goals supports the acceptance and awareness of measures required to be taken in order to achieve these goals.
- **The use of risk scenarios**, which were ideally already developed in the risk assessment process, to represent various possible future development pathways and support decision making with respect to protection goals.

(II) Residual risk management

The second set of recommendations aims at *integrating residual risk in risk management*.

1. Consideration of residual risk in land use and spatial planning procedures for risk management (also suggested by CAMENZIND-WILDI et al. (2005) and CAMENZIND and LOAT (2014)) and to guide the location, type, intensity, design, quality and timing of urban development. The supporting aspects listed below are based on the publication of BURBY et al. (2000) as well as on experts interviewed for this study.

Important aspects in this regard are:

- **Incorporate uncertainties** introduced by climate change and derived from changing natural hazards dynamics as well as possible incorrectness in the generation of design events, when carrying out spatial planning and delineating risk-prone zones.
 - **Arrangement of nature- and eco-system-based adaptation measures** such as protection forest as well as buffer and retention zones in land use plans to reduce potential impacts and to allow a controlled flow of material (from landslides, rockfall, snow, water, debris, water). Consider co-benefits of using ecosystem services and their protective functions.
 - **Provide mandatory information about residual risk** for planning, selling or buying properties in risk prone areas.
 - **Acquisition of undeveloped land** in high-risk areas by municipalities in order to prevent the development of such areas,
 - **Visualize residual risk** and its dynamic aspects as well as various risk scenarios in maps and land use plans as part of risk-oriented spatial planning
2. Introduce an integrated set of measures that increases the overall resilience of a community and their critical infrastructure. When dealing with residual risk, such resilience can significantly reduce adverse direct and indirect potential effects of hazardous processes.

Further considerations in regard of this recommendation are:

- **Take into account the possible failure of a protection measure** and prepare for the case of overload. Ensure that the communities in risk-prone zones are prepared and reduce potential damage by building up a certain level of redundancy in protection measures, where possible.

- **Develop and implement innovative technical protection measures** against natural hazards, which are regularly maintained. These measures should be designed in a way that allows a controllable and 'smooth' overloading without causing major damages. In any case, sudden failure of protection measures potentially leading to uncontrollable consequences must be avoided. Steering a hazard's impacting forces into areas of little damage potential is of crucial importance and technically feasible in many cases. Within the Alpine region, this approach represents a rather new perspective on how to deal with natural hazards and requires conviction of all actors involved in decision-making processes or affected by a hazard.
3. Establishment of legal and policy frameworks supporting residual risk management.

This may be achieved through:

- **Stricter building standards**, which imply protection measures for residual risk and the case of overload.
- **Development of regulations** that allow for the relocation of critical infrastructure (such as schools, public buildings, roads, power plants, etc.) out of high-risk areas to minimize possible disruptions caused by hazards. These regulations should also prohibit the planning of new critical infrastructure facilities in such areas.
- **Taxation and fiscal policies** for the development of hazard-prone areas for example incentives for reducing land-use intensities in hazard-prone areas. Revenues from these fiscal policies can be redirected to support emergency management services.

(III) Actors involvement and processes for assessing and dealing with residual risk

The third set of recommendations aims at *improving the involvement of actors in residual risk management*. The influence of stakeholders involved in technical risk management services (i.e. flood prevention services, road and infrastructure services) as well as elected officials in other relevant positions must be able to participate in decision-making processes in order to be able to have an influence at the administrative level. Decisions that are taken by mutual agreement are more likely to be accepted and applied afterwards.

1. Establishment of a process with increased engagement of actors and participative processes in assessing and dealing with residual risk. The final goal of this process is the achievement of a '**risk-competent society**' in which each actor or member of the community has responsibilities for the safety at community as well as individual level.

Important aspects in this perspective are:

- **Give individuals and members of the community the opportunity** to contribute to risk management activities and decision-making processes.
 - **Enable citizens to contribute to the selection of protection measures** based on their perception of most significant actions.
2. Promotion of a cross-sectoral approach, which fosters synergies between technology, economy and social life.

Possible measures to achieve this goal are:

- **Support the cooperation** across sectors and hierarchical levels through task forces and round tables composed of representatives from various departments and administrative levels as well as the generation of cross-sector information platforms and underlying databases.
- **Direct the involvement of actors** through structured processes of participation.
- **Establish sound decision-making mechanisms** to support actors' participation under uncertain framework conditions such as MCA.

(IV) Residual risk communication

The last set of recommendations aims at an *improved strategy to communicate the issues of residual risk and the case of overload to the public*. The intention is to make the public aware of the fact that – despite all the structural and non-structural measures that have been implemented - there is always a residual risk that should not be neglected. Through improving residual risk communication, individuals and communities are better prepared to consider residual risk when relevant decisions need to be taken.

1. Create a risk culture with an awareness about residual risks.

Important aspects in this regard are:

- **Produce knowledge** about the risks related to natural hazards by means of early education: children should be educated about natural hazards, vulnerabilities and related risks from an early age on.
 - **Spread information** about residual risks associated with natural hazards.
 - **Establish cross-border communication strategies** that improve dealing with residual risk and overcome administrative barriers.
 - **Include storytelling** to benefit from past impacts and the knowledge about how the society and individuals dealt with them.
2. Create a vivid risk dialogue and foster the distribution of information through multiple channels. The dialogue for this purpose needs to be an open, conscious, and transparent one. It further needs to consider all hazards and risks.

Further considerations with respect to this aspect are:

- **Use digital and print media** accessible for all citizens.
- **Cooperate with local distributors** to benefit from their networks.
- **Foster the use of modern, personal and interactive communication** such as mobile phone applications.
- **Make use of local infrastructure** to organise public debates and presentations that give insight into decision-making processes related to residual risk and the case of overload.
- **Organize communication campaigns** to inform about the absence of absolute safety against natural hazards.
- **Challenge** a community's well established traditional approach to living with risks by introducing innovative measures such as social learning or co-creation of knowledge considering local knowledge of natural phenomena.

- **Pay attention** to the wording. On one side, clear messages, precise information and concrete guidance/actions must be used. On the other side, the terms residual risk and case of overload should be communicated with care, as they are sensitive topics.

Thematic Box #3: Further (ethical and societal) considerations

The recommendations listed in this study are predominantly based on the input received from the experts through questionnaires and interviews. These recommendations tackle a number of concrete issues that could and should be improved within the context of fostering IRM. However, they represent the points of views of experts and stakeholders who are dealing with hazard risks and their potential impacts on a daily basis. When we step back for a moment and look at the role of risk management – particularly of residual risk - within the everyday life and wellbeing of our entire societies and communities some questions arise, which are of great societal relevance and - in our opinion - need to be discussed in a wider societal context. They comprise issues such as:

Do we have to discuss our recommendations concerning residual risk governance with the entire society? Are they applicable in the first place and are they ethically justifiable (key points: relocation)?

In how far is it desirable, to share all information about residual risks with the general public and could an open access to related data be counterproductive?

What are the limitations of the visualization and delineation of residual risks and is it worth striving for respective maps?

Who in the society has to pay for precautionary measures and who decides in cases that measures favour some members of the community but disadvantage others?

Summarising, dealing with the residual risks of natural hazards and related potential damages raise general questions of the importance of equality, security and prosperity within a society. The overarching guidelines of how to approach and how much resources to use for the governance of such risks is a topic to be discussed by entire communities and not only by risk managers.

6. Concluding remarks

Due to its topographic and morphologic characteristics, the Alpine territories and communities are strongly exposed to risks of gravitational geo-hydrological hazards of which the most relevant are torrential floods (including debris flows), rockfall, landslides and avalanches.

The activities carried out and the measures taken to mitigate these risks usually protect the territory and particularly the population up to a certain magnitude or intensity of hazardous events. Events that exceed this intensity are called 'cases of overload' and refer to the category of residual risk. These events are typically characterised by a low probability of occurrence combined with a great potential for damages and losses. Hence, they should be explicitly taken into account when planning structural protective measures. Beyond these structural measures, adverse impacts can be reduced by means of non-structural interventions related to improved organisation, communication, warning and altering as well as response measures. In recent years, the significance of an appropriate consideration of cases of overload has increased due to changing climate conditions and the associated rise in uncertainty of future risks related to geo-hydrological hazard events. There is a mutual agreement across the Alps that dealing with residual risks and the cases of overload requires an IRM and improved approaches in risk governance in order to provide best possible protection of the citizens.

With respect to the current situation of risk governance in the context of residual risk and the case of overload in the Alps there are many challenges to be tackled in the future. As of now, many differences in the Alpine region and sub-regions hinder the development of a common approach of managing natural hazards. Though there is a general common understanding in the concept of residual risk and – to a smaller extent also of the case of overload - there are significant variations in details of existing definitions for the terms and the manifoldness of approaches to determine protection goals. Amongst those who provided input to this study, there is a common awareness of the need to standardize and integrate risk governance approaches and in implementing measures in the context of residual risks in the Alps and for the different types of natural hazards. Based on the data collected for this study it appears that the focus of definitions, activities and strategies are linked to river flooding and torrential hazards, while there is less information available for the other hazards addressed in this study, namely avalanches, rockfall and landslides. When assessing risk and taking measures to mitigate potential impacts, there is still a strong focus on the hazardous processes themselves whilst exposure and vulnerabilities do not obtain sufficient prominence. Furthermore, the findings of this study have shown that the awareness of the concept of residual risk and the case of overload is insufficient for both actors involved in decision-making processes related to risk governance and the wider public.

In order to address options to improve the risk governance of natural hazards in the context of residual risk and the case of overload this study has collected good practice examples and provides some elaborated recommendations.

- To foster successful risk governance of natural hazards in the context of residual risk and the case of overload, more emphasis should be given to communication strategies. These strategies should comprise tools that motivate stakeholders involved in risk governance activities as well as those potentially affected by the impacts of natural hazards to participate in decision-making process. An increased awareness about residual risk and the case of overload would enlarge the acceptance to establish IRM strategies and carry out related measures. The final aim of appropriate communication

and awareness raising are risk competent communities in which the individual is prepared to society to deal actively with natural hazards' risks.

- To date, uncertainties in data used for risk assessments represent a major limitation when deciding upon structural and non-structural protection measures. More and reliable inventories as well as the development of innovative risk assessment tools are required to increase the accuracy of cost-benefit analyses of various options to intervene. Ideally, these tools would take into account the challenging issues of cascading hazards and multiple risks.
- A central part of mainstreaming IRM is to go beyond structural measures and to explicitly extend the recognition of the importance of ecosystem-based protection measures and nature-based solutions for reducing residual risk. Innovative and adjustable protection systems, which combine technical measures with organisational and societal ones, constitute promising ways to address residual risk and cases of overload in the future.
- Finally, more attention should be paid to the reduction of exposure and vulnerabilities by strengthening resilience rather than focusing on the control of the hazardous processes. The long-term goal of all Alpine countries should be to build resilient socio-ecological systems that are able to adapt and respond to a multiplicity of natural hazards.

Both, the authors of this report and experts contributing to it see the need for further in-depth studies to fill gaps in knowledge about specific issues of risk governance in the context of residual risk and the case overload. An in depth-analysis should be carried out to scrutinize liabilities and responsibilities for determining protection goals and managing residual risks. Based on this, the extent to which a common approach would be feasible in the Alps could be elaborated. It would also be useful to look further into the ways of cooperation between various actors and to identify potential overlaps of tasks, lack of synergies, responsibility gaps, and approaches to develop risk-oriented spatial planning in the Alpine region.

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Annex 1: Extraction of table with results from the literature review

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Leben mit Naturgefahren- Ratgeber für die Eigenvorsorge	BMLFUW, 2015	Austria	Communi- cation material	Multiple	Summarizes information on the typical Alpine hazards (floods, debris, avalanches, rockfall, landslides) and offers considerations for the local population to be able to reduce residual risk. The different types of hazards are dealt with individually, offering risk mitigating strategies for each of them.
Nationaler Hochwasserrisik omanagementpl an RMP 2015	BMLFUW; 2016	Austria	Policy reading	Flood	Full flood protection is not possible. Therefore, residual risk needs to be taken into account. Awareness needs to be risen with the population. The paper proposes an integrated risk management. Areas of potential residual risk have to be marked on the hazard maps.
Hochwasseransc hlaglinien - Standardisierun g der Berechnung	BMLFUW, 2008	Austria	Policy reading	Flood	Flood protection planning must nowadays include investigations on increased risk (due to discharge rates exceeding the calculated events) and residual risk (if protection structures fail). It is proposed to consider HQ300 (HQ100*1.3 if no other data available).
Floodrisk: Bewusstseinsbil dung und Öffentlichkeitsb eteiligung	Umweltbundesam t, 2015	Austria	Policy reading	Flood	Evaluation of information and awareness measures in flood management in various projects. While technical development of protection is fairly advanced, information and awareness of population needs further increasing. Especially a continuous information of the population is needed. Financial public information and civil participation is not sufficiently supported so far.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Sonderalarmplan Hochwasser March	NÖ Landesregierung, Abt. Feuerwehr und Zivilschutz; 2008	Austria	Policy reading	Flood	Presents new emergency plan for flood event, including also assessment of residual risk (dike break and overflowing) with different scenarios.
Assessing the economic case for adaptation to extreme events at different scales	O. Kuik, P. Scussolini, R. Mechler, J. Mochizuki, A. Hunt, J. Wellman; Econoadapt: The Economics of Adaptation; 2016	Austria	Policy reading	Flood	This report examines Disaster Risk Management (DRM) strategies of European countries with the aims of understanding how decisions are taken in the selection and design of DRM options at different scales, to examine how climate change, and its associated uncertainty, is or could be integrated into DRM strategies. The country case studies show the complexity of decision-making of flood risk protection at national, regional and local levels.
Law and Regulation for the Reduction of Risk from Natural Disasters in Austria	Georg Potyka; International Federation of Red Cross and Red Crescent Societies, 2012	Austria	Policy reading	Multiple	Due to Austria's geographical position, floods and landslides are the main source of disasters during the humid months of June and July, as well as avalanches during winter. Thunderstorms may cause considerable damage, while tsunamis and hurricanes do not occur. Earthquakes occur only rarely. The principal task of disaster prevention thus lies in the maintenance of forests that give protection against landslides and avalanches, and to prevent flooding of the landscape by careful regulation of rivers.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
EU Floods Directive implementation in Austria	Clemens Neuhold, BMLFUW; EDP sciences, 2016	Austria	Scientific reading	Flood	The paper reflects on how the requirements of the FD had been achieved in Austria and how the nationwide comparability and transferability of results as well as the international coordination had been obtained.
Flood risk, climate change and settlement development: a micro - scale assessment of Austrian municipalities	Löschner, L., Herrnegger, M., Apperl, B. et al.; Reg Environ Change, 2017	Austria	Scientific reading	Flood	This paper analyses the influence of climate change and land development on future flood risk for selected Austrian flood - prone municipalities. The case study analysis highlights the general need for a more comprehensive consideration of the local determinants of flood risk in order to increase the effectiveness of an adaptive management of flood risk dynamics.
Mitigating mountain hazards in Austria_ legislation, risk transfer, and awareness building	M. Holub, S. Fuchs; Natural Hazards and Earth System Sciences, 2009	Austria	Scientific reading	Avalanche	Embedded in the overall concept of integrated risk management, mitigating mountain hazards is pillared by land use regulations, risk transfer, and information. In this paper aspects on legislation related to natural hazards in Austria are summarised, with a particular focus on spatial planning activities and hazard mapping. The study results in recommendations of how administrative units on different federal and local levels could increase the enforcement of regulations related to the minimisation of natural hazard risk.
Report Pericoli Naturali 2016	Autonome Provinz Bozen - Südtirol; 2016	Italy	Communication material	Multiple	The 1st edition of the Report Pericoli Naturali 2016 (Natural Hazard Report 2016) tries to offer an overview of the natural events happening in the Province with the aim to create an official document easy to understand, both to technician and to inhabitants.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
PGRA_soggetti e responsabilità	Autorità di Bacino del fiume Po, 2016	Italy	Policy reading	Flood	In this paper, an overview of the Italian actors involved in the flood management process is illustrated. The following topics are illustrated: Flood management in the Italian context, Soil Protection System, Civil Protection System, Summary of the regulatory framework for flood risk management in real time in Italy, Coordination activities of the Civil Protection Department under the alert system.
Aree a rischio significativo di alluvione ARS Distrettuali	Autorità di Bacino del fiume Po; 2014	Italy	Policy reading	Flood	The Flood Directive calls for the identification of territorial risk management units where risk conditions are particularly significant, for which specific risk management is required. ARS districts correspond to critical places for high-risk conditions, involving highly resourced and productive housing and major infrastructure and communication paths.
Il rischio alluvionale sui fiumi in pianura: stato dell'arte in materia di valutazione e gestione del rischio di alluvioni	Autorità di Bacino del fiume Po, 2009	Italy	Policy reading	Flood	Approximately ten years after PAI's approval, significant and priority levees protection measures have been or are underway and the adaptation of urban planning tools, which are currently being completed, will help to prevent new constructions inside the fluvial bands in the future. Nonetheless, as the latest alluvial events have highlighted, the only passive defence from floods is not enough to fully reach the level of security expected along the Po river and its tributaries.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Progetto strategico per il miglioramento delle condizioni di sicurezza idraulica dei territori di pianura lungo l'asta medio - inferiore del fiume Po	Autorità di Bacino del fiume Po, 2005	Italy	Policy reading	Flood	This report collects and reports all activities carried out by the Basin Authority as part of the basin plan preparation and the numerous initiatives launched since the flood of October 2000. It aims at defining strategic planning lines to be activated for the control and mitigation of the residual risk and in general to improve the safety conditions of the plains along the Po river.
Scenari di rischio residuale	Autorità di Bacino del fiume Po, 2012	Italy	Policy reading	Flood	The Po river and all its tributaries are continually dammed and the embankments are dimensioned and constructed to contain, with an adequate frank a 200 years return flood. The breaking/overflowing scenario of the Po river embankments constitutes a scenario of national catastrophe, which, due to its intensity and extent, must be faced with extraordinary participation of civil protection.
Assessing the physical vulnerability of check dams	Dell'Agnese et al.; Journal of Agricultural Engineering, 2013	Italy	Scientific reading	Flood	A comprehensive analysis of flood risk in mountain streams has to include an assessment of the vulnerability of the protection systems. Hence, the knowledge of how effectively control structures perform is essential for risk management. A procedure was developed to assess the physical vulnerability of check dams based on empirical evidence collected in South Tyrol, Northern Italy.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Levee breaches and uncertainty in flood risk mapping	Roberto Ranzi, Baldassare Bacchi, Stefano Barontini, Michele Ferri, Maurizio Mazzoleni; IAHR 2013	Italy	Scientific reading	Flood	The aim of this study is to implement a conceptual framework to consider, in a statistical sense, the residual risk related to possible levee failures in flood hazard mapping.
Risk Nexus - Central European floods 2013: a retrospective	Achim Dohmen, Oliver Gywat, Michael Szönyi; Zurich Insurance Company, 2013	Switzerland	Communication material	Flood	As part of Zurich's Flood Resilience Program, the Post Event Review Capability (PERC) provides research and independent reviews of large flood events. It seeks to answer questions related to aspects of flood resilience, flood risk management and catastrophe intervention. It looks at what has worked well (identifying good practice) and opportunities for further improvements. It has begun to consolidate the knowledge it has gained and to make this available to all those interested in progress on flood risk management.
Kombinierter Geschiebe- und Holzrückhalt am Fallbeispiel Engelberger Aa	Karin Anhorn, Lukas Schmocker, Volker Weibrecht; Wasser, Energie, Luft 104.Jg 2012	Switzerland	Policy reading	Torrential hazard	Description of a combined debris-wood retention with emergency spillway. The retention basin is designed for HQ300; in case of EHQ the emergency spillway will prevent the retention construction from failure.

Title:	Published by: author(s), institute(s), year of publication	Country:	Docu ment typolo gy	Natural hazard(s)	Short description:
Von der Risikoanalyse zur Maßnahmenplanung - Arbeitsgrundlage für Hochwasserschutzprojekte	BAFU, 2016	Switzerland	Policy reading	Flood	The publication aims to close the gap between strategic tools to cope with natural hazards and the actual determination of protection goals in a protection project. Based on experiences from 8 flood protection projects a process was developed to enable the risk-based determination of protection goals in flood protection projects under consideration of local framework conditions. The publication provides the central questions, which have to be answered for the determination of the desired protection goal. This ensures that the right questions are asked at the right time.
Was macht ein Hochwasserschutzprojekt erfolgreich? Eine Evaluation von Projektablauf und Risiko basierend auf den Perspektiven Schweizer Gemeinden	H. Suter, O. Martius, M. Keiler; INTERPRAEVENT 2016, Conference Proceedings 1, 2016	Switzerland	Policy reading	Flood	Evaluation of 71 flood control projects in Switzerland, through evaluation of technical reports, online survey and interviews. Flood protection measures were mostly initiated after flood events, a systematic coordination of risk mitigating measures could not always be observed. The flood protection measures reduce the risk in the short term, but long-term effects were not analysed. The building activities in the now "protected" areas increased by 30% (also due to the fact that these area were moved).
Alpine strategy for adaptation to climate change in the field of natural hazards	T. Probst, W. Wicki, A. Zischg, A. Pichler; PLANALP c/o BAFU	Switzerland	Policy reading	Multiple	With this document, PLANALP presents the Alpine strategy for adaptation to climate change in the field of natural hazards. Based on an overview of climate change in the Alpine region, its impacts on natural hazards and the consequences for risk management, this strategy defines a common vision for climate change adaptation and recommends adequate action options, which are illustrated by good practice examples from the Alpine countries.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Disasters and Emergencies in Switzerland 2015	FOCP, 2015	Switzerland	Policy reading	Multiple	The past shows that Switzerland is highly adapted at managing events at the local and regional level. Yet, the infrastructure density means that Switzerland has become increasingly vulnerable. The analysis of risks is a process that must be continually fine-tuned to keep pace with a changing risk landscape. For this reason, the FOCP has launched the National Risk Assessment. Intensive dialogue with all of the actors concerned will help to improve disaster risk assessments and, thus, Switzerland's security in general.
Integrated natural hazard risk management: recommendations	PLANALP, 2008	Switzerland	Policy reading	Multiple	The delegates of the Alpine countries participating in PLANALP focus on 4 of the most important problems of integrated natural hazard risk management, which they designated as "Hotspots". This document proposes recommendations that each concerned actor is able to extract useful information from, in order to improve the existing natural hazards management methods.
Integrated Risk Management On the River Engelberger Aa	Tiefbauamt Kanton Nidwalden; 2009	Switzerland	Policy reading	Flood	Safety from natural hazards is a basic need of humans and society. The way we deal with natural hazards and the associated risks has changed over the course of time. As a result of economic development and the increasing demand for land, the settlements spread extensively on the Nidwalden flood plain and, hence also, in the hazard areas. The risk reduction achieved by means of protective structures was counteracted by the rapidly increasing hazard potential created by the new settlements.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Living with natural hazards in Switzerland	BAFU, 2011	Switzerland	Policy reading	Multiple	This document concerns the approach adopted to natural hazards, in particular flood protection (floods, bank erosion, debris flows), avalanche protection, mass movements (fall, slide and flow processes) and earthquakes, in Switzerland. It does not cover the hazards arising from technological and industrial structures and plants or from accidents. However, given that major accidents can be triggered by the aforementioned natural hazards, it is important to note that interactions with these phenomena may arise.
Spatial planning and Natural Hazard	R. Camenzind-Wildi, R. Baumann, C. Guggisberg, R. Loat, I. Diethelm; 2006	Switzerland	Policy reading	Multiple	Natural hazards such as avalanches, floods, and mass movements in Switzerland should be recognized, recorded, and presented spatially by unified criteria. In order to minimize existing risks, hazard maps are being prepared, and their implementation with spatial planning tools represents the priority of the Swiss Government at present and in the near future. This aspect is central to the current recommendation. It pursues the goal of pointing out the potential and limitations of spatial planning tools and presents sensible applications from the Confederation's vantage point.
Termini tecnici nell'ambito dei pericoli naturali	PLANAT, 2012	Switzerland	Policy reading	Multiple	Document for municipal authorities, affected persons and those concerned. Based on: Glossary «Strategy against natural hazards Switzerland», Action Plan PLANAT, January 2009.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Risk management of natural hazards in Switzerland	Roberto Loat; BAFU, 2010;	Switzerland	Policy reading	Multiple	In Switzerland, considerable efforts have been made to mitigate the impacts from natural hazard. Absolute safety cannot be achieved, but great steps forward were made in the past few years on the road from conventional hazard protection to an integrated risk management. Residual risk, which has to be defined considering social, economic and ecological criteria, must thereby be accepted.
Überlastfall - Definition, Strategien und Konzepte	Gian Reto Bezzola, Roberto Loat, M. Buser; 2008	Switzerland	Scientific reading	Torrential hazard	The case of overload as an integrated part of risk assessment and design of flood protection. There is a trend towards robust protection structures, which still work during the case of overload and do not collapse because of it.
Neue Anforderungen an den Wasserbau	H.-E. Minor	Switzerland	Scientific reading	Flood	Flood protection not sufficient if design event is exceeded. Direct "object" protection needs to be supplemented by indirect protection like retention (space is needed!)
Zum Umgang mit dem Überlastfall bei Hochwasserschutzprojekten	Hans-Erwin Minor, ETH Zürich, 2004	Switzerland	Scientific reading	Flood	Flood protection needs to meet different demands: sociological (Population protection, economic development), environmental and economical. Multi-level protection concepts are to choose over single-level concepts, even better are multi-level protection concepts with resilient buildings. Flood relief measures are designed for HQ1000 (QD), with safety calculation for EHQ=1.5*QD. The case of overload can be mitigated with object protection and emergency concepts.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Avalanche detection systems: A state-of-the art overview on selected operational radar and infrasound systems	Walter Steinkogler, Lorenz Meier, Stian Langeland, Sam Wyssen; Lucerne - Switzerland, Interpraevent 2016	Switzerland	Scientific reading	Avalanche	The developments and advances of radar (LARA) and infrasound (IDA) avalanche detection systems and especially the integrated visualization (PIA) significantly improved the operational applicability and showed their capability to support the avalanche control work. In this work, results, benefits and limits from operational experience and recent developments of these systems are presented.
Crash tests for forward-looking flood control in the city of Zürich	M. Zappa, N. Andres, P. Kienzler, D. Näf-Huber, C. Marti, and M. Oplatka; Copernicus Publications on behalf of the International Association of Hydrological Sciences, 2015	Switzerland	Scientific reading	Flood	Floods in the city of Zürich (Switzerland) were already reported in the 13th century. The most severe threat are floods from the Sihl river with peaks exceeding 350m ³ s ⁻¹ . An assessment using a rainfall-runoff model has been completed to evaluate extreme flood situations. These scenarios identified deficits for the safety of Zürich. Crash-tests with 41472 combinations of measures and scenarios have been evaluated. The combination of measures can lead to an optimal safety also in case of unfavourable initial conditions. Anyway, pending questions remain, concerning the costs, political decisions and the environmental sustainability.
Hazard assessment of mass movements	H. Raetzo, O. Lateltin, D. Bollinger, J.P. Tripet; Bull Eng Geol Env, 2002	Switzerland	Scientific reading	Landslide, Rockfall	Natural hazard maps and the zoning of mass movements to restrict development on hazard-prone land. The paper discusses the proposed 3-step procedure of hazard identification, hazard assessment and risk management.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Landslide risk management in Switzerland	Olivier Lateltin, Christoph Haemmig, Hugo Raetzo, Christophe Bonnard; Landslides, 2005	Switzerland	Scientific reading	Landslide, Rockfall	In this paper, the present state of landslide hazard mapping in the 26 cantons, the transcription of hazard maps to local management plans and the corresponding rules are presented.
Review of legislation in the field of protection against landslides in Slovenia	Magda Čarman, Tina Peternel, Mitja Janža, Matjaž Mikoš, Jože Papež; Geological Survey of Slovenia, 2014	Slovenia	Policy reading	Landslide, Rockfall	This paper is a state-of-the-art review of the present status of the Slovenian national legislation and procedures for the hazard and risk assessment of landslides, rockfall and debris flows. Thanks to the EU Flood Directive, the procedures have already been regulated in the field of floods, but have still to be regulated in the field of other water related natural hazards and geo-hazards. In the last decade, several methodologies and different hazard maps have been prepared, but no legal acts (such as decrees, regulations, recommendations or similar acts, let alone standards) have been accepted on their basis.
Hazard Mapping based on the new guideline in Slovenia	Franci Steinman, Joze Papez, Daniel Kozelj	Slovenia	Scientific reading	Flood	Floods are severe, common and costly natural disasters and their magnitude and frequency are increasing presently. Efficient predicting of flood extents and their propagation is necessary to reduce flood damage. Based on flood propagation prognosis and previously calculated flood prone areas, for the river and tributaries' stretches early warning could be given, presented also as information to the public via internet map of predicted flood prone areas.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Warnen und informieren bei Hochwasser - Der Hochwassernachrichtendienst in Bayern	LfU, 2013	Germany	Communication material	Flood	Summarizes the information accessible through the homepage of the "Hochwassernachrichtendienst" (Flood news service), as well as other possibilities to get information on the local flood situation
Bayrisches Hochwasserschutz-Aktionsprogramm 2020plus	Andreas Rimböck; DWA Korrespondenz Wasserwirtschaft, 2015	Germany	Policy reading	Flood	Case of overload needs to be taken into account when planning flood protection. Resilience of protection structures must be enhanced. Systemic safety and constructional safety should be considered. Retention spaces as possibility to deal with case of overload. DIN 19712 "Hochwasserschutzanlagen an Fließgewässern": Residual risk must be taken into account when planning flood protection
Was bringt die neue DIN 19700 für die Sicherheitsbewertung von Stauanlagen	Hans-Ulrich Sieber; 2005	Germany	Policy reading	Flood	New regulations require extending risk assessment and protection planning to residual risks, which remain beyond the calculated risk (design event). The regulations focus on the unpredictable stress caused by extreme events.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
A Primer on Flood Protection: protecting property and building wisely	BMUB, 2016	Germany	Policy reading	Flood	This manual on flood protection offers building and homeowners valuable information in these areas. In addition, it might serve as a valuable planning aid for architects and engineers, who develop protection concepts in connection with building planning. Consequently, it might support efforts to prevent major damage and unnecessary financial burdens. Besides, this document on flood protection might help raise awareness of the need for effective precautions even in areas that have had no experience with floods to date.
Guide for Emergency Preparedness and Correct Action in Emergency Situation	Klaus Brouwers; Federal Office of Civil Protection and Disaster Assistance, 2017	Germany	Policy reading	Flood	Once an emergency has occurred, it is generally too late for precautionary measures. In this brochure, tips on how to prepare for emergencies and how to behave correctly in an emergency are reported. Here, you will find information on all the important topics – from the stockpiling of food supplies to the emergency pack.
Water Resource Management in Germany	BMUB, 2013	Germany	Policy reading	Flood	The precautionary protection of waters as a component of the natural balance and guaranteeing public water supply and public wastewater disposal are 2 central tasks for the federal, regional and local German authorities when drafting their environmental policies. For these reasons, flooding, and more generally all natural hazards, need to be managed and coordinated with several activities related to regional development and public service systems.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Grenzen des Hochwasserschutzes - Umgang mit dem Überlastfall	Andreas Rimböck, Christoph Oberacker; DWA Landesverband BY, Landesverbandtagung Straubing 2015	Germany	Scientific reading	Flood	Perfect protection is neither possible nor reasonable (in terms of cost-benefit). Extreme events must be considered when dimensioning protection measures. 2 aspects of residual risk must be considered: hazard (might increase due to climatic changes) and vulnerability (damage potential increases as flood protection measures suggest safety, leading to intensified use of "protected" areas). With increasing hazard and vulnerability, residual risk increases.
Jeder Hochwasserschutz hat Grenzen - Umgang mit dem Überlastfall	Andreas Rimböck, Christoph Oberacker, Tobias Hafner; Die Flussmeister, 2016	Germany	Scientific reading	Flood	Perfect protection is not possible. Residual risk must be taken into account even though the probability of an extreme event is very small. Problem of increasing residual risk due to intensified use of "protected" areas. Need for resilient protection systems in order to make case of overload manageable. If residual risk is met with a strategy, damages can be reduced and reaction time for personal and object protection can be increased. Within resilient protection system, structures are necessary: e.g. allow overflowing to areas with low damage potential.
Flexible und gutmütige Schutzkonzepte und -bauwerke	Christoph Bornstein; TU München, 2010	Germany	Scientific reading	Flood	Different concepts for case of overload: retention basins will divert peak discharge of flood event. Relief corridors will divert and redirect water that exceeds the river's capacity to other water bodies with sufficient capacity. Channel widening to enlarge channel capacity. All these concepts need sufficient space.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Effect of river training on flood retention of the Bavarian Danube	Daniel Skublics, Günter Blöschl, Peter Rutschmann;	Germany	Scientific reading	Flood	The Bavarian Danube River has experienced numerous large flood events in recent years. The propagation of flood waves along the river is heavily influenced by controlled and natural flood retention. Over the past centuries, natural flood retention areas were lost due to modifications of the hydraulic characteristics of the channel-flood plain system. The purpose of this paper is to understand the effect of river training on the flood retention characteristics along the Bavarian Danube.
Flood-risk mapping_contributions towards an enhanced assessment of extreme events and associated risks	B. Büchele, H. Kreibich, A. Kron, A. Thieken, J. Ihringer, P. Oberle, B. Merz, and F. Nestmann; 2006	Germany	Scientific reading	Flood	Currently, a shift from classical flood protection as engineering task towards integrated flood risk management concepts can be observed. In this context, a more consequent consideration of extreme events, which exceed the design event of flood protection structures have to be investigated. This study aims to enhance existing risk assessment methods for extreme events.
Indicator based strategy to adapt urban drainage systems in regard to the consequences caused by climate change	M. Siekmann, J. Pinnekamp; 2011	Germany	Scientific reading	Flood	The presented approach is an assessment of problems arising in highly industrialized regions due to global warming, increasing storm water intensities, demographic changes and migration. In the future the runoff following extreme rainfall events cannot be drained in the existing centralized sewage system. In order to evaluate the requirement of adaptation of drainage systems an indicator-based assessment system is being developed.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Planning of Technical Flood Retention Measures in Large River Basins under consideration of imprecise probabilities of multivariate hydrological loads	D. Nijssen, A. Schumann, M. Pahlow, B. Klein; Natural Hazards and Earth System Sciences, 2009	Germany	Scientific reading	Flood	Because of the severe floods in Europe at the turn of the millennium, the ongoing shift from safety oriented flood control towards flood risk management was accelerated. With regard to technical flood control measures it became evident that the effectiveness of flood control measures depends on many factors. Considering these aspects a flood control system should be evaluated with a broad range of hydrological loads to get a realistic assessment of its performance under different conditions.
La démarche française de prévention des risques majeurs	Ministère de l'Écologie, du Développement durable, des Transports et du Logement; Direction de la Prévention des risques, 2011	France	Policy reading	Multiple	Risk events are causing more and more victims around the world. French policy of management of major risks has the goals of reducing vulnerability of people and goods. Consideration of risks is necessary at all stages and levels of organisation.
Une nouvelle méthode d'identification des sites à haut risque d'avalanche	Rapin, F., Meunier, M., Bolognesi, R.; Ingénieries n°39, 2004	France	Scientific reading	Avalanche	A new classification method was developed in order to select 100 to 200 French sites from a wide sample of about 3000 avalanche sites. The advantage of this method is its fast utilization. The disadvantage is that one cannot take into account all particularities of the sites.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Evolution du regime d'indemnisation des catastrophes naturelles	Erhard-Cassegrain, A., Masse, E., Momal, P.; Ministère de l'écologie et du développement durable, Série Synthèse n°04-S06, 2006	France	Scientific reading	Multiple	Natural disaster insurance in France is mainly based on the compensation fund. In this context, the role of insurers is mainly limited to collecting these premiums and compensating for damage. The State intervenes twice: as a player in the management and as guarantor of reinsurance. Urban pressure in flood-prone areas as well as the growth of the amount of the insured property constitute structural elements calling into question the viability financial system. The reflection allows to put into perspective this questioning and to propose 3 ways of evolving the compensation regime: - the introduction of risk-based premium modulation; - remuneration for prevention from third parties not subject to risk; - improving the prevention of natural disasters through the establishment of a Risk manager: the public insurer.
Risque d'inondation: une notion probabiliste complexe pour le citoyen	Gendreau, N., Grelot, F., Garcon, R., Duband, D.; Ingénieries - E A T, IRSTEA edition 2003	France	Scientific reading	Flood	Floods and inundations are hazardous phenomena that require difficult decisions. The stochastic description of the river behaviour is difficult to explain, even sometimes for experts. At the end, people usually misunderstand the flood risk notions. Meanwhile, clear messages are necessary due to social and economic stakes. We try to identify some obstacles to objective flood risk perception and we propose some ways to build a representation of hazardous phenomena. We propose a formalisation through the image of coloured balls, function of floods probabilities.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
Flood Risk Management Plan for the Danube River Basin District	Karoly Gombás, Péter Bákonyi, Sándor Tóth; International Commission for the Protection of the Danube River, 2015	Alpine	Policy reading	Flood	Through the centuries the Danube countries suffered from many disastrous flood events. In recent years the major floods occurred in 2002, 2006, 2010, 2013 and 2014 resulting in casualties and damages to economic activities amounting to billions €. In this paper, flood management strategies (structural and non structural measures both for existing flood risk reduction and new risk avoidance) implemented by different countries in the Danube River are shown. A more detailed level of information is presented in the national Flood Risk Management Plans.
Floods in June 2013 in the Danube River Basin_Brief overview of key events and lessons learned	Igor Liska, Zoran Major; ICPDR – International Commission for the Protection of the Danube River, 2014	Alpine	Policy reading	Flood	In this paper, a comparison between the 2013 flood happened on the upper and lower Danube and the one happened in 2002 has been made. In particular, aim of the document is showing how countries reacted to past flooding events in terms of structural and non - structural measures.
Multilingual Glossary on Geomorphological Processes and Definition of Minimal Standards for Hazard Map	B. Lochner; alpS – Centre for Natural Hazard and Risk Management, 2011	Alpine	Policy reading	Multiple	In order to tackle that complexity and ambiguity, found not only in the German speaking geology, but generally throughout Europe, a multilingual glossary was created. This glossary aims at an international harmonization by providing the user with a selection of official terms used by the geological agency in a specific country and by setting relations to similar terms employed in other countries.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
AdaptAlp AP6: Risikomanagement an Alpinen Wildbächen und Flüssen	Elisabeth Streitel, Thomas Probst; Alpenforschungsins- titut GmbH, 2009	Alpine	Scientific reading	Torrential hazard	Strategies of risk management need to be refined. The committee proposes suggestions for future risk management, in order to meet climate change related challenges. Effect of climate change has to be considered with scenarios when planning protection measures. Protection measures in high risk areas must be legally compulsory. The Aosta valley is missing social consensus and political strategy to manage residual risk. In general call for insurance companies to cover residual risk
Adaptation de la gestion des risques naturels face au changement climatique	Carine Peisser, Benjamin Einhorn; PARN, 2011	Alpine	Scientific reading	Multiple	Climate change is now an accepted reality and the Alps are among the most sensitive regions of Europe in terms of temperature rise (measured and modelled), but they are also part of the regions where the modelling of the evolution of precipitation is the most difficult. This ongoing change questions different sectors of society in the short, medium or long term. Natural hazards are often mentioned in terms of a worsening of their impact, particularly among the general public due to extreme weather events, although statistical analysis of these rare phenomena is not easy and it cannot be directly related to climate change.
Richtlinie 2007/60/EG über die Bewertung und das Management von Hochwasserrisiken	Eu Parlament, EU Rat	EU	Legal document	Flood	European legal guideline for the assessment and management of flood risk. It states in Cap.III, Art.6 3a that flood risk maps must include scenarios of improbable occurrence and extreme events.

Title:	Published by: author(s), institute(s), year of publication	Country:	Document typology	Natural hazard(s)	Short description:
SUFRI Methodology for pluvial and river flooding risk assessment in urban areas to inform decision-making	Ignacio Escuder Bueno, Adrian Morales Torres, Jesica Tamara Castillo Rodriguez, Sara Perales Momparler; 2011	EU	Scientific reading	Flood	Flood analyses have shown that structural measures of flood protection are limited applicable, especially in urban areas, and that absolute protection is not feasible. The project Sufri aspires an improvement of flood risk management in case of extreme flooding disaster especially in respect of non - structural measures.
Planung und Umsetzung einer Kommunikations- und Beteiligungsstrategie im Hochwasserrisikomanagement	M. Fleischhauer, K. Firus, S. Greiving, P. Grifoni, T. Stickler; IMRA, 2011	EU	Policy reading	Flood	The guideline describes a 12-point approach for the communication and participation process in flood risk management.
L'approche hydrogéomorphologique pour la cartographie des zones à risque d'inondation dans les vallées de petites et moyennes tailles.	Lelièvre, M.A., Buffin-Bélanger, T., Morneau, F.; Géorisques	Canada	Scientific reading	Torrential hazard	This paper aims at underlying the importance of a better understanding of the fluvial dynamics of small streams for the determination of flood risk zones. The hydrogeomorphological method is based on the principle that the outer limits of a stream's flood plain represent the outer envelope of past floods. Inside the boundary of the modern flood plain, the intrinsic limits of frequent, rare and exceptional flood envelopes are determined by the use of aerial photographs and field surveys.

Annex 2: Questionnaire

Dealing with the case of overload in the Alps

Goals and expected results of the survey

This survey is part of a study 'Risk governance in the case of overload: status quo and possible ways for improvement in the EUSALP region'. It is carried out within the context of the implementation of the EU Strategy for the Alpine Region (EUSALP) and it is financed by means of the Interreg Alpine Space project AlpGov. The study will result in an overview of the different ways to manage residual risk, it will provide good practice examples and it will develop some recommendations for future changes.

The goal of this survey is to collect basic information about risk governance in the case of overload in the EUSALP region. It is addressed to experts, spatial planners, public administrators and other relevant actors in the field of natural hazard related risks. It covers definitions, technical specifications and various approaches to deal with cases of overload.

The structure of the survey

The following survey consists of 7 parts:

1. collection of general data about the interviewed person,
2. protection goals set in the region,
3. defining the case of overload and residual risk,
4. risk governance procedures in the region,
5. collecting data about the status quo of the approaches to risk management,
6. recommendations for the improvement of the status quo and finally,
7. good practice example collection.

It takes from 45 to 60 minutes to complete the questionnaire. The questionnaire can be saved as draft and completed in more stages. There is also the possibility to leave questions unanswered if your expertise does not cover this area. Please feel free to contact us in case of any questions. Please feel free to contact us in case of any questions.

About Privacy and data processing

Eurac Research, Bolzano/Italy, takes full responsibility for the protection of data collected. The data will be processed with the highest level of confidentiality and anonymity, under legal norms of the statistical secret, and in respect of the norms of privacy.

Contact persons

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Thank you for taking part in our study.

Definitions

Please take in consideration the following definitions while completing the survey.

Residual risk: the part of natural hazard risk, which remains after realizing the protection measures based on a protection goal/design event.

Protection goal: defined through the border between acceptable risk/hazard and non-acceptable risk/hazard specified in the design event.

Case of overload: natural hazard events, which exceed the design event with the potential to cause damage to people and goods, even though protection is realized.

Structural measure: any physical construction to reduce or avoid possible impacts of hazards, or the application of engineering techniques or technology to achieve hazard resistance and resilience in structures or systems (UNISDR).

Non – Structural measure: Non-structural measures are measures not involving physical construction which use knowledge, practice or agreement to reduce disaster risks and impacts, in particular through policies and laws, public awareness raising, training and education (UNISDR).

Risk governance: the institutions, rules conventions, processes and mechanisms by which decisions about risks are taken and implemented. Risk governance goes beyond traditional risk analysis to include the involvement and participation of various stakeholders as well as considerations of the broader legal, political, economic and social contexts in which a risk is evaluated and managed. It thus pertains to the complex whole of what traditionally has been called -and treated as separate activities- "risk assessment", "risk management" and "risk communication". (RENN 2008; RENN and SELLKE, 2011)"

Risk management: Risk management is the identification, assessment, and prioritization of risks followed by coordinated and economical application of resources to minimize, monitor, and control the probability and/or impact of unfortunate events (HUBBARD and DOUGLAS, 2009)

1 General information about the interviewed person

1) Please indicate if you are referring to the national, regional or local level when completing the survey (in the following you should provide all your answers with reference to this level)

- ☐ National
- ☐ Regional
- ☐ Local

2) Please indicate which country

(countries) _____

3) Please indicate which region

(regions) _____

4) Age

5) What is your highest level of education?

- ☐ Postgraduate
- ☐ Graduate
- ☐ High school diploma
- ☐ Other (please specify _____)

6) Which field of education did you specialize in?

- ☐ Engineering
- ☐ Spatial planning or Architecture
- ☐ Economics
- ☐ Social and political sciences
- ☐ Natural sciences (e.g. forestry, hydrology)
- ☐ Geography
- ☐ Law
- ☐ Other _____

7) Which type of institution are you working for?

- ☐ National department (public administration)
- ☐ Regional department (public administration)
- ☐ Municipality department (public administration)
- ☐ International organisation (NGO) or interest group
- ☐ Research institute
- ☐ Private enterprise
- ☐ Other _____

8) At which administrative level are you dealing with risk governance?

- ☐ Local (e.g. municipality)
- ☐ Regional (e.g. country, province, region, canton, department)
- ☐ Interregional / sub-national (e.g. river basin authority)
- ☐ National

- ☐ Transnational (e.g. Euregio)
- ☐ European
- ☐ Other _____

9) Please specify your exact position or function

10) Please indicate your field of expertise in natural processes or emergency management

- ☐ river flood
- ☐ torrential hazard
- ☐ avalanches
- ☐ rockfall, landslide
- ☐ emergency response
- ☐ other _____

11) How many years of working experience do you have in the field of natural hazard / risk?

- ☐ 0-2 years
- ☐ 3-5 years
- ☐ 6-10 years
- ☐ more than 10 years

12) Please shortly describe your experience in risk management, and particularly in dealing with the case of overload and residual risk for natural hazard

2. Protection goal in the region

13) Please indicate which protection goal(s) is (are) used for the different natural processes and indicate if it is risk or hazard based.

	Please specify the protection goal(s)	Risk	Hazard	N/A*
a. River flood	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Torrential hazard	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Avalanches	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Rockfall, landslide	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Other	_____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

risk based: e.g. means annual vulnerability/ damage potential

hazard based: e.g. annuality (100 years, 30 years); annuality

14) Are there different protection goals for the following land use types?

	Yes	No	Not Known	If yes, please specify the reference (legislation number, plan, document)
a. Built-up areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
b. Residential	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
c. Industrial / Commercial areas	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
d. Public buildings (e.g. schools, council building)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
e. Transport network	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
f. Critical supply infrastructure (e.g. electric power station)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
g. Agriculture	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
h. Forest	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____
i. Other	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____

15) Can protection goals be adjusted (e.g. based on scenarios of changing climate or demographic conditions or settlement expansion)?

☐ Yes ☐ No ☐ Not known

If yes, please indicate how this is regulated

3. Definition of residual risk and case of overload

16) Do definitions for the following terms exist in your region / country?

	Yes	No	Not known	If yes, please give the formal definition and reference document	or indicate informal definition and reference document
a. Residual risk	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____ _____	_____ _____
b. Case of overload	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	_____ _____	_____ _____

Would you consider the following events as a case of overload?

17) "Discharge case of overload": Real event is bigger than the design event:

	Yes	No	Not Known
a. Higher peak, overflowing the protection measures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Higher volume, depleted retention space	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

18) Water level is higher than the design water level

a. Silting up/sedimentation	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Other external influences that reduce the stability such as storm damages or damage caused by burrowing animal	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Increased roughness (vegetation, flow obstructions, lack of river maintenance)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

19) Technical failure/ incidence / accident: protection measures do not fulfill the degree of protection: "technical case of overload":

	Yes	No	Not known	N/A
i. Structural measures lose their performance (material properties, construction errors, aging of structures or lack of structural maintenance)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
k. Incorrect estimation of magnitude of event (due to insufficient data, calculation errors ...)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
l. Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

20) Other case

	Yes	No	Not known	N/A
a. Incorrect statistics / changed basis of assessment (e.g. due to climate change or land use change). The design event is not a design event anymore	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

21) Please rate the severity of the following potential problems arising when a case of overload occurs:

	0	1	2	3	4
a. Insufficient awareness (everybody felt safe)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Some areas were hit unexpectedly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Unexpected extent of losses	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Unexpected processes (e.g. blockage, triggering other natural processes)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. People reacting unexpectedly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Reaction of media and politics	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. Gaps in regulations	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. Overburdening of public finances or disaster relief mechanisms (e.g. due to compensation and reconstruction payments)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
i. Insufficient preparedness	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
j. Potential failure of critical infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
k. Unexpected extent of losses	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. Other, please specify _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Rating: 0 = not severe at all, 4= very severe

22) Please rate the importance of maintaining the basic functionalities of the following types of infrastructure or facilities in the case of overload:

	0	1	2	3	4
a. Power supply / water supply / telecommunication systems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Motorways, intercity railway lines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Major roads, regional railway lines	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. District and local roads	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Hospitals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Fire brigades	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. Retirement homes	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. Facilities for children (kindergarten, school)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
i. Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Rating: 0 = not important at all, 4 = very important

4. Status quo of risk governance for residual risk

23) Which public administration departments are involved in risk governance for each natural hazard? (several answers are possible)

	Technical departments	Civil Protection	Spatial Planning	Other department
River flood	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Torrential hazard	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Avalanches	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Rockfall, landslide	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
Other risk _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

24) Is there a special task force or working group in your region / country, that deals with issues of residual risk management?

- ☐ Yes ☐ No ☐ Not known

25) Which actors are involved in the process of policy making related to risk governance?

- | | |
|---|--|
| <input type="checkbox"/> Public administration – municipality level | <input type="checkbox"/> Public administration – regional level |
| <input type="checkbox"/> Professional associations | <input type="checkbox"/> Public administration – national level |
| <input type="checkbox"/> NGOs | <input type="checkbox"/> Non-professional associations / federations |
| <input type="checkbox"/> Others _____ | <input type="checkbox"/> Public / civil society |

26) Is the involvement of these actors mandatory in the process of policy making related to risk governance?

- ☐ Yes ☐ No ☐ Not known

27) If yes, which have to be mandatorily involved?

- | | |
|---|--|
| <input type="checkbox"/> Public administration – municipality level | <input type="checkbox"/> Public administration – regional level |
| <input type="checkbox"/> Professional associations | <input type="checkbox"/> Public administration – national level |
| <input type="checkbox"/> NGOs | <input type="checkbox"/> Non-professional associations / federations |
| <input type="checkbox"/> Others _____ | <input type="checkbox"/> Public / civil society |

28) How are the actors involved in the process of risk governance?

- | | |
|--|--|
| <input type="checkbox"/> Online consultation | <input type="checkbox"/> Referendum or public consultation |
| <input type="checkbox"/> Focus groups | <input type="checkbox"/> Public debates |
| <input type="checkbox"/> Other, please specify _____ | |

29) What responsibility (e.g. tasks) does each administrative level entail in the different phases of risk management?

	Planning	Implementing protection measures	Case of emergency
Municipality	_____	_____	_____
Regional/provincial level	_____	_____	_____
National institutions	_____	_____	_____

5. Status quo of approaches of risk management

a. Prevention

30) Is there any information (e.g. maps), which describes or delineates hazard zones or zones of different exposure to hazardous events in your country / region?

☐ Yes ☐ No ☐ Not known

31) If yes, does this information include areas, which are protected from the impact of natural hazards by means of protection structures?

☐ Yes ☐ No ☐ Not known

32) Is there any information in your region / country (e.g. maps) on areas potentially affected by cases of overload?

☐ Yes ☐ No ☐ Not known If yes, please indicate which type of information

33) Is there any information on the amount of potential damage?

☐ Yes ☐ No ☐ Not known

34) If hazard maps exist, are they integrated in spatial plans, and at which scale?

- ☐ Local – municipal level, map scale _____
- ☐ Regional (e.g. country, province, region, canton, department), map scale _____
- ☐ Interregional (e.g. river basin), map scale _____
- ☐ Transnational (e.g. Euregio), map scale _____
- ☐ Other level _____
- ☐ Maps are not integrated in spatial plans

35) Is expropriation possible?

☐ Yes ☐ No ☐ Not known

If yes, how is this regulated? (technical rule, building codes, law, strategy)

36) Are there any communication strategies and/or concrete activities to communicate residual risk to local decision makers and the affected population?

☐ Yes ☐ No ☐ Not known

37) If yes, the population is

- ☐ informed through mass media
- ☐ informed through official media channels (e.g. public booklets, guidelines of behavior in the case of overload, flyers)
- ☐ provided with specific information for highly vulnerable groups (e.g. children, old people, people living alone, disabled people)
- ☐ involved in discussion and informative events
- ☐ involved in training and workshops
- ☐ Other _____

38) Are such communication strategies/activities mandatory?

☐ Yes ☐ No ☐ Not known

39) Are there any measures concerning personal provision (e.g. initiatives, advisory services, awareness-raising measures) for the case of overload?

☐ Yes ☐ No ☐ Not known

If yes, please indicate which measures

b. Preparedness and response

40) Are there any alerting or warning systems in place, which are particularly designed for the case of overload?

☐ Yes ☐ No ☐ Not known

If yes, which systems are used?

41) Are there emergency plans for the case of overload?

☐ Yes ☐ No ☐ Not known

If yes, which emergency plans are used?

42) Which tools are used for communication in case of emergency?

- | | |
|--|--|
| <input type="checkbox"/> Internet | <input type="checkbox"/> Newspaper |
| <input type="checkbox"/> Local TV | <input type="checkbox"/> Special technologies (Apps, megaphones,...) |
| <input type="checkbox"/> Social networks | <input type="checkbox"/> Other _____ |

43) Are there any special communication strategies for the most vulnerable people (e.g. children, old people, people living alone, disabled people)

☐ Yes ☐ No ☐ Not known If yes, please name the strategy

c. Recovery

44) Are there any legal regulations that allow for compensation for the damage caused in the case of overload?

- ☐ A full compensation is foreseen for damage
☐ A partial compensation is foreseen: ____ %
☐ No compensation is foreseen, a damage compensation is only possible through commercial/voluntary insurance

45) Is there any compulsory insurance for citizens which also covers cases of overload?

☐ Yes ☐ No ☐ Not known If yes, please indicate which type of insurance

d. Mitigation

46) In general, what structures or measures are in place in your country/region to reduce the potential negative impacts of the case of overload?

	Please indicate which measures (e.g. providing space for emergency relief, chambering, second dike lines, spillways, relief segments)	Please indicate legal requirements	Not known	No structures/measures exist
River flood	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>
Torrential hazards	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>
Avalanches	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>
Rockfall, landslide	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>
Other _____	_____	_____	<input type="checkbox"/>	<input type="checkbox"/>

47) In your opinion, are there any missing structures?

☐ Yes ☐ No ☐ Not known If yes, can you name which?

e. Consideration of Climate Change

48) In your region / country, has climate change been considered when the design events were calculated, which are currently in use?

☐ Yes ☐ No ☐ Not known

49) In your country/region, do the existing (spatial) plans consider the influence of climate change on natural hazards?

☐ Yes ☐ No ☐ Not known

50) If yes, in what procedural step(s) are these changes assessed or considered? (several answers are possible)

- ☐ In the calculation for hazard zone planning
- ☐ In the definition of design events for protective measures (e.g. climate change supplement, safety margin...)
- ☐ In the definition of protection goals
- ☐ Additional strengthening of protective measures
- ☐ Through improved statistical evaluation of previous observations
- ☐ By increasing the frequency of verification and updating of hazard zone maps
- ☐ Other, please specify : _____

51) Is it foreseen that possible future change of climate conditions lead to adjustments of the adopted protection goals?

☐ Yes ☐ No ☐ Not known If yes, can you name a relevant document?

Personal considerations and recommendations

In this part we would like to gather your opinion about different options in the process of risk management and risk governance. Please base your answer on your personal opinions and your experience in dealing with hazardous events particularly in cases of overload

How do you rate the importance of the following principles for dealing with the case of overload in each stage of risk management?

	0	1	2	3	4
1. Prevention	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Spatial planning in general	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Spatial planning especially for critical infrastructure	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Building protection: individual object-related protection measures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Personal provision: individual behavioural precautions (e.g. alarm plan on household level, escape plan on building level, etc.)	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	0	1	2	3	4
2. Protection	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Adequate technical measures	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Adequate protection goals	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Awareness building events	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. More intensive monitoring, better maintenance, regular repair	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Prioritization of measures according to different risk levels	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Other _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
	0	1	2	3	4
3. Preparedness and response	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
a. Civil protection, operational planning, evacuation plan	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Early warning systems	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Information	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Insurance	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

- e. Evacuation and shelters ☐ ☐ ☐ ☐ ☐
- f. Other _____ ☐ ☐ ☐ ☐ ☐

Rating: 0 = not important at all, 4 = very important

52) Please indicate the degree of agreement of the following possibilities¹ to address risk management / governance in the case of overload and residual risk in your region (tick the corresponding box). Add any recommendation missing in your opinion at the end.

	0	1	2	3	4
a. reducing the negative consequences in cases of overload by controlling land use and construction activities .	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
b. Greater prioritization of non-structural measures (in contrast to structural measures).	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
c. Ease the access to data and information about cases of overload and residual risk e.g. by means of open GEO data bases.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
d. Collecting and analyzing of historic and current events (particularly in the case of overload) in a preferably standardized form.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
e. Definition of harmonized measuring units and standardized levels of security with respect to cases of overload and residual risk.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
f. Improved communication of residual risks and the potential cases of overload as well as awareness-raising measures.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
g. Development of cross-sectoral protection concepts for the coordination of planning, technical, organisational, and other measures.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
h. No further development of areas with high residual risk and high potential for cases of overload.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
i. Safeguarding of natural areas with protective function.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
j. Development of land use regulations that consider scenarios of cases of overload.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
k. involvement of the different technical fields and actors with their varying views and approaches in an inter-sectoral and inter-disciplinary coordination process.	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
l. Other recommendations _____	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

¹ Based on recommendation developed in the Alpine Space project – START_it_up - State of the art in risk management technology, 2014.

Collection of good practices

53) Do you have good practice examples for dealing with the case of overload?

For each good practice, please indicate:

- a. Name of the good practice
- b. Nature of the good practice: technical, social, governance related, juridical, communication related
- c. Where it is located (municipality, region, country)
- d. Contact person, website
- e. Why you consider this a good practice

Contacts

54) We would be pleased if you could leave here your name and email address and allow us to contact you for follow up questions

- a. First name
- b. Last name
- c. Email address

We would like to thank you for your precious contribution to our research

Annex 3: Example of Interview guideline

Risk Governance in the Case of Overload and Residual Risk: Status Quo and Possible Improvements in the EUSALP region - Guidelines for expert interviews

Overview

The in-depth expert interviews are to be understood as surveys, which allow a specific and thorough processing of individual questions. They aim at providing clarification in the case of missing or misleading information collected so far and further collecting information about cross-cutting topics, or topics that are too articulated to be asked in the questionnaire. For this purpose, a semi-standardized interview guide will be prepared.

Before formulating the interview structure, a database was created to give an overview of all existing and missing information in each of the Alpine regions. The database presents an overview of all data retrieved from the literature review and the questionnaire. It allows the identification of missing information and has helped to identify interview partners. Basing on this database, the following questions have been formulated.

This guide aims to structure the conversation process through pre-formulated questions and keywords. On the other hand, it allows to flexibly follow the conversation during the sequence of questions and topics. 2 types of interviews are designed: 1 to retrieve data from regions where no data was collected through questionnaire and/or literature review, 1 to further deepen knowledge on the data collected. In this way, the interviews will be used in a targeted way to obtain missing information or to check existing data if necessary.

Conduction of interviews

The number of interviews to be conducted and the selection of interview partners is based on the results obtained from the literature review and the survey. It is assumed that a maximum of 20 interviews are conducted, giving priority to the countries and regions where no data was obtained in the previous phases. The interview partners are selected in close consultation with the client, whereby a geographical and balanced distribution should be sought. The interviews will be made by telephone, via Skype or, if possible, personally. Each interview will be recorded. The interviews could take place in the respective alpine language (except for Slovenia), or in English to ease comparability of answers.

Evaluation of interviews:

Each interview will be transcribed and entered into the existing database. The evaluation of interviews will contribute to fill existing gaps in knowledge and open questions from the literature review and the questionnaire. In addition, each interview will be analyzed specifically for possible 'good practice' examples and aspects, which will contribute to the formulation of final recommendations.

General rules for conducting interviews:

- Always remind interviewee to refer to their region / country
- Always aim to collect recommendations and good practices
- Always emphasize the focus on overload / residual risk

Format of the semi-structured interview:

Introduction

<5 min Introduction by Eurac – based on a sheet with basic information about the project and the objectives of this interview, length (time) and aspects of privacy

--- start recording ---

1. Personal Questions:

1.1 What is the connection of your daily work with the topic of residual risk governance and case of overload management related to natural hazards?

1.2 How many years of experience do you have in the field of natural hazards and related risks?

1.3 Which hazards are you most acquainted to?

1.4 (Optional): What is the hazard that is most likely to cause damage (always referring to settlements) in your region?

2. Questions: (only asked to interview partners from regions where no information exist yet → according to matrix)

2.1 Do definitions for the term residual risk exist in your region?

2.1.1 Where can be found the definition?

2.1.2 How is the term residual risk applied in your region (legislation, spatial planning)?

2.2 Do definitions for the term case of overload exist in your region?

2.2.1 Where can be found the definition?

2.2.2 How is the term case of overload applied in your region (legislation, spatial planning)?

2.3 Do you know of existing protection goals in your region for the following types of hazards:

2.3.1 River floods

2.3.2 Torrential hazards

2.3.3 Avalanches

2.3.4 Rockfall/landslides

2.4 Are there different protection goals in your region for different land use types?

2.5 Are these protection goals hazard based or risk based? (We need to be able to explain what this means!)

2.6 Is climate change considered in the context of residual risk and the case of overload in your region?

3. Risk governance Questions:

3.1 Responsibilities during different phases of risk governance in your region:

3.1.1 Who is responsible for planning?

3.1.2 Who is responsible for implementing measures?

3.1.3 Who is responsible for emergency response?

3.1.4 Who is responsible for communication?

3.2 How is the work distributed between different administrative levels (regional with municipal, regional with national)? (e.g. exchange of information, support etc...)

3.3 Which actors are involved in risk governance in your region? (e.g. public authority departments, civil society, private sector?)

3.4 How does the cooperation between actors work? What is your opinion about what works well, what does not work and why?

3.5 How would you describe the level of awareness amongst the society concerning residual risk and the case of overload?

3.6 How is the risk culture / risk awareness in your region considering the restrictions of new constructions in hazardous (red) zones?

3.7 Are communication strategies implemented mostly before, during or after an event? What is your opinion about existing strategies? (tools / vulnerable people / warning systems)

4. Risk Management Questions (with a focus on traffic, spatial planning & tourism):

4.1 How are residual risk and the case of overload considered in spatial planning, traffic (transport routes), and tourism?

4.2 Are residual risk and the case of overload considered in any maps in your region?

4.3 Is there a process to monitor the quality of your structural measures in your region?

4.4 How is the potential influence of climate change taken into consideration in your region (protection measures / spatial planning / tourism / traffic)?

4.5 Are there any legal regulations or insurance schemes that allow for compensation for the damage caused in the case of overload?

4.6 Do plans for recovery exist in your region? Are there priorities to bring certain services back into function?

4.7 Are there any lessons learnt (procedures) available in your region with respect to recovery? What could be improved ? What is already working well?

5. Further Recommendations

5.1 Do you have any further recommendations?

5.2 Do you have any additional good practices from your region?

--- end recording ---

Annex 4: Complete list of recommendations gathered throughout the study

Recommendations from online questionnaire

A part of the questionnaire was dedicated to a structured collection of personal considerations and recommendations: experts were asked first to rate the importance of principles about risk management and then in a second question to state their agreement to recommendations for improvements of residual risk governance.

According to the results of question 52 of the online questionnaire, spatial planning both in general and especially for critical infrastructure is rated to be very important by the majority of experts in all 6 countries in order to prevent the case of overload. The building protection and personal provision of protection measures, are also rated to be important but do not show a distribution as homogeneous as seen in the answers to the first 2 principles. Awareness building events are considered to be most important followed by adequate technical measures more intensive monitoring, better maintenance, regular repair, adequate protection goals and prioritization of measures according to different risk levels. Highest rates were given to availability of prepared civil protection, operational planning and evacuation plans followed by adequate early warning systems, adequate information, evacuation and shelters as well as insurance against damages.

Table 2: Importance of prevention principles provided by experts using a scale from 0 (not important at all) to 4 (very important) (Source: Authors).

1. Spatial planning in general		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	0	2
Level of importance	1	0	0	0	0	0	0	0
Mean value: 3.3	2	1	0	1	1	0	0	3
	3	4	2	1	1	2	0	10
	4	7	7	3	3	3	1	24
Total		15	10	6	5	5	1	42
2. Spatial planning especially for critical infrastructure		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	0	2
Level of importance	1	0	0	0	0	0	1	1
Mean value: 3.2	2	0	1	0	0	0	0	1
	3	6	1	1	0	0	0	8
	4	6	7	4	5	5	0	27
Total		15	10	6	5	5	1	42

3. Building protection: individual object- related protection measures		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.4	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	0	2
	1	1	1	0	0	1	0	3
	2	3	6	3	0	1	1	14
	3	2	0	1	3	3	0	9
	4	6	2	1	2	0	0	11
Total		15	10	6	5	5	1	42
4. Personal provision: individual behavioral precautions (e.g. alarm plan on household level, escape plan on building level, etc.)		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.7	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	0	2
	1	1	1	1	0	0	0	3
	2	2	1	0	2	2	0	7
	3	4	4	2	1	0	1	12
	4	5	3	2	2	3	0	15
Total		15	10	6	5	5	1	42

Rating: 0 = not important at all, 4 = very important

Table 3: Importance of protection principles provided by experts using a scale from 0 (not important at all) to 4 (very important) (Source: Authors).

1. Adequate technical measures		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.9	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	0	2
	1	0	0	0	0	1	0	1
	2	1	0	2	1	0	0	4
	3	4	5	1	1	3	1	15
	4	7	4	2	3	1	0	17
Total		15	10	6	5	5	1	42
2. Adequate protection goals		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.6	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	1	3
	1	0	1	0	0	1	0	2
	2	3	2	2	1	0	0	8
	3	5	3	1	1	2	0	12
	4	4	3	2	3	2	0	14
Total		15	10	6	5	5	1	42
3. Awareness building events		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 3.0	N/A	0	1	1	0	0	0	2
	0	2	0	0	0	0	0	2
	1	0	0	0	0	0	1	1
	2	4	2	2	1	0	0	9
	3	3	2	2	1	1	0	9
	4	6	5	1	3	4	0	19
Total		15	10	6	5	5	1	42

4. More intensive monitoring, better maintenance, regular repair		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.9	N/A	1	1	1	1	0	0	4
	0	2	0	0	0	0	0	2
	1	0	0	0	0	0	0	0
	2	0	1	2	0	1	1	5
	3	4	3	1	1	2	0	11
	4	8	5	2	3	2	0	20
Total		15	10	6	5	5	1	42
5. Prioritization of measures according to different risk levels		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.6	N/A	1	1	1	1	0	0	4
	0	1	0	0	0	0	0	1
	1	1	0	1	0	0	0	2
	2	5	1	1	0	2	0	9
	3	5	5	1	0	3	0	14
	4	2	3	2	4	0	1	12
Total		15	10	6	5	5	1	42

Rating: 0 = not important at all, 4 = very important

Table 4: Importance of preparation and response principles provided by experts using a scale from 0 (not important at all) to 4 (very important) (Source: Authors).

1. Adequate prepared civil protection, adequate operational planning and adequate evacuation plans		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 3.2	N/A	1	1	1	0	0	0	3
	0	2	0	0	0	0	0	2
	1	0	0	0	0	0	0	0
	2	0	0	0	0	0	0	0
	3	3	3	3	3	1	0	13
	4	9	6	2	2	4	1	24
Total		15	10	6	5	5	1	42
2. Adequate early warning systems		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 3.0	N/A	0	1	1	0	0	0	2
	0	1	0	0	0	0	0	1
	1	0	0	0	0	1	1	2
	2	2	2	0	1	1	0	6
	3	4	2	3	2	1	0	12
	4	8	5	2	2	2	0	19
Total		15	10	6	5	5	1	42
3. Adequate information		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 3.0	N/A	1	1	1	0	0	0	3
	0	1	0	0	0	0	1	2
	1	0	0	0	0	0	0	0
	2	3	0	0	0	0	0	3
	3	4	3	3	4	1	0	15
	4	6	6	2	1	4	0	19
Total		15	10	6	5	5	1	42
4. Insurance		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.1	N/A	2	1	1	0	0	0	4
	0	3	0	0	0	0	0	3
	1	1	0	0	0	0	0	1
	2	5	1	2	4	1	0	13
	3	4	4	3	0	2	1	14
	4	0	4	0	1	2	0	7
Total		15	10	6	5	5	1	42

5. Evacuation and shelters		Austria	Italy	Switzerland	Slovenia	Germany	Liechtenstein	Total
Level of importance Mean value: 2.6	N/A	1	1	1	0	0	0	3
	0	1	0	0	0	0	0	1
	1	1	0	0	0	0	0	1
	2	4	2	1	3	2	1	13
	3	7	3	3	1	1	0	15
	4	1	4	1	1	2	0	9
Total		15	10	6	5	5	1	42

Rating: 0 = not important at all, 4 = very important

In question 53 of the online questionnaire, experts were asked to state their agreement towards a number of recommendations. The following figures illustrate all data collected for this question. Recommendations receiving most agreement by experts were about improved communication and awareness raising initiatives on residual risk and case of overload, about safeguarding natural areas with protective function, and about developing land use regulations that consider scenarios of cases of overload.

a) Reducing the negative consequences in cases of overload by controlling land use and construction activities.

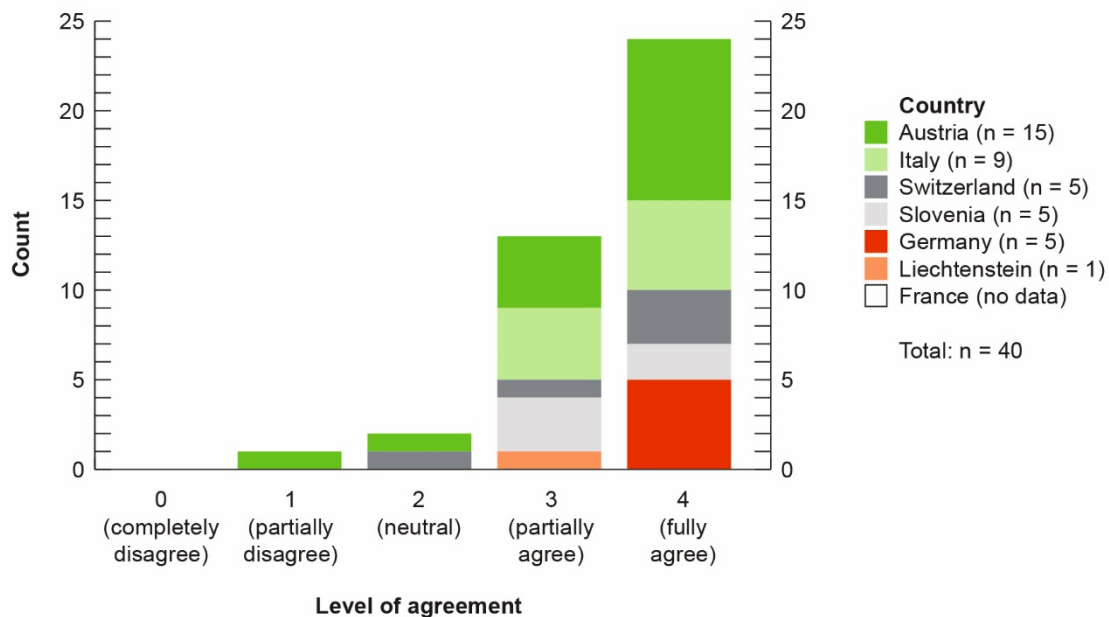


Figure 20: Recommendation a (Source: Authors).

**b) Greater prioritization of non-structural measures
(in contrast to structural measures).**

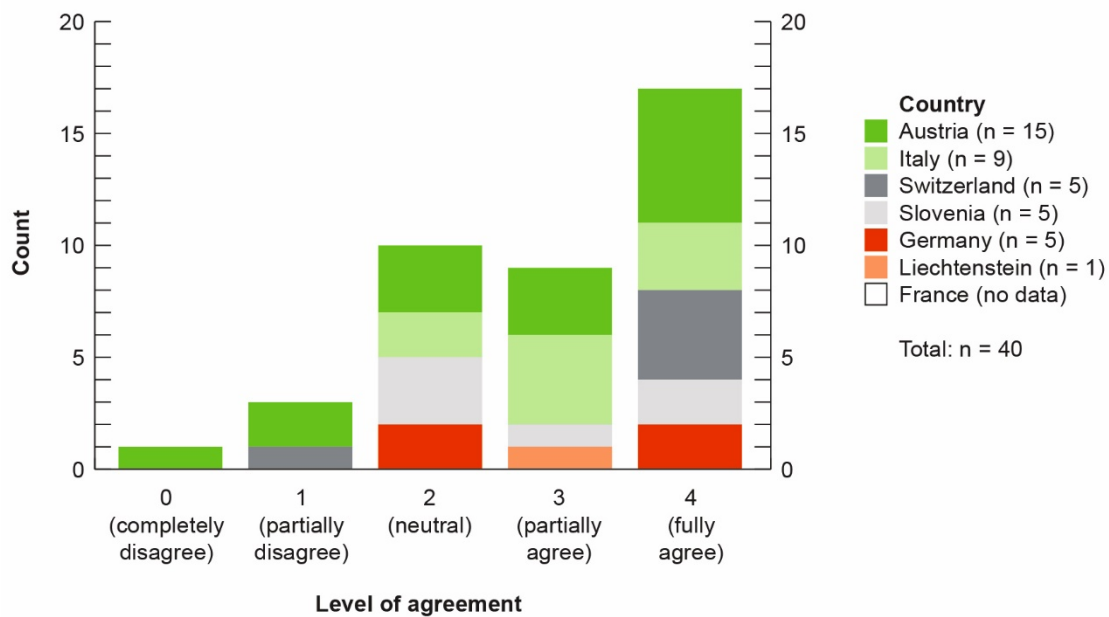


Figure 21: Recommendation b (Source: Authors).

**c) Ease the access to data and information about cases of overload
and residual risk e.g. by means of open GEO data bases.**

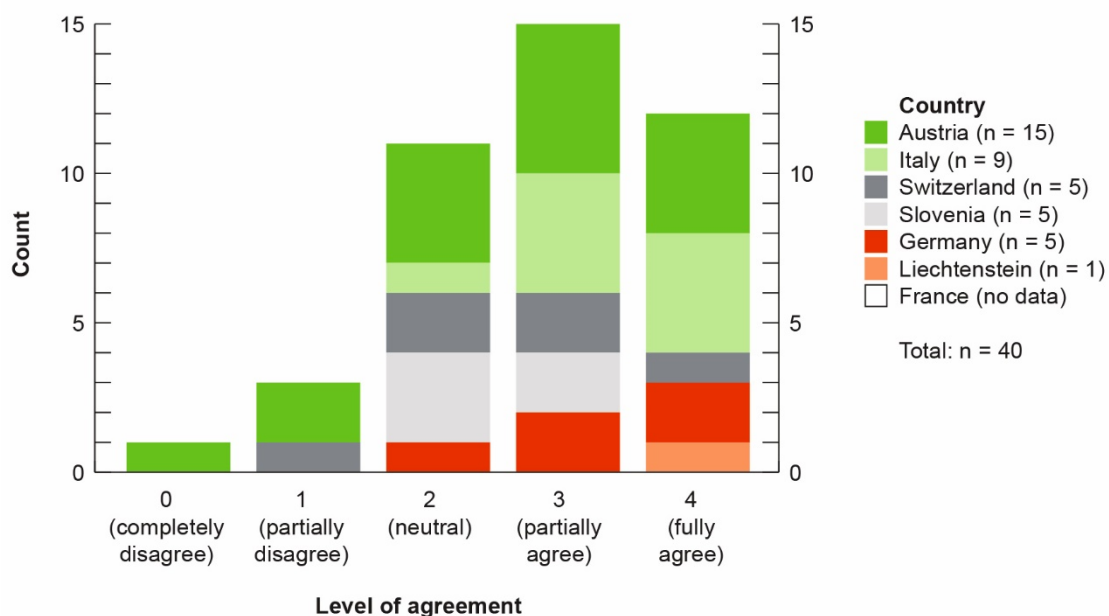


Figure 22: Recommendation c (Source: Authors).

**d) Collecting and analyzing of historic and current events
(particularly in the case of overload) in a preferably standardized form.**

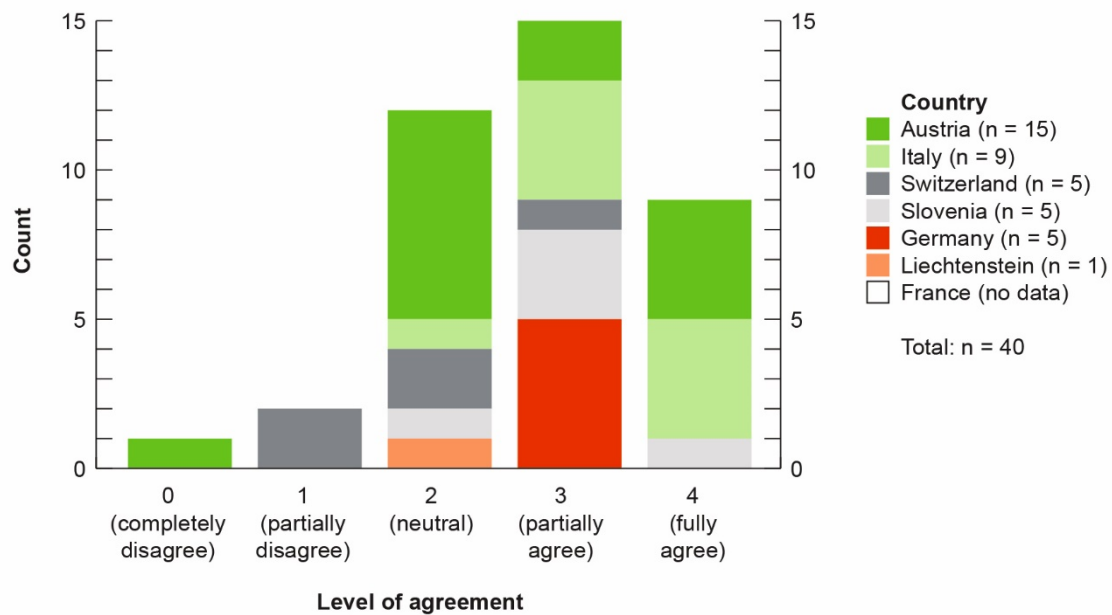


Figure 23: Recommendation d (Source: Authors)

**e) Definition of harmonized measuring units and standardized levels
of security with respect to cases of overload and residual risk.**

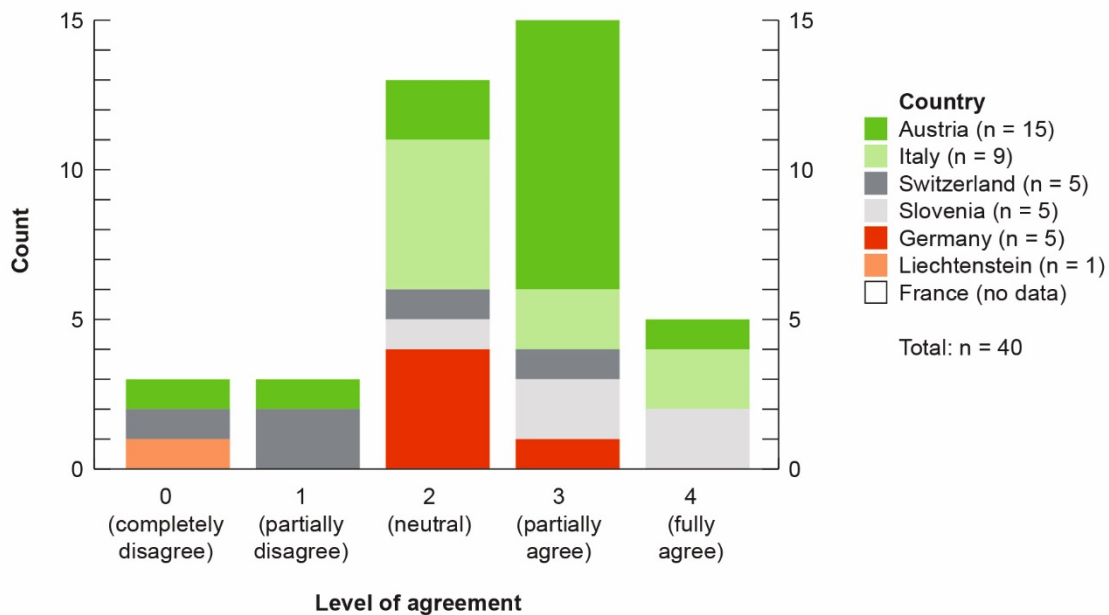


Figure 24: Recommendation e (Source: Authors).

f) Improved communication of residual risks and the potential cases of overload as well as awareness-raising measures.

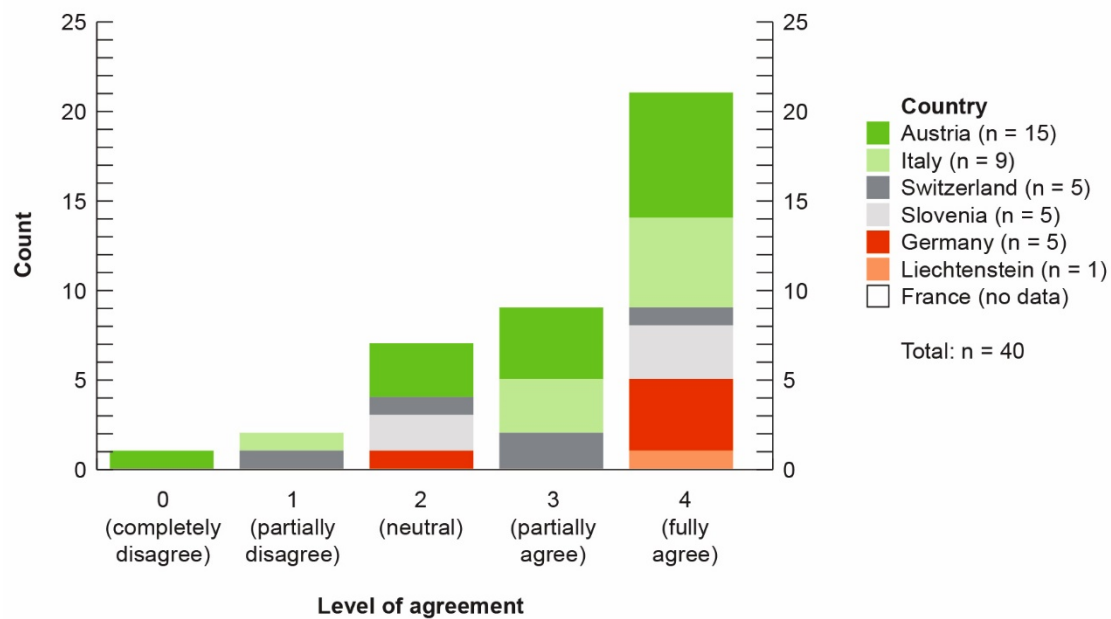


Figure 25: Recommendation f (Source: Authors).

g) Development of cross-sectoral protection concepts for the coordination of planning, technical, organizational, and other measures.

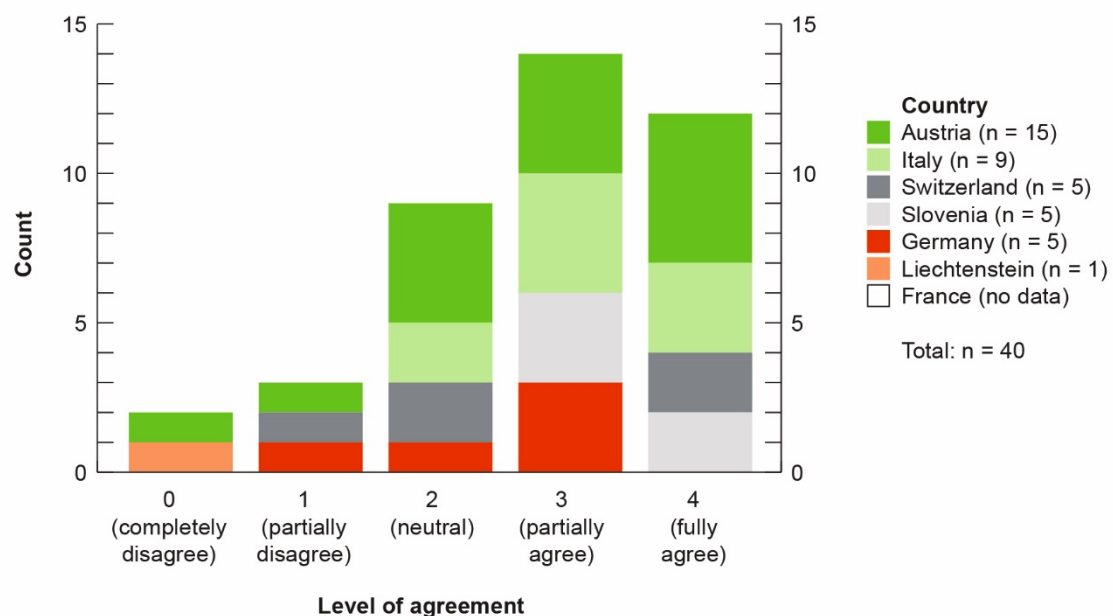


Figure 26: Recommendation g (Source: Authors).

h) No further development of areas with high residual risk and high potential for cases of overload.

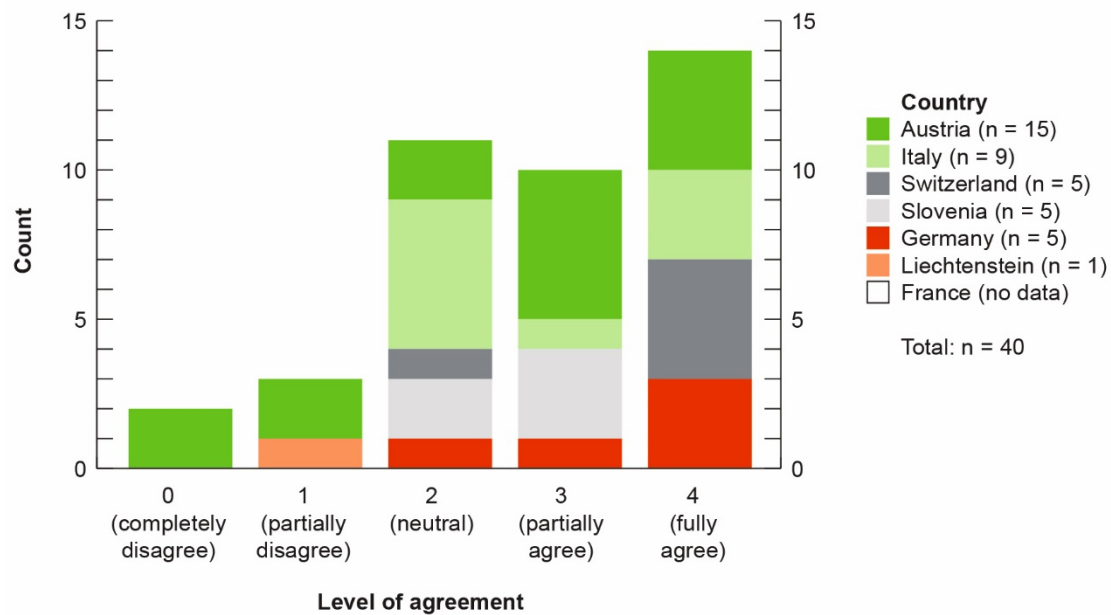


Figure 27: Recommendation h (Source: Authors).

i) Safeguarding of natural areas with protective function.

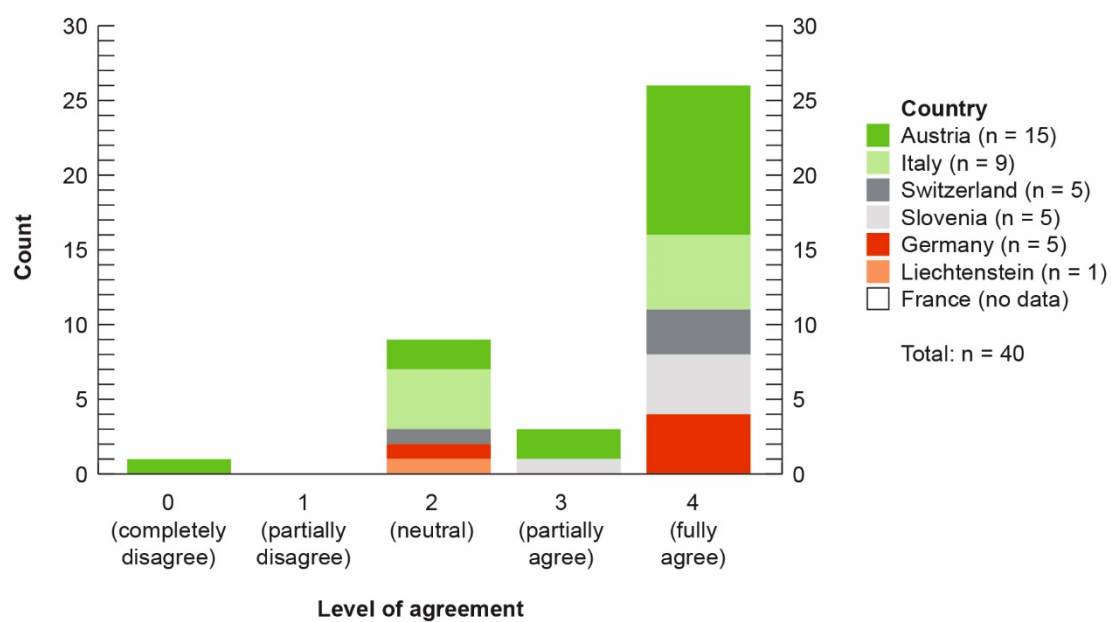


Figure 28: Recommendation i (Source: Authors).

j) Development of land use regulations that consider scenarios of cases of overload.

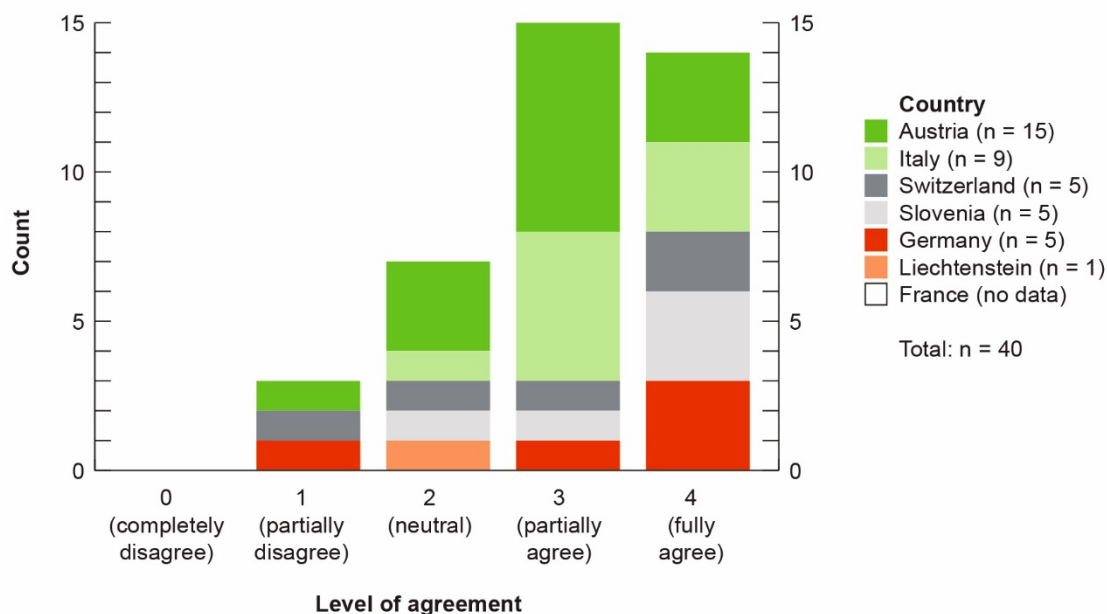


Figure 29: Recommendation j (Source: Authors)

k) Involvement of the different technical fields and actors with their varying views and approaches in an inter-sectoral and interdisciplinary coordination process.

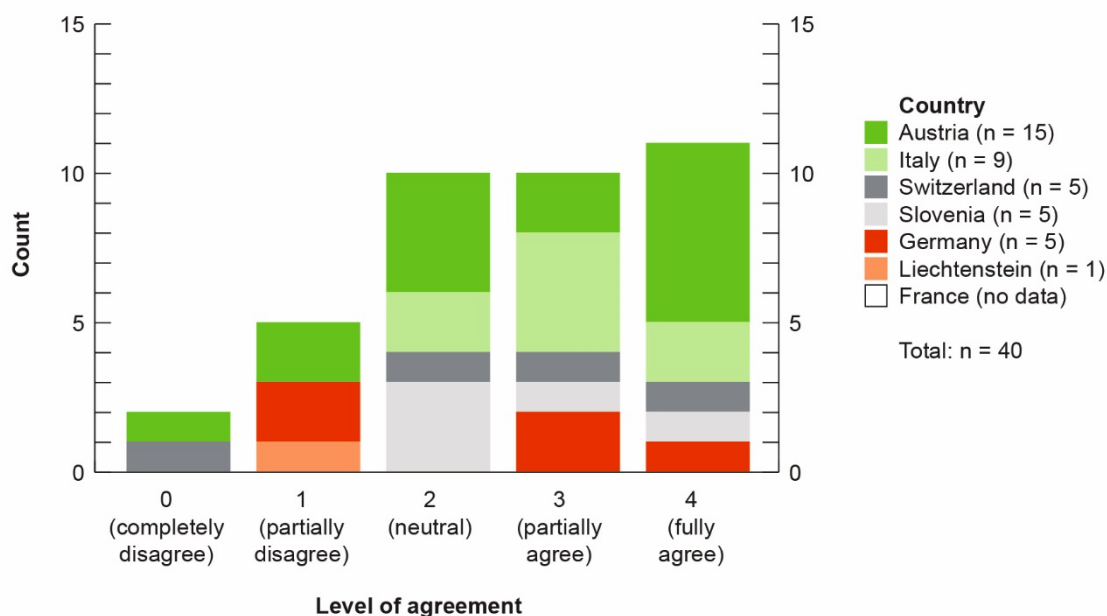


Figure 30: Recommendation k (Source: Authors).

Further recommendations from interviews (clustered according to topics)

Residual risk definition

- There is the clear need to exactly define the terms residual risk and case of overload both for the society but also amongst actors involved in risk governance within Europe and amongst different languages. If the experts don't agree on a definition, the citizens have no chance to understand these concepts.
- Formalization of residual risk and overload case concepts at least at national level and quantify both using thresholds. This would help to better raise awareness among people. Swiss approach is good in the sense that it created a common vocabulary, though simplifying a bit too much.
- Alternative approach to protection goals setting. On the methodological side: find a method to treat the changes (by climate), using a scenario approach rather than a return period.

Spatial planning

- In the future, residual risks should be part of hazard zone planning (e.g. through yellow zones). When the case of overload takes place there should be a planned buffer zones and material directed towards areas with low damage potential. Citizens need to be informed on a constant basis. Beyond the actually classes characterizing the actual hazard zones plan, it might be useful the introduction of buffer/bearing areas. These areas could be left free for a flood, thus cushioning potential climate change impacts. In the future, one option could be to impose restrictions upon the usage of certain areas to create spaces for controlled flooding.
- Land use plans should include uncertainty in each risk level when planning zones (*zonage*). Wrong to assume that by choosing a return period, the calculated values are the real values. Risk level in the zones should be increased to include calculation uncertainties, possible errors. In this way, a component of residual risk (miscalculation) is included in the risk level to be protected from.

Between spatial planning and protection measures

- Special attention in the Plan should be given to natural measures employing areas which have the potential to retain flood water, such as natural flood plains as well as the other areas enabling controlled flooding.

Towards an integration of structural and non-structural measures

- Assess the average expected residual functionality of structural protection measures. These results may help plan appropriate check protection measures maintenance. Residual functionality should be assessed also for sewerage system.
- Important to always consider potential climatic and social changes and to aim for integrated risk management (going away from purely determining protection goals and implementing measures). Keep in mind: Where does it still make sense to invest? What if certain areas are not inhabited anymore in the future due to demographic and socioeconomic changes?
- Think about how human structures could contribute in raising risk level of related hazards. Hazard analysis of some installations/projects that could hinder the security of the area should include the consideration of case of overload. It should be compulsory that for those projects raising the risk level, constructors/owner should foresee protection measures (technical/non-technical) aiming at reducing risk to the accepted level.
- The case of overload should be considered in every project as it forces the planning engineers to investigate whether other options might be better solutions. As part of this, spatial and emergency planning need to be carried out and sensitivity of citizens has to be done. And: all of this has to be done with respect to the overall goal to save lives
- An integrated risk management which considers the case of overload and in which structural measures are equally important as emergency planning

- Realize measures which increase resilience. These measures should not aim at avoiding that phenomena will happen, but assume the existence of residual risk and case of overload and eventually assure that everyone is prepared to that when are the consequences and avoid that those cause damage. It is therefore considered necessary avoiding designing flood risk strategies exclusively on structural protection and emergency setting, opting instead for a holistic approach able to reduce both the hazard and the vulnerability of receptors.
- Develop an integrated approach, where risk is only one issue in place besides phenomena and hazards. Integrated also in the sense that human and social sciences are also included within risk governance.
- The insurances are another part of integrated risk management and help to better deal with the remaining residual risk. The insurance system is the goal that should be pursued. The involvement of insurance is a shift in risk management and its sharing. The insurance is ready to take the risk of paying the damages, but only if the insured will follow a certain type of behavior. The goal is to pay less for those who follow virtuous behaviors, creating a differentiation and thus avoiding the creation of a tax.

Between Integrated Risk Management and communication

- Challenges for the future concern dealing with ever smaller economic resources that will inevitably lead to prioritization and residual risk management since there cannot be a total control over hazard prone territories. In this case, since administrations will not be able to protect the entire territory, citizens, entrepreneurs, etc. will have to learn to accept a potential residual risk.

Residual risk communication & awareness

- The case of overload and residual risk are terms that need to be constantly explained because people who are not working with these terms are not familiar what they mean. Within municipalities, there should be more events to educate and raise awareness about hazards and existing maps and measures. This should be done in every village and should be very effective.
- It is necessary to create a “Grundrauschen”/background noise about potential risks
- Ideally, a society that is risk-competent and in which dealing with natural hazards and the case of overload is part of everyday life. At the same time, everyone should know about potential residual risks and contribute to become safer and to incorporate risk management as implicitness.
- To develop the aspects of communication for the residual risk, explaining the limited protection capacity of technical measures. To raise awareness among people that even though structural protection measures exists, they are not in a risk-0 situation. Good example of Austria: each technical analysis has a budget for the communication done by communication experts.
- Openness and raising awareness are crucial, early warning systems, involvement in decision making and cooperation amongst actors
- Need to concentrate and merge communication to raise awareness of different types of floods and potential cases of overload
- Furthermore, the residual risk that remains despite protection measures should be visually mentioned in hazard plans. Doing so, this might not affect spatial planning but it notifies citizens. At the same time, residents should be better informed about potential hazards and notified about the possible impacts of climate change
- The participative arrangement of planning offers opportunities to discuss and inform about residual risk. An efficient way to keep the level of awareness high is to carry out exercises and to do emergency planning to show the residents that an event can happen anytime
- Citizens should be informed in advance of the potential risk they could face, avoiding relying exclusively on emergency communication.

- Documentation of past events and implemented projects to increase the acceptance amongst citizens and to show which areas were affected in the past (also: lessons learnt!)

Between spatial planning and involvement of actors and processes

- Improve the process and exchange venues so that risk management is done more in a more integrated way, Putting the issue of risks more upstream of the development projects of the territory, to reach a compromise.

Involvement of actors and processes

- On the operational side: work with methods for decision-taking, e.g. Multi-Criteria Analysis: what is the decision to be taken, who is involved, what are the issues. From that build decision trees, which allow to aggregate the evaluation of certain criteria.
- The exchange of information and data between different administrative levels could be improved. In particular, co-operation should be improved in non-emergency phases
- Related to forecasting and warning systems, over the last 10 years, many improvements have been made. However, no concrete action has been taken by the various administrative levels, but also by the citizens themselves. We believe that a participatory planning could increase risk awareness and can also improve the behavior of the citizens themselves.
- There is a need to assume responsibility today that can not be covered exclusively with information. It is necessary to create a system through which the citizen should be involved in the responsibility (prevention and reaction phase) and not only in the information (passive prevention phase).
- It would be advisable to start thinking about the concept of overload in the planning phases of structural measures and land planning. In case of overload, competence is no longer of a single office because falls within a dimension not only related to the protection of land: it is therefore necessary to start a new form of cooperation which provides for the involvement of more subjects.
- Importance should be given to the flood management at the river basin scale, trying to avoid that the actions taken at local scale could have any repercussions downstream.
- Residual risk should be reduced by including the population in risk management and suggesting self-provision.