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The development of mountain risk governance: challenges for application

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Abstract

The complexity the management of mountain risks in the Alps has considerably increased since its institutionalisation in the late nineteenth century. In the history of approaches to dealing with mountain risks four successive paradigms can be distinguished on the basis of key indicators such as guiding principles, characteristic elements and typical instruments: “hazard protection”, “hazard management”, “risk management”, and “risk governance”. In this contribution, special attention is paid to the development of hazard zone planning and the growing importance of communication and participation over the course of this transformation. At present, the risk management paradigm has reached maturity. In the Alps, risk governance frameworks are not yet applied to risks from natural hazards. Based on a historical analysis, the suitability and applicability of general risk governance frameworks in the context of mountain risks are discussed. Necessary adaptations (e.g., in administration, educational, and legal structures) are proposed for the upcoming transformation towards mountain risk governance.

1 Introduction

In mountain regions, natural hazard processes are threatening people, existing buildings, and infrastructure, as well as their future development. Distinct paradigms have shaped the approaches to mountain risks over time. In the Alps, the paradigm of risk management is currently at a mature stage. Risk governance has been discussed in broad terms as a new paradigm that will succeed risk management, but risk governance has not yet been applied to the context of mountain risks. The scope of this contribution is threefold: first, it seeks to trace back the succession of four distinct paradigms for the dealing with mountain risk in the Alps, with special attention focused on the role of communication and participation in this developmental process. Second, it aims to discuss the suitability of general risk governance frameworks for the spe-

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cific context of mountain risks. Third, it targets to identify challenges, and to propose necessary adaptations for the application of risk governance on mountain risks.

In this contribution, characteristics of mountain risks are introduced, and aspects of risk communication and participation are discussed, as they represent core elements of risk governance. Historical perspectives and outlooks on approaches to mountain risks are represent the basis of a paradigm based model for dealing with mountain risks. This model differentiates four distinct paradigms: hazard protection, hazard management, risk management and risk governance. Finally, conclusions for the application of general risk governance concepts to the context of mountain risks in the Alps can be drawn.

1.1 Characteristics of mountain risks

"Risk" is understood as an amalgam of hazard and vulnerability (Hufschmidt et al., 2005). Mountain risks result from hydrological, geological or gravitational hazard events (e.g., floods, rock and snow avalanches, debris flows, rock falls, and landslides) and their temporal and spatial coincidence with societal values (e.g., infrastructure, buildings, people and cultural values). In this paper, the term "mountain risks" is used to describe a set of natural risks typically found in mountain regions that are managed under common frameworks.

Mountain risks exhibit intrinsic characteristics that require particular analysis. In contrast to man-made risks (e.g., technical risks), mountain risks are a combination of natural hazard processes and societal values. However, most natural hazard processes are also sensitive to human activities, through which they can be intensified or mitigated in the short term (e.g., through structural protection, or deforestation) and in the long term (e.g., through anthropogenic global warming, or changing land use patterns). Mountain risks are local, and unevenly distributed phenomena that are in part sensitive to global (climate) parameters; these discrepancies in spatial scales produce uncertainties for risk management. Acting under conditions of uncertainty is an inherent principle of general risk management. Greiving et al. (2014) present an overview

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of uncertainties for the prediction of a range of mountain hazards; they vary greatly depending on the types of hazard. For landslides, Hufschmidt et al. (2005) illustrate the complexity of hazard prediction, which is due in part to the non-linear relationships between triggering events and landslide events. Changes in land-use patterns and other socio-economic developments entail even greater uncertainties, at least in the long term. Furthermore, strong but diverse traditions of state interventions through protective structures, dedicated institutions, legal systems, and risk transfer mechanisms characterise the dealing with mountain risks across the Alpine region, as well be described below. These divergent approaches to state interventions are accompanied by a wide variety of regional mountain risk cultures (Angignard et al., 2014).

1.2 Risk communication and participation

This contribution pays special attention to the role of communication and participation in dealing with mountain risks for three primary reasons. First, empirical observations reveal a high level of public demand for enhanced communication efforts in mountain risk management (Peltier, 2005; Link et al., 2010; Angignard and Greiving, 2010). Second, overarching legislative frameworks and policies stipulate the central role of communication and stakeholder participation (Amendola, 2002), e.g., the EU flood directive (European Parliament and Council, 2007). Finally, communication and stakeholder involvement are conceptualised as constant companions and core elements within recent governance models (Löfstedt, 2005; Klinke and Renn, 2012), and the importance and intensity of communication and participation in the management of mountain risks has gradually increased over time, as will be shown below.

Here, "risk communication" is understood as an umbrella term covering all forms of the mono- and bidirectional exchange between actors of information, knowledge, experiences, interpretations, concerns, and perspectives on risks (cf. Leiss, 1996; Löfstedt, 2003).

This comprehensive understanding of risk communication calls for the conceptual delimitation of participation. Depending on one's perspective, discipline and specific

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interest, participation may be understood in various forms (Strategiegruppe Partizipation, 2010; Arbter et al., 2005). In this contribution, "participation" describes opportunities for stakeholders to contribute to risk management processes in three stages (derived and simplified from Arnstein, 1969). In the first stage, "information" refers to the mono-directional information transmission from experts to stakeholders or the general public. The availability of information for interested actors is seen as an indispensable foundation for the shaping of opinions and therefore a prerequisite for participation. In stage two, "consultation", selected stakeholders become somewhat involved through a bi-directional exchange of information; their expertise, concerns and evaluations are taken into account, especially during the risk assessment process. However, the decision-making power remains exclusively at the expert level. Stage three, "(co-)-decision-making", describes the highest level of participation. Both, the power to decide and responsibility for the results are shared between experts and stakeholders.

2 Historical perspectives and outlooks

In a historical review, societies have always faced risks form natural hazards. Distinct approaches to dealing with these hazards have been developed and applied in every historical period and in every region worldwide. Covello and Mumpower (1985) outline the roots of and historic developments in risk management. They indicate a tipping point in this history: when hazard-related fatalities came to be socially interpreted as avoidable events instead of acts of God. Inspired by the progress of the Enlightment the understanding that "something could be done" to reduce risks soon led to the demand that "something should be done" by society. The Lisbon earthquake of 1799 exemplifies the struggle over the societal interpretation of the responsibility for the fatalities resulting from natural hazards. After this catastrophic event, European philosophers claimed that society was responsible for the fatalities, as the overcrowded city with its unstable building structures was man-made; meanwhile the Catholic Church still interpreted the fatalities as an act of God (Sanides-Kohlrausch, 2002). The responsibility for hazard

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protection remained with individuals or was transferred within local communities up until the governmental institutionalization of hazard management. At the beginning of the 19th century, collective interventions against flooding along Europe's rivers represent an early stage of institutionalised risk reduction. Shortly after, the governmental institutionalisation of mountain hazards was initiated (e.g. Duile, 1826).

Montz and Tobin (2011) provide a review on the natural hazard research tradition in geography, tracing the interplay between physical and socio-economic perspectives in the move towards broadened interdisciplinary approaches. Hufschmidt et al. (2005) address time as a connecting element in the dichotomy between natural science and social science approaches, arguing that increasing connectivity is likely to result in higher complexity in risk science. This prediction of greater complexity is supported by Montz and Tobin (2011) with regard to natural hazards and by Covello and Mumpower (1985) at a more general level. Additionally, in future Covello and Mumpower (1985) expect increasing stakeholder participation as well as public interest in, concern over, and demand for protection. This early assessment is in line with contemporary developments in European environmental and risk policies and legal frameworks (Amendola, 2002).

In Europe, the management of mountain risk was institutionalised from beginning in the late nineteenth century. Peltier (2005) compares mountain risk management approaches across Europe, roughly differentiating three phases since institutionalisation: reforestation, hazard zone mapping, and climate change response. The author highlights the differences in regional risk cultures (*philosophique du risque*). Based on investigations in Italy and France, Angignard (2011) emphasises and explains the coexistence of multiple approaches to mountain risks in the Alps: "Basically, the history and background of each region shaped the policies and decision-making processes. Several elements participate in this differentiation" (Angignard, 2011, p. 48). These elements include the understanding of public goods, the political system (federal vs. centralised), the culture of cooperation, cultural interpretations of nature, and common expertise with regard to natural hazards. In the future, the issue of regional risk cultures will require close attention.

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3 Paradigm based model for the dealing with mountain risks

The dealing with mountain risks has considerably advanced over the decades since its institutionalisation. In a stepwise process, several stages have gradually developed over time, and a succession of paradigms in the approach to mountain risks in the European Alps can be observed. In this regard, a conceptual model of four paradigms in chronological order is proposed:

- hazard protection (approx. from 1850)
- hazard management (approx. from 1951/52)
- risk management (approx. from 1995)
- risk governance (currently in discussion)

Each paradigm characterises a temporal phase in the approach to mountain risks. Figure 1 illustrates the stepwise development of paradigms for dealing with mountain risks. Each phase incorporates the prior one and significantly extends it; transition phases connect consecutive paradigms. The following six key characteristics indicate milestones in the historical development process: guiding principles, central elements, typical instruments, spatial coverage, main actors and, the level of participation involved.

In science, paradigms describe dominant, commonly accepted frameworks for interpretation in certain time periods (Kuhn and Hacking, 2012), recent scholars identify coexisting, rivalling paradigms at a time, e.g. Arnreiter and Weichhart (1998). Here the term paradigm describes dominant, commonly accepted frameworks for action and interpretation at a certain period of time comprising both pillars, science on handling mountain risks as well as its practical application in society.

The developmental model of mountain risk paradigms shows the gradual increase in complexity in the approach to mountain hazards. Complexity increases over time as the perspective is successively extended in several dimensions (e.g., from protection to

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management, from hazard to risk, and from government to governance, both spatially and in terms of actors). The rising demands over the historical development of the approach to mountain risks is highlighted and explained.

The conceptual model presented here refers to both dimensions of dealing with mountain risks, scientific discourse as well as practical applications – while keeping in mind the temporal offset between the two. However, this model has certain limitations. As a conceptual model it does not acknowledge the vast natural, cultural, legal and institutional diversity in mountain regions, nor does it reflect the non-synchronous development of the management of mountain hazards across space and time. Nevertheless, the model outlines the general development of the approach to mountain risks in the Alps, providing both a descriptive perspective on the past and an outlook on the transition towards mountain risk governance.

3.1 Hazard protection

Phase one "hazard protection" began with the institutionalisation of the approach to natural hazards through legislation and the emergence of organisations dedicated to handling these. A basically positivistic attitude supported the idea of the controllability of mountain risks, and a stepwise shift in responsibility for hazard protection from individuals to the state was initiated. The guiding principle for the paradigm of hazard protection was the avoidance of adverse impacts, this was mainly addressed through the construction of structural protection measures such as deflection and retention walls, levees or torrential barriers (Holub and Fuchs, 2009). Reforestation and bio-engineering measures complemented conventional structural protection measures. The spatial coverage of protection measures was limited to hot spots of hazard activities and selective points or linear segments of interest (Vischer, 2003).

In Austria, severe flooding in 1882 promoted the enactment of the "Law on precautions for the discharge of mountain streams without damages" (Österreichisch-Ungarische Monarchie, 1884) and the creation of the "Forest Engineering Service for Torrent Control" (Länger, 2009; Lebensministerium, 2011). In Bavaria, the pre-

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decessors of the Office for Geology and the Office for Water Management had been dedicated to controlling natural hazards since the mid nineteenth century (Poschinger, 2001). In 1874, Article 24 of the Swiss constitution delegated the supervision of mountain forests and mountain hazards in Switzerland to the federal level (Vischer, 2003), and an avalanche register was initiated in 1878 (Frutiger, 1980c).

During this stage, experts (e.g., foresters and civil engineers) were educated and employed in state services for the development, planning and construction of mitigation measures (Länger, 2009). They were the main actors in the discourse on mitigating mountain hazards. Intensive information exchange and communication within disciplinary borders promoted technical progress. The establishment of research and education organisations dedicated to mountain hazards supported this process; for example, BOKU (the University of Natural Resources and Life Sciences, Vienna) was founded in 1872. The affected population and local representatives were seen as beneficiaries of state interventions. At best, information on the state's undertakings was provided to them through official statements. In general, directly affected people were allowed to submit technically justified objections during the planning process. This phase corresponds to the lowest level of public participation – or as Fischhoff puts it: "All we have to do is get the numbers right, [and] tell them the numbers" (Fischhoff, 1995, p. 140).

3.2 Hazard management

Triggered by the avalanche winter of 1950/51 and other similar events, the approach to mountain hazards made considerable advancements towards a new paradigm, "hazard management". The guiding principles of this paradigm were hazard process understanding and mitigation; statistical modelling and the spatial effects of mountain hazards were emphasised. A more profound understanding of hazard processes and, the availability of time series and damage statistics were systematically utilised to derive probability functions, recurrence intervals, design events and frequency-intensity relationships. Methods to delineate the spatial susceptibility of runout zones were concep-

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tualised. The key instruments in use were hazard mapping and the statistical modelling of selected areas.

Pilot projects in hazard mapping (in particular avalanche runout maps) are developed throughout the Alpine arch (Burkard, 1992; Länger, 2005). A variety of approaches to hazard mapping were developed, for the various types of hazards and the statistical protection levels involved (Petraschek, 2005). The combination of a variety of technical approaches and the diverse political systems of Alpine countries resulted in complex legal frameworks governing the integration of hazard management into spatial planning law (Frutiger, 1980a; Aulitzky, 1994; Stötter and Fuchs, 2006).

Between 1954 and 1975 more than 200 surveys on local avalanche conditions were conducted by the EISLF (Federal Institute for Snow and Avalanche Research), paving the way for standardised avalanche zone maps (Frutiger, 1980c). Legal frameworks for the integration of hazard information in spatial planning laws were developed accordingly. In Switzerland, at the federal level, the following legislation makes reference to hazard-based spatial planning: the forest-police law (Bundesversammlung der Schweizerischen Eidgenossenschaft, 1965), the spatial planning law (Bundesversammlung der Schweizerischen Eidgenossenschaft, 1997), and laws on hydraulic engineering and forests (Bundesversammlung der Schweizerischen Eidgenossenschaft, 1991b; Bundesversammlung der Schweizerischen Eidgenossenschaft, 1991a).

In France innovations in hazard management were also triggered by hazard events – for example, the snow avalanche in Val d'Isere in 1970 (Antoine, 1990). Hazard planning legislation grew out of the initial *carte des risque naturel* and *carte R 111-3*, with the eventual development in 1982 of risk exposure plans (PER) that considered different hazards separately (Peltier, 2005; Greiving and Angignard, 2014).

Beginning in the 1960s, additional passive and non-structural protection measures were discussed in Austria, as the conventional strategies exhibited deficiencies with regard to their financing over the long term (Stötter et al., 1997). The Austrian forest law of 1975 and its subsequent regulations created the legal framework for hazard zone mapping (Republik Österreich, 1975, 1976; Aulitzky, 1994; Holub and Fuchs, 2009).

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The Italian hazard management approach emphasized the role of civil protection and crisis management. During this phase, individual hazard surveys were conducted at selected spots.

Spatial planners and municipal representatives gradually became involved in local decision-making focussed on future loss prevention. During the phase of hazard management discussions on the legal aspects of sovereign interventions involving private property rights were initiated (Frutiger, 1980b). The national and international exchange of expertise among researches and practitioners was fostered and enabled through the creation of risk related platforms such as Interpraevent (1967) and the Society of Risk Analysis (1980). More actors, (including "non-hazard-experts" such as municipal politicians and spatial planners) became involved in the process of information exchange and decision-making. Hazard maps were publicly displayed, serving as sources of information for interested individuals. The enhanced involvement of more and heterogenic actors led to new communicative demands; however from an experts' point of view, "All we have to do is explain what we mean by the numbers" (Fischhoff, 1995, p. 140). Despite the provision of more detailed information by experts, the communication gap between experts and laymen was maintained. This phase still corresponds to the "information" level of participation.

3.3 Risk management

In the second half of the twentieth century, rapid socio-economic developments in selected mountain regions resulted in huge increases in the values at risk, prompting policy makers to call for a new approach to mountain risk management. The paradigm shift from hazard management to risk management was characterised by a broader perspective on dealing with mountain risks, the dissemination of risk cycles, and the intense attention devoted to elements at risk, their values, and their vulnerabilities.

Risk cycles integrate elements and stakeholders from prevention, crisis management, and reconstruction under common frameworks. The concept of risk management follows a holistic idea of reducing risk over the long term through the harmon-

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isation of prevention, mitigation and reconstruction. The integrative character of risk cycles bypasses well-established disciplinary borders and paves the way for multi-risk approaches and risk comparisons. Risk management approaches were originally developed in the context of technical risks but were subsequently adapted to mountain hazards. The guiding principle of risk management involves the standardisation of decision rules and administrative processes. A three-step process describes risk management approaches:

- Risk assessment: what kind of risk is posed to a certain location or value?
- Risk evaluation: is the risk acceptable?
- Risk mitigation: what can be done to reduce the risk?

At present, the paradigm of risk management is prevalently applied in the European Alps, despite the vast regional diversity in terms of history, culture, institutions, and legal and political systems throughout the Alpine arch. The broadening of perspectives in the approach to mountain risks has also raised expectations regarding communication and participation; not only among the general public (Link et al., 2010; Angignard and Greiving, 2010) but also within and between governmental institutions (Link and Stötter, 2015). Despite countless efforts to improve risk communication and participation, the traditional primacy of disciplinary experts remains in place, and the deficit model of communication (see, e.g., Frewer et al., 2003) between experts and the public is still applied.

New aspects under the paradigm of risk management include the in-depth consideration of the values at risk, the (re-)-acknowledgement of residual risks, and the scrutiny of the cost-effectiveness of mitigation measures. The acknowledgement and communication of residual risks creates a new role for individuals, as they become responsible for acting. There is a particular emphasis in this phase on risk perception research, the creation of individual awareness through the dissemination of informational materials, and self-prevention measures. Concepts for technological as well as social

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vulnerability assessments are deepened have been elaborated and partially applied (Fuchs, 2009). The comparison of risks from different hazard processes facilitates risk-based decision support, allowing the prioritisation of mitigation measures (Staffler et al., 2008). Non-structural mitigation measures (such as the temporary limitation of access or hazard zone planning) as well as reinforcements of the existing infrastructure are key prevention strategies in this phase. Under the paradigm of risk management, hazard zone planning has made considerable advancements towards risk zone planning through the incorporation of spatial information on the values at risk and their vulnerabilities. However, the established term "hazard zone planning" is still widely in use, also in risk-based planning approaches. In the spatial dimension, the comprehensive application of hazard zone planning is the primary goal, along with the harmonisation of local approaches. The international standardisation of mountain risk management across the Alps has been explicitly declared an objective and has been addressed by the EU project Startitup (Startitup Project Consortium, 2014). Science-practitioner dialogues and international exchanges on mountain risk management have been enhanced by many EU-funded projects in the Alpine Space Programme, e.g., ClimChAlp, PARAmount, AdaptAlp, SedAlp and CliSp. The multi-risk approach in risk management has broken down disciplinary borders. Pragmatic approaches to local risk assessment incorporate local knowledge and the experience of "civic experts". Under this paradigm, the second stage of participation (consultation) has been achieved, with key local individuals in affected regions being consulted for their views on risk assessment (Bründl et al., 2009).

Switzerland pioneered the introduction of risk management in the field of mountain hazards. The research programme "Risk and Safety" (1990–1995) initiated these activities in the mountain community. Heinimann et al. (1998) applied the risk concept to multiple mountain hazards. The national platform for natural hazards was established in 1997 prescribing the programmatic change "from hazard protection towards a culture of risk" (Nationale Plattform für Naturgefahren, 2002). Innovative instruments were subsequently developed and applied (Bründl, 2009). Standardised federal methodolog-

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ical guidelines for risk assessment for mountain hazard processes were developed by Borter (1999). The “pragmatic approach” to risk assessment was developed by Bähler et al. (2001); this “includes the analysis of hazards [based] on existing data as well as expert judgements and local experiences gained in workshops with experts, practitioners, and regional representatives of the population” (Bähler et al., 2001, p. 194). In addition, EconoMe, an online tool for risk-based cost-benefit analysis that compares the economic performance of possible mitigation alternatives was introduced. This tool is used by financial institutions, engineers and planners for decision support and communication purposes.

In Austria, the paradigm of integral risk management is widely accepted (Holub and Fuchs, 2009), and a fairly straightforward transformation from hazard management to risk management is underway. Specific pilot activities concentrate on local protection measures (Holub and Hübl, 2008), structural vulnerability assessments (Fuchs, 2009; Fuchs and Zischg, 2014) and public information and participation efforts (Ottisch and Rappold, 2007). Apart from technological innovations in hazard process modelling, spatial planning approaches have not been significantly adapted towards risk-based planning. In France, the introduction of PPR (Plan Prévention des Risques) in 1995 marked an innovation towards integrated risk management (Greiving and Angignard, 2014). The PPR has created a national standard, harmonising existing legislation and has a legally binding character; however it only applies to future land use and new construction. The PPR follows a multi-risk approach, including technical and mining risks. The Italian risk management culture traditionally focusses on preparedness and response, mainly motivated by civil protection interests (Veyret et al., 2004; Peltier, 2005). In Italy, hazard mapping was introduced in legislation at the federal level in 1998 (Republica Italiana, 1998) and on provincial level in the Autonomous Province of South Tyrol in 1997 (Landesregierung der Autonomen Provinz Bozen-Südtirol, 1997). In 2008, risk-based hazard zone planning was introduced in South Tyrol on the basis of provincial guidelines (Landesregierung der Autonomen Provinz Bozen-Südtirol, 2008). The Italian approach represents an innovation in spatial

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planning in the European Alps: specifically, this was the first time that legislation was based on a risk concept. In South Tyrol, standardised risk maps for the entire province allow the comparison of risks and serve as an instrument of decision support in the prioritisation of structural protection measures as well as in spatial planning projects.

3.4 Risk governance

At present, the paradigm of mountain risk management at a mature stage. In general, from a practitioner's point of view, risk governance is a relatively new paradigm, although scientists have been discussing it for years on a general level.

"Risk governance" describes theoretically driven meta-concepts for the handling of risks. Risk governance frameworks have progressed since the millennium from initial layouts to more recent highly developed concepts. These frameworks provide an analytical as well as a normative basis for coping with multiple risks and have been developed and discussed for a wide range of risks, from technical risks such as the treatment of nuclear waste to global challenges such as climate change (Amendola, 2002; Renn and Klinke, 2012). Early initiatives including the EU project Trustnet (Heriard-Dubreuil, 2001) and its successors have paved the way for the advancement of risk governance towards generalised multi-risk frameworks (International Risk Governance Council, 2005; Renn et al., 2011). In an analytical sense, risk governance can be described as " the totality of actors, rules, conventions, processes and mechanisms [...] concerned with how relevant risk information is collected, analysed and communicated and how management decisions are taken" (International Risk Governance Council, 2008, p. 4). In a normative sense, "governance emphasizes a change in the balance between state intervention and social autonomy. Risk governance likewise extends from regulations to multi-actor participation and negotiation and from technical management to legal, institutional, social and economic contexts" (Assmuth et al., 2010, p. 3944).

Risk governance allows the additional incorporation of intangible values and local or case-specific preferences in risk evaluations. It adds socio-cultural perspectives to

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the existing risk management approaches and proposes case or local specific adaptive management as well as inclusive communication (Djalante et al., 2011). Significantly, "the idea of risk governance aims to serve a paradigm shift that helps risk professionals to familiarize themselves with a broader concept of risk" (van Asselt and Renn, 2011, p. 439). Risk governance augments existing approaches by incorporating (indirect) socio-economic and political aspects and taking regional-specific preferences, structures, and risk cultures into consideration (Boholm et al., 2012). The guiding principles under the paradigm of risk governance are context specification and inclusion. (Re-)building public trust through communication and the inclusion and participation of stakeholders are normatively demanded. However, this poses key challenges for the practical application of risk governance (Wachinger et al., 2013). Stakeholder involvement, inter- and trans-disciplinary collaboration, the consideration of intangible, cultural and traditional goods, risk dialogue, and inclusion all increase the complexity of risk management under the paradigm of risk governance.

Critics of risk governance view it as merely a new way of managing public acceptance. Other criticisms are based on the perceived loss of democratic accountability, raising justified questions regarding the legitimacy of the outcomes of participatory processes. Rayner (2007) and Beck (1992) point out the double-sided nature of governance: namely the displacement of governmental control and organised irresponsibility. Rothstein et al. (2006) indicate epistemic, institutional, and normative pitfalls of risk-based decision regulation.

Over the last decade, general risk governance concepts have advanced considerably, but comparably few scientific publications have dealt with mountain risk governance so far. Here again, EU projects have fostered research activities. The project CapHaz-Net (2007–2011) focussed on the social capacities of European societies in relation to natural hazards, additionally addressing risk governance and natural hazards (Walker et al., 2010). In CapHaz-Net, attention was also devoted to social capacity-building with regard to Alpine hazards (Bianchizza et al., 2011). The EU project Mountain Risks (2007–2011) concentrated in parts on the application of risk

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governance principles to natural hazards and risks in mountain regions (van Asch et al., 2014). The implications for mountain risk governance of the differences in local risk cultures and legal aspects between two mountain regions in France and Italy have been presented by Angignard (2011) and Angignard et al. (2014). The demand made by these authors for locally, culturally, and legally adapted approaches and instruments for mountain risk governance is supported by Peltier (2005), who conducted research in the Italian Alps, Switzerland, and the French Pyrenees. Link and Stötter (2015) observed obstacles to the application of risk governance concepts within risk managing-bodies in South Tyrol, Italy (e.g., in the communicative and organizational structures).

4 Conclusions for mountain risk governance

Despite a wide range of scientific activities, no consistent approaches to the implementation of risk governance principles in the mountain risk context have yet been developed. Therefore, it seems appropriate to question the suitability and applicability of risk governance for the context of mountain risks. Based on the preceding analysis, the following conclusions can be drawn.

Over the recent decades, remarkable scientific progress in all related fields has been made and the complexity of dealing with mountain risk has gradually increased. Parallels can be drawn here to the “hydra effect” of risk, a principle stating that more risk science creates more risks (Covello and Mumpower, 1985).

The role of communication in dealing with mountain risks has significantly evolved, moving from intradisciplinary information exchange towards trans-disciplinary discourses, from single interventions towards international harmonisation, from the right to object towards risk dialogues, and information towards co-decision-making. Calls to continue this move towards intensified inclusion and specification, with respect to local risk cultures, have been raised from three sides, public in affected regions, science and international policy-makers. Stakeholder integration in the handling of mountain risks should be applied throughout all phases of the risk management cycle, from prevention

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and crisis management to reconstruction, as well as in risk assessment, risk evaluation and the development of mitigation measures.

Mountain risk management is currently at a stage of maturity. Standardised procedures, in accordance with the triad of risk assessment, risk evaluation, and risk mitigation have been developed for multiple mountain risks and are widely applied. Mountain risks are phenomena occurring at local and regional spatial scales (apart from large-scale floods); therefore, stakeholder integration must be implemented at relatively low administrative levels, e.g., at the (sub-)-municipality or regional level. The integration of stakeholders in local risk decision-making (bottom-up approaches) will produce locally specific outcomes.

Shared decision-making competencies and bottom-up approaches imply co-responsibility for the outcomes for all parties involved. The reversal of the historical trend towards increased state responsibility for mountain risks through the application of stakeholder participation is therefore foreseeable.

Risk governance follows the principles of inclusion and context specification, which are well-suited to the public, scientific, and political demands regarding the future dealing with mountain risks. Consequently, mountain risk governance can be regarded paradigm suitable for application.

Mountain risk governance is still in its infancy. Challenges in the application of mountain risk governance are manifold, as the new paradigm demands profound adaptations and innovations in all domains of dealing with mountain risks. Universal or standardised schemes for the application of mountain risk governance throughout the Alps will fail: the diversity of regional risk cultures and their respective institutional embedding calls for context-specific approaches. Here, only general challenges can be outlined.

In most cases, the existing legal regulations are currently in accordance with the principles of risk management (and vice versa). They rely on common rules such as the definite assignment of responsibilities. Legislation acknowledges only constitutionalised forms of participation. Instruments for the legal institutionalisation of stakeholder participation processes in mountain risk governance are yet to be developed, as are

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innovative regional risk-transfer mechanisms at the local, regional, and (inter-)-national levels. Questions concerning democratic legitimacy must be addressed at the national or regional levels, depending on the form of government involved.

Historical institutions in risk management are commonly characterised by rigid disciplinary boundaries and hierarchical organisation structures. The transformation towards the implementation of mountain risk governance will entail changes in self-conceptions and fundamental structural reorganisation. Mountain risk governance will fundamentally reposition all stakeholders including science, administrations and civil society: namely the primacy of experts will be replaced by dialogue among peers. The design of participatory processes demands communication, moderation, and mediation skills at all levels; as a result, qualification profiles will have to be adapted, not at least in the administrations. Social learning (e.g., McDaniels and Gregory, 2004; Pahl-Wostl et al., 2008) and adaptive management (e.g., Djalante et al., 2013) may provide promising approaches therefore.

The paradigm of mountain risk governance represents a significant evolution from past approaches. Nevertheless, it is strongly rooted in a history of over a century of the institutionalised management of mountain risks in the European Alps. Mountain risk governance and its associated rules, processes, and instruments are broadening the spectrum, but they cannot be seen as be-all and end-all replacements for existing risk management (Löfstedt, 2005).

Prior to the implementation of mountain risk governance, rules, specific instruments, administrative processes, and adaptations to legal frameworks must be developed and evaluated within regional risk cultures. Here, an urgent need for further research and development should be noted, as the effectiveness and acceptance of mountain risk governance will determine its overall societal value. At this point we can state: we think mountain risk governance is the right thing to do, but we don‘t yet know how to do it right.

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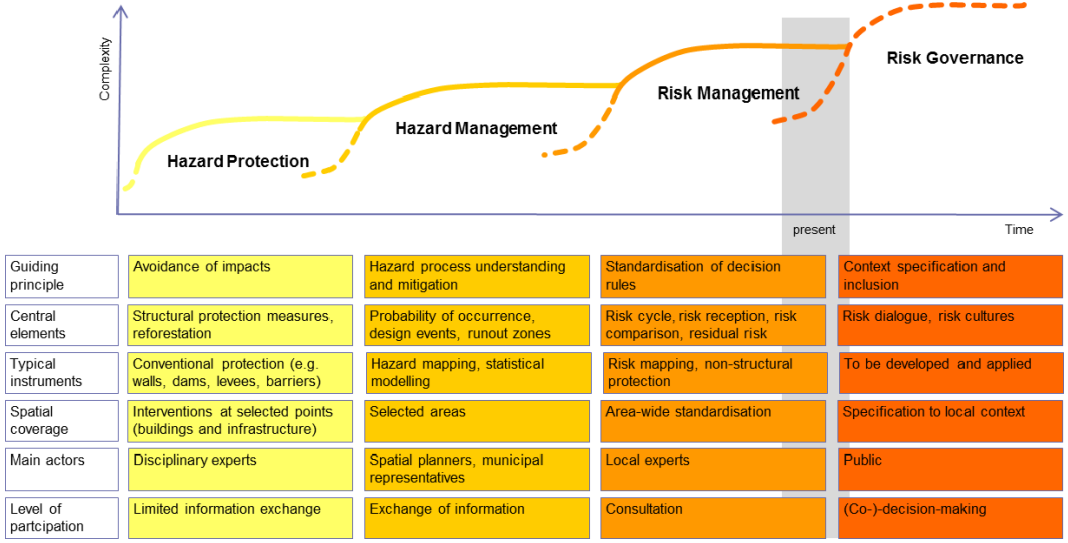

Guiding principle	Avoidance of impacts	Hazard process understanding and mitigation	Standardisation of decision rules	Context specification and inclusion
Central elements	Structural protection measures, reforestation	Probability of occurrence, design events, runout zones	Risk cycle, risk reception, risk comparison, residual risk	Risk dialogue, risk cultures
Typical instruments	Conventional protection (e.g. walls, dams, levees, barriers)	Hazard mapping, statistical modelling	Risk mapping, non-structural protection	To be developed and applied
Spatial coverage	Interventions at selected points (buildings and infrastructure)	Selected areas	Area-wide standardisation	Specification to local context
Main actors	Disciplinary experts	Spatial planners, municipal representatives	Local experts	Public
Level of partcipation	Limited information exchange	Exchange of information	Consultation	(Co-)-decision-making

Figure 1. Paradigm based model for dealing with mountain risks.

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The development of mountain risk governance

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