



Focus Issue: Addressing Challenges of Hazards, Risks, and Disaster Management in Mountain Regions

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Focus Issue: Addressing Challenges of Hazards, Risks, and Disaster Management in Mountain Regions

Dear Readers,

Healthy social–ecological systems in mountains are essential for reducing disaster risk and achieving sustainable development globally. Natural hazards and disaster risks in mountains differ significantly from those in lowlands, with multiple factors complicating disaster management and rescue operations in mountainous environments. Mountain social–ecological systems are highly sensitive to global warming, increasing climate variability, and related hazardous processes. Future scenarios include extensive melting of glaciers in mountain regions around the world, intrinsically interconnected with increased risks of glacial lake outburst floods (GLOFs). Furthermore, changes in precipitation patterns and the hydrological cycle involve changes in the cryosphere and vegetation cover. Altogether, these changes lead to more frequent disasters triggered by flash floods, landslides, or forest fires, with devastating consequences. Moreover, particularly in mountainous terrain, the interplay between geological setting and meteorological events often induces multihazard situations, leading to the simultaneous occurrence of several different hazard processes in the same location or their consecutive occurrence as cascading events (Kappes et al 2012; Terzi et al 2019). Disruption of livelihoods, increased pressure on natural resources, and effects on agricultural productivity, as well as food insecurity, land tenure, escalating poverty, and migration, are among the main areas of concern (Wymann von Dach et al 2017).

These challenges represent a clear need for paradigm shifts from classical natural hazard studies to a more holistic and comprehensive understanding of disaster risk, implying more complex and multifaceted perspectives for research and practice. In this sense, a strong commitment to integrated disaster risk management and its incorporation into sustainable development and climate change adaptation strategies are pivotal to reducing the vulnerability and exposure of mountain communities to hazards. This is even more significant in light of projections made by the Intergovernmental Panel on Climate Change (IPCC) Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC 2019), which indicates a general increase in risks associated with mountain hazards and risk drivers. Growing social inequality and marginalization, in particular, may exacerbate these risks (UNISDR 2009; UNDRR 2019). In this context, the often-neglected small-magnitude hazards that seriously affect local livelihoods as everyday disasters (eg destruction of irrigation infrastructure) also need to be considered (Nüsser et al 2019).

Correspondingly, in the most recently published IPCC Working Group II Sixth Assessment Report Cross-Chapter Paper on Mountains, Adler et al (in press) highlight the increasing impacts of climate change on mountains, their attribution to human influence, and how climate-related hazards have contributed to multiplying disasters. Because disasters affect a growing number of people in mountainous and downstream regions, the authors also emphasize the importance of increasing exposure as the main driver of disaster risk.

Against this background, it is important to further analyze the reciprocal links between disaster risk and sustainable development in mountains, including the implications for coping strategies and integrated disaster risk management in the context of socioeconomic inequalities and climate change. As identified by the Mountain Research Initiative, one important long-term and interconnected knowledge need is “to enable pathways and TRANSFORMATIONS to sustainability by identifying, assessing, and supporting decisions, policies, and actions, as well as their fitness-for-purpose in closing the problem–solution gap, specific to diverse mountain contexts, from the observed changes (systems knowledge) to the desired outcomes (target knowledge)” (Adler et al 2020: P2).

An aggravating factor in disaster management is that relief operations in remote mountain environments are often severely hampered by destroyed infrastructure and by shortcomings of key elements of emergency response, such as logistics, communication, first response activities, and humanitarian aid to support dispersed and often isolated communities. Adaptation strategies need to embrace an integrative continuum approach that spans all disaster risk management processes from prevention to recovery, including appropriate reconstruction and rehabilitation programs. Possible entry points for factoring climate change into disaster risk reduction (DRR) and risk management include hazard and vulnerability analysis and spatial planning coupled with risk monitoring and improved people-centered early warning systems. All these activities should be in line with implementation of the 2030 Agenda for Sustainable Development (UN 2015), the New Urban Agenda (UN 2017), the Sendai Framework for Disaster Risk Reduction (UNISDR 2015), the Paris Climate Agreement (UNFCCC 2015), and the Agenda for Humanity (UN 2016), leading to more tailored solutions to reduce disaster risks in mountain areas.

However, such global frameworks do not necessarily provide solutions at the local level. In addition, numerous recent DRR and development activities in support of these frameworks are often still dominated by Western narratives that, in part, obscure traditional and local Indigenous knowledge. Thus, they ignore the cultural and spiritual importance of specific mountain areas. The so-called process of “localization” of DRR, emergency response, and sustainable development activities is therefore a fundamental base for transformative resilience in mountain regions. Existing governance structures need to be redesigned, with local actors taking the lead in implementation (Szarzynski et al 2020).

In terms of future challenges, COVID-19 has made it even more evident that systemic and multihazard perspectives must be part of any DRR effort (Maskrey et al 2021; Tucker et al 2021). The need for a systemic and mountain-specific perspective also pertains to emergency preparedness and response, cascading risks, early warning–early action approaches (eg anticipatory action or forecast-based financing), and transboundary disaster risk governance. Interactions between hazards, vulnerability, and exposure configure emerging risks and pose significant challenges for policymaking in mountains. At the same time, the rapid strengthening of national ownership, enhanced regional capacities, and a strong

movement toward decentralization and localization across the humanitarian–development divide will shape the future of international assistance and development aid, requiring the international community to adapt better and faster.

This focus issue contributes to a better understanding of the dynamic and complex interconnections between hazards, underlying vulnerabilities, integrated disaster risk management, and resulting impacts in mountains, presenting insights on how to improve disaster management. It contains 8 peer-reviewed articles (3 MountainDevelopment articles, 2 MountainResearch articles, and 3 MountainAgenda articles) addressing diverse issues related to hazard and risk management in different mountain regions and presenting different types of knowledge.

Neelakshi Joshi and colleagues use a mixed methods approach to quantify the deficit in land use plans for mountain urban centers in Uttarakhand and explore the reasons for their absence. Their findings corroborate previous work suggesting that, while land use plans and building regulations are opportunities to incorporate disaster risk understanding in urban planning, outlining and enforcement demand both human and financial resources. These are often constrained in emerging countries. In the Himalayan region, when resources are available, they might be allocated to pressing daily necessities, such as waste collection and water provision. In their final views, despite probable financial constraints, the authors emphasize that the potential engagement of municipalities with universities and nongovernmental organizations could enhance existing local knowledge and capacities to address urban risks.

Induced by climate change and the resulting decline in glaciers, snow, and permafrost, Vatnajökull's Svínafellsjökull, an outlet glacier in southeast Iceland, has suffered a series of tourism challenges as a fracture formed in the surrounding Svínafellsheiði mountainside. This could lead to a large landslide that is likely to affect visitors. Stephanie Matti and coauthors conducted a series of semistructured interviews and extensive participant observation to address risk communication. They found that despite demographic changes, the local Icelandic inhabitants are the basic unit on which risk management processes focus, with implications for the way exposure is calculated and risk is communicated. Although most people living in the risk area were foreign tourism employees and tourists, the risk communication channels available to foreigners were generally one-way and often hampered by language barriers. The authors conclude that adapting risk communication to the needs of the tourism sector should be included in disaster risk policies, especially in the context of high uncertainty derived from the potential occurrence of sudden and large-scale hazards.

The relevance of implementing multihazard and people-centered early warning systems for Caribbean small island developing states is illustrated by Victoria L. Miller and colleagues. Looking at the impact of the explosive volcanic eruptions of La Soufrière volcano, St. Vincent and the Grenadines, in April 2021, they analyze the scientific and operational activities during an official response mission of the United Nations. In particular, they focus on the interplay and collaboration with the University of the West Indies. Outcomes reported from these efforts include an increased resiliency in St. Vincent to volcanic eruptions and frequent meteorological hazards and a series of important lessons concerning monitoring, responsibilities, communication, awareness, and preparedness. They also highlight the role of planning and mitigation to ensure volcanic hazard is a component of the multihazard approach adopted by authorities to guarantee the safety of communities and economic development.

Insights concerning linkages between local climate vulnerabilities and migration in the Indian Himalayan Region are provided by Riccardo Biella and colleagues. Based on a mixed methods approach, they developed a series of key quantitative indicators to express socioeconomic and ecological drivers of climate vulnerabilities. Structural factors, such as the unsustainability of rainfed mountain agriculture, the lack of alternative livelihood options, access to roads, and irrigation infrastructure are noted as critical to migration decisions. They also find an increase in migration among populations living in more rural areas, which is consistent with an increase in short-term labor migration, especially among men. A significant conclusion of Biella and coauthors is that, while climate change exacerbates risk, the role of uneven development processes and inequality in the region remains a cardinal challenge. Consequently, policies need to focus on bridging this gap by enabling sustainable livelihoods in rural mountain areas and considering long-term climate change adaptation needs.

From a hazard perspective, Koichi Sakakibara and Keisuke Suzuki performed a series of hydrological observations and monitoring to better explain the runoff dynamics influencing peak runoff in an alpine headwater under the Asian monsoon climate. They identify differences in runoff characteristics between melt and post-thaw seasons, which have implications for water-related hazards and disaster prevention. They observe that river flows respond rapidly to precipitation. Given that magnitude and timing of peak runoff generation are important for the implementation of prevention measures, they suggest the rainfall–runoff processes in alpine headwaters are simpler than in forests and other lower-elevation regions. This suggests that prediction of water-related hazards and the extent of damage based on precipitation records over the previous few hours can provide important insights for decision-making.

The MountainAgenda article by Alton C. Byers and coauthors provides a review of lesser-studied cryosphere-related hazards, with a focus on case studies in Nepal. Particular attention is paid to englacial conduit floods, debris flows, and earthquake-induced GLOFs. The authors argue for stronger integration of sophisticated technological approaches with adequate ground surveys and participatory approaches in future research to develop best practices in prevention, mitigation, and adaptation. The example of the disastrous Chamoli event that struck a Himalayan valley in Uttarakhand on 7 February 2021 (Shugar et al 2021) shows the need for early warning mechanisms and reassessing the construction of hydropower plants close to glacierized valley heads.

The contribution by Emilie Dupuits and colleagues examines institutional arrangements and local perceptions regarding the implementation of climate change adaptation policies in the Andes. Based on subnational case studies from Argentina, Bolivia, Chile, Colombia, Ecuador, and Peru, the authors analyze synergies, opportunities, and conflicts among different actors that potentially arise from adaptation policies. They show that climate change adaptation policies often lack coherence between initiatives designed at the national level and their adaptation to local realities. Based on their sociopolitical analysis, they argue for an agenda of multiscale and multiactor climate change adaptation governance as a strategy for Andean countries.

Romano Wyss and coauthors provide a scientific literature review about mountain resilience. Relevant dimensions include livelihoods, disaster prevention, community engagement, agriculture, tourism, economy, and forests. Their analysis reveals a major focus of published research on topics linked to DRR and ecology. The lack of integrated research, the absence of research on methods to evaluate resilience and of social–

ecological framing of resilience, and innovative and transformative capacities are identified. Interestingly, in their review, they highlight the need to better understand interdependencies not only among lowlands and mountain regions but also among cultural regions. Clearly, a deeper understanding of current challenges, especially regarding science–practice interactions and concrete action-based activities, is paramount to designing sound and sustained strategies for resilient mountain regions and communities.

The 2 reviews in the MountainMedia section discuss books that also address issues relevant for DRR. One book provides an excellent overview of most snow- and ice-related hazards, while the other presents experiences of applications of earth observation technologies for DRR in the Hindu Kush Himalaya.

Through a range of approaches, concepts, frameworks, and case studies, all these articles illustrate the deep commitment of research to reducing disaster risk and, in particular, to fostering partnerships among the great variety of DRR stakeholders.

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