

## Focus Issue: Adaptation to Climate Change and Sustainable Mountain Development—Assessing Approaches and Understanding Implications for the Future

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Source: Mountain Research and Development, 39(2) : 1-3

Published By: International Mountain Society

URL: <https://doi.org/10.1659/mrd.3902>

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# Focus Issue: Adaptation to Climate Change and Sustainable Mountain Development—Assessing Approaches and Understanding Implications for the Future

Dear Readers,

When the Intergovernmental Panel on Climate Change (IPCC) Working Group II contribution to the 6th Assessment Report (AR6, due in 2021) was being scoped, a number of stakeholders with a mountain focus from research, government, policy, and development communities highlighted the importance of mountains in global assessments such as those conducted by the IPCC. This ultimately led to the approval of a **cross-chapter paper on mountains**. The articles in this issue of MRD contribute to the body of literature that is being assessed by the IPCC in AR6, integrating mountain contexts and issues into the climate change adaptation debate. Mountains have long been recognized as being among the regions most sensitive to climate change (Beniston et al 1996; Kohler et al 2014), and yet many key drivers and processes in mountain environments remain poorly understood (Mountain Research Initiative EDW Working Group et al 2015). Despite these gaps, observed impacts are evident, both on ecosystems and for mountain communities, whose vulnerability and exposure to climate-induced hazards increase the risk of climate-related disasters (Hock et al 2019). From a climate justice perspective (see Hansen and Cramer 2015; Huggel et al 2016), there is an urgent need to support mountain people by improving our understanding of key drivers and processes of change, and therefore our data and information on observed and projected changes and impacts in mountains (Adler et al 2018), thereby enhancing their resilience, ie their ability to cope with change (adaptation) and to develop new options to address risks (IPCC 2018; IPCC 2019). This requires a better understanding of how climate change affects mountain ecosystems and societies; it also requires knowledge on innovative institutional, collaborative, socioeconomic, and other approaches to adapting to climate change in mountains; and—of course—it requires action.

The complexity of climate change and its impacts in mountain regions is one of the major challenges we face, especially as it is linked with other drivers of change. Addressing this complexity requires structuring and combining knowledge that draws on multiple lines of inquiry on these other drivers of change, for example through anticipatory planning that also looks at drivers of land use change. In the MountainDevelopment section of this issue of MRD, Welling and co-authors present a participatory scenario planning approach tested in Iceland. Their paper describes how they integrated all relevant stakeholders in discussions and decision-making about the future of glacier tourism in an area impacted by glacial retreat. Workshop participants were asked to reflect on what socioeconomic changes they assumed needed to be taken into account in addition to climate change scenarios; as a result, stakeholders reframed their guiding assumptions and will hopefully maintain their more future-oriented perspective.

Raising risk awareness requires adequate communication strategies that take into account the needs of intended audiences, especially given the diversity of social groups in mountain communities, as discussed by Weber et al in their paper focusing on improving awareness of people with a migrant background in rural Austria. Interestingly, they found that social networks and ownership structures—rather than ethnicity alone—had an important influence on people's ability to recover from past events and prepare for future events. They recommend developing target-group oriented communication channels to ensure that all sociocultural groups in mountain areas are properly informed about hazards in the places they live in or visit.

Risk awareness in relation to resource use in alpine pastures is also essential, as pasture use in century-old high-mountain farming systems has led to important biodiversity. Deléglise and co-authors propose a transdisciplinary process developed within the framework of the Sentinel Mountain Pastures project, to assess the vulnerability of the pastoral system across the French Alps. The aim of their comprehensive, 3-step assessment of pastures is to help farms adapt their pasture management in an effective way while maintaining the resilience of the system. This process is an important contribution to transformation knowledge and will hopefully also influence policy-making in the area.

In the MountainResearch section, 4 out of 5 articles offer insights from different, combined sources of knowledge for climate change adaptation and express awareness that the nature of the corresponding results is shaped by these different sources. Indeed, for science, another factor that contributes to the complexity of adaptation to climate change is that the required knowledge relies both on systematic empirical observations and on people's perceptions of the observed phenomena. In the Venezuelan and Colombian water user associations described by David Leroy, perception of climate change (seasonal, precipitation, and temperature changes) was only one factor for consideration with regard to adaptation. Just as relevant to farmers in both countries was their perception of the socioeconomic causes of water scarcity (increase in cultivated area and population, aging irrigation infrastructure, system management problems). Thus, Leroy concludes, it is essential to consider more than the "climate change factor" when assessing what elements influence adaptation strategies.

In addition to these factors that are not exclusively related to climate change, another complexity in the discussion of adaptation measures is the difference between quantitative and qualitative understandings of climate change phenomena. This is explored in the article by Kieslinger et al, who used an inter- and transdisciplinary approach to adaptation strategies in Ecuador: the authors analyzed qualitative and quantitative data on climate change and adaptation, concluding that local knowledge could help overcome the challenges of mountain specificities and contribute to selecting representative climate datasets, to better estimating local impacts of climate change, and to developing more fit-for-purpose and socially-acceptable adaptation policies.

Chakraborty and co-authors explore complementarities between sources of knowledge from yet another perspective. In their interdisciplinary study, they argue that the difference between the natural and social sciences is not the only factor that influences the nature and influence of produced knowledge: another source of complexity are the different epistemologies within mountain communities and the risk of not including perspectives that should in fact also be heard. On the one hand, they argue against using one source of knowledge to triangulate the other source, as each source should be heard in its own right. On the other, they suggest conducting parallel analysis to cover the different epistemologies and serve the ideal of equity, and illustrate this in an extensive analysis of perceptions of climate change in rural households in Uttarakhand, Indian Himalaya, and how these perceptions are rooted in communities' livelihood aspirations, the politics of disaster relief, and highland–lowland mobility.

In their long-term socio-hydrological analysis of remote, high-mountain study locations in 3 different areas in the Hindu Kush–Himalaya (Nanga Parbat region, Hunza–Karakoram, and Ladakh), Nüsser and co-authors discuss availability of water resources and explore adaptation practices. They show that local communities have developed sophisticated techniques to cope with water scarcity caused by glacier retreat, glacier thinning, and changing snow-cover dynamics. In this paper as well, methods from the social and natural sciences are combined, leading to a systemic understanding of the current situation.

Caleb Pan and colleagues present important results from research on the state of glaciers in northwestern Mongolia. Their study of glacier runoff in the Upper Khovd River Basin, using glacier measurements, satellite-derived glacier extent records, and a simple ice ablation model, shows that the tipping point has already been reached and the contribution of glaciers to water resources in the area is already declining. This poses significant challenges for future water resource management in the Mongolian Altai.

In their MountainAgenda paper, Gärtner-Roer and co-authors offer insights from their worldwide assessment of national glacier monitoring. They present their method for conducting an analysis of the gap between current implementation of glacier monitoring and the target implementation agreed upon in the international monitoring strategy developed by the Global Terrestrial Network for Glaciers. Given the importance of glacier shrinkage and retreat on the hydrological cycles within countries and across borders, it is essential to increase monitoring efforts. Empirical data will support analyses that generate information on how to increase the efficiency and acceptability of irrigation, energy production, and natural hazard prevention measures.

Finally, in the MountainPlatform section, Philbert Nsengiyumva presents the results of a desktop study conducted by the Albertine Rift Conservation Society (ARCOS) to compile latest knowledge on climate change trends, impacts, and existing adaptation initiatives in African mountains. He draws recommendations on how best to address the impacts of climate change in African mountains, insisting on the need for more research on mountains on this continent.

The articles in this focus issue present empirical findings on how communities in mountains and elsewhere address current and impending losses to what societies value, not least when faced with the exacerbating conditions that climate change brings. Collectively, they enrich our understanding of relevant aspects that align with a much needed and yet still understudied area of research, ie improving an evidentiary basis for climate change adaptation and its role in supporting climate-resilient development pathways in mountain areas (Adler et al 2019; Hock et al 2019). In climate change adaptation, “each case is unique [...] there is no ‘one best way.’ Nor are there ‘best’ practices—only better practices, assessed according to local circumstances” (Brunner 2014, p 6; see also Dilling et al 2019). In this respect, systematically harvesting, comparing, and assessing experiences with the unique conditions and mechanisms that lead to successes (or failures) in adaptation in any given mountain context, is a worthwhile pursuit for joint reflection among researchers, practitioners, and communities as relevant information for policy and decisions on adaptation.

In the Summary for Policy Makers of the IPCC's recent Special Report on the Ocean and Cryosphere in a Changing Climate (IPCC 2019), the urgency of action on climate change adaptation was very prominently highlighted, not least given the assessment conclusions that assert greater opportunities, effectiveness, and lower costs for adaptation under low emission scenarios, when compared to higher emission scenarios. The collection of evidence and experiences reported in this focus issue very much support the knowledge base needed to realize this goal, and we hope this provides an impetus to foster a rich scholarship on adaptation to one of the most pressing issues of our time.

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