



# Safer lives and livelihoods in mountains

Making the Sendai Framework for Disaster Risk Reduction  
work for sustainable mountain development

**Sustainable Mountain  
Development Series**



Sustainable Mountain Development Series

# Safer lives and livelihoods in mountains

Making the Sendai Framework for Disaster Risk Reduction  
work for sustainable mountain development

2017

This publication was supported by the Austrian Development Cooperation and  
the Swiss Agency for Development and Cooperation

Publisher:

Centre for Development and Environment (CDE), University of Bern, with Bern Open Publishing (BOP)  
Hallerstrasse 10, CH-3012 Bern, Switzerland  
www.cde.unibe.ch  
publications@cde.unibe.ch

© 2017 The Authors

This work is licensed under a Creative Commons Attribution-NonCommercial 4.0 International (CC BY-NC 4.0) Licence. See <http://creativecommons.org/licenses/by-nc/4.0/> to view a copy of the licence. The publisher and the authors encourage the use, reproduction and dissemination of material in this information product. Contents may be copied, downloaded and printed for private study, research and teaching purposes, or for use in non-commercial products or services, provided that the original authors and source are properly acknowledged and cited and that the original authors' endorsement of users' views, products or services is not implied in any way. Permission for commercial use of any contents must be obtained from the original authors of the relevant contents.

The designations employed and the presentation of material in this information product do not imply the expression of any opinion whatsoever on the part of the publisher and partners concerning the legal or development status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The mention of specific companies or products of manufacturers, whether or not these have been patented, does not imply that these have been endorsed or recommended by the institutions mentioned in preference to others of a similar nature that are not mentioned. The views expressed in this information product are those of the author(s) and do not necessarily reflect the views or policies of the institutions mentioned.

This publication was supported by the Austrian Development Cooperation and the Swiss Agency for Development and Cooperation.

Citation:

Wymann von Dach, S., Bachmann, F., Alcántara-Ayala, I., Fuchs, S., Keiler, M., Mishra, A. & Sötz, E., eds. 2017. *Safer lives and livelihoods in mountains: Making the Sendai Framework for Disaster Risk Reduction work for sustainable mountain development*. Bern, Switzerland, Centre for Development and Environment (CDE), University of Bern, with Bern Open Publishing (BOP). 78 pp.

DOI: 10.7892/boris.99068

ISBN (print): 978-3-906813-35-6

ISBN (e-print): 978-3-906813-36-3

Editors: Susanne Wymann von Dach (CDE), Felicitas Bachmann (CDE), Irasema Alcántara-Ayala (UNAM), Sven Fuchs (BOKU), Margreth Keiler (GIUB), Arabinda Mishra (ICIMOD), Elisabeth Sötz (WWF, Austria)

Authors and members of sounding board: see list on pp. 70–72

Concept: CDE, SDC and ADA, with contributions by BOKU, ICIMOD, GIUB, UNAM and WWF, Austria

Design: Simone Kummer (CDE)

Language editing: Tina Hirschbuehl and Marlène Thibault (CDE)

Proofreading: Stefan Zach (z.a.ch GmbH)

Printing: Werner Druck & Medien AG, Basel, Switzerland

The e-print is available at:

[www.cde.unibe.ch](http://www.cde.unibe.ch)

[www.sdc.admin.ch](http://www.sdc.admin.ch)

[www.mountainpartnership.org](http://www.mountainpartnership.org)

Cover photo: Goods had to be transported by boat after the Atta Abad landslide flooded 25 km of the Karakoram Highway, Pakistan, in 2010 (D. Butz)

# Contents

|  |           |
|--|-----------|
| <b>Foreword</b>  | <b>5</b>  |
| <b>Dynamic mountains – vulnerable communities</b>  | <b>7</b>  |
| Disasters threaten sustainable mountain development  | 8         |
| Diverse natural hazards – high human and economic losses                                       | 12        |
| <b>Sendai priority 1: Understanding disaster risks</b>   | <b>19</b> |
| <b>Uncovering causality of disasters and disaster risk in mountains</b>                        | <b>20</b> |
| From analysing geohazards to managing georisks   | 22        |
| Identifying vulnerable dwellings in urban slums  | 24        |
| Participatory risk assessment for priority setting   | 26        |
| Identifying and targeting vulnerable communities   | 28        |
| <b>Sendai priority 2: Strengthening governance</b>   | <b>31</b> |
| <b>Enhancing governance capacities and collaboration to manage disaster risks in mountains</b> | <b>32</b> |
| Effective risk management requires political will  | 34        |
| Strengthening disaster risk governance from the bottom up                                      | 36        |
| Analysing costs and benefits to set the right DRR priorities                                   | 38        |
| Preventing water disasters: Different interests, common goals                                  | 40        |
| <b>Sendai priority 3: Increasing resilience</b>  | <b>43</b> |
| <b>Linking risk reduction and development</b>  | <b>44</b> |
| Women-centric approach to enhance resilience   | 46        |
| Microinsurance to reduce impacts of climatic hazards   | 48        |
| Preventing the “White Death”: More than an avalanche dam                                       | 50        |

|  |           |
|--|-----------|
| <b>Sendai priority 4: Enhancing preparedness</b>             | <b>53</b> |
| <b>Strengthening local capacities for effective response</b> | <b>54</b> |
| Enhancing preparedness for glacial lake outburst floods      | 56        |
| “Why this storm ... this flood ... this hospital?”           | 58        |
| Fostering gender-inclusive emergency preparedness            | 60        |
| Earthquake-proof reconstruction                              | 62        |
| <br>   |           |
| <b>Enabling safer livelihoods in and beyond mountains</b>    | <b>65</b> |
| <b>Messages for policy-makers</b>                            | <b>66</b> |
| <br>   |           |
| Authors, editors, sounding board                             | 70        |
| References and further reading                               | 73        |

## Foreword

More than 900 million people live in mountain regions worldwide, where they face multiple natural hazards and increasing disaster risks. Mountain regions are particularly susceptible to earthquakes. In many places, the topography – in combination with heavy rainfalls, and compounded by land degradation – heightens the risk of frequent landslides and flash floods. In other mountain areas, extreme temperatures and droughts affect people's livelihoods. Mountains are among the most sensitive regions to global warming and intensifying climate variability, and it is likely that climate change will further increase the frequency of natural hazards.

Many of the people living in mountain regions – either in remote communities, rural centres or large cities – suffer from poverty and are highly vulnerable to shocks, stresses and other hazards. Safe zones in mountains are limited in space and often located next to land exposed to hazards. Rapid urbanization, population growth, infrastructure development and degradation of the environment result in ever more people and assets being pushed to the fringes of safe land. There, they become more exposed to natural hazards and, consequently, greater disaster risk – unless this is prevented by far-sighted planning and sustainable land management. Disasters associated with natural hazards not only jeopardize mountain people's livelihoods and the fruits of social and economic development, but also often strike people living in adjacent lowlands.

To reduce mountain people's vulnerability and exposure, a strong commitment to disaster risk reduction and its integration into sustainable development and climate change adaptation strategies is pivotal. The Sendai Framework for Disaster Risk Reduction 2015–2030 provides us with important guidance for reducing disaster risks, strengthening the resilience of affected populations and fostering coherent and concerted action at the local, national, regional and global levels. However, mountain regions deserve more specific attention in international frameworks due to the distinct challenges and disaster risks they pose for their inhabitants and for people living downstream in the lowlands.

The present publication highlights 15 cases of good practice in development and applied research from mountain regions, and illustrates how the Sendai Framework's four priorities can be put into practice. The publication aims to create awareness about the specific challenges mountain communities face in preventing, coping with and recovering from disaster risks, and to inform policy- and decision-makers how they can contribute to making the Sendai Framework instrumental for sustainable mountain development.

Austria and Switzerland – both mountainous countries – strongly support risk-informed development approaches in mountain regions. Disaster risk reduction and climate change adaptation will be key elements embedded into these sustainability endeavours in the years ahead. We therefore hope that this publication will help to raise awareness of the specific needs of mountain regions and their inhabitants, in order to contribute to inclusive and lasting development progress.



Manuel Sager  
Director General  
of the Swiss Agency for  
Development and Cooperation  
(SDC), Ambassador



Martin Ledolter, LL.M.  
Managing Director  
Austrian Development  
Agency (ADA)



Manuel Sager



Martin Ledolter

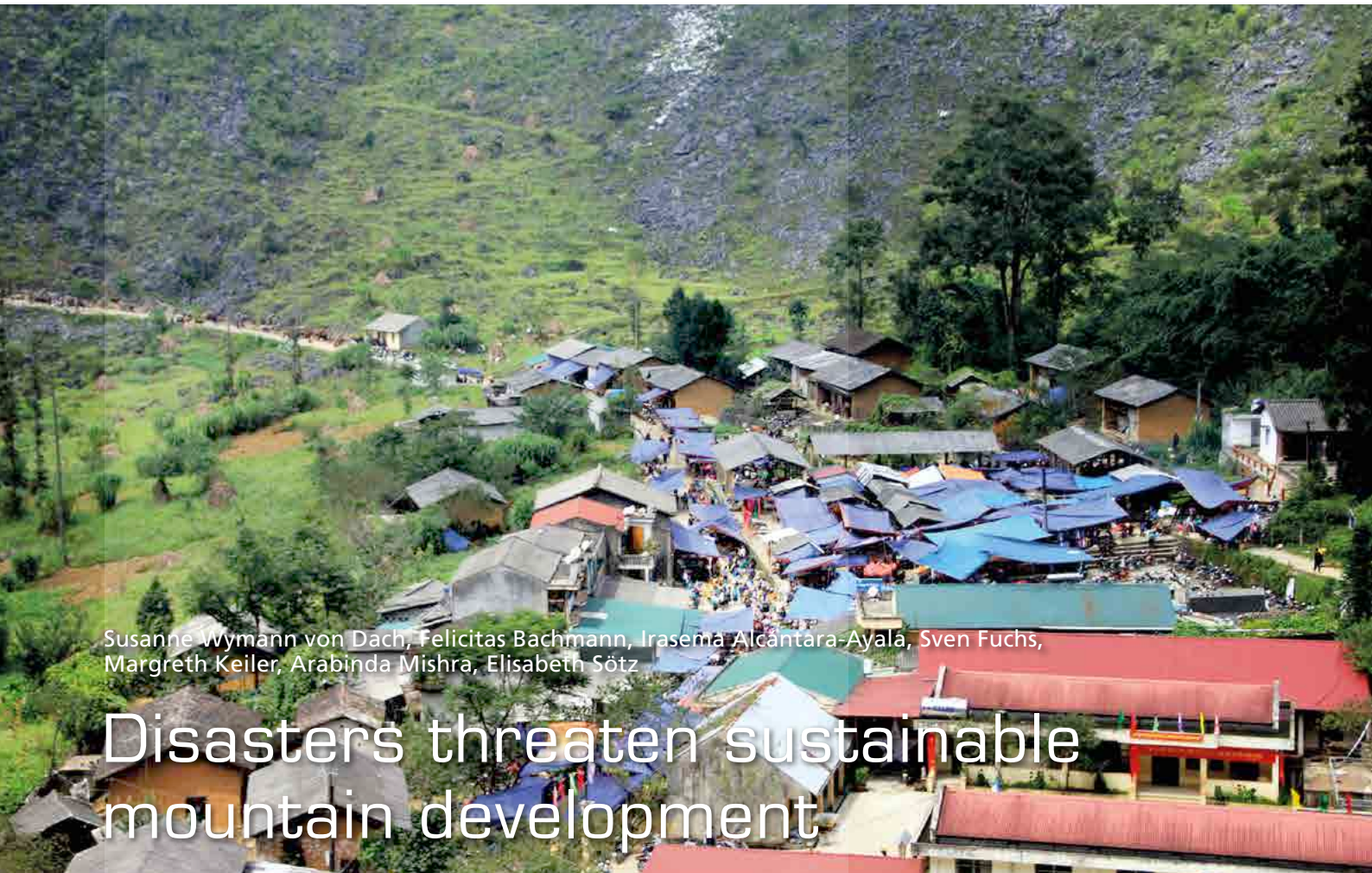




An aerial photograph of a mountain valley. The landscape is rugged and arid, with steep, rocky slopes and a wide, sandy riverbed. A small village with white buildings is situated on a hillside. The overall scene depicts a dynamic and vulnerable environment.

# Dynamic mountains – vulnerable communities

The village of Lingshed in Ladakh, India – a region affected by droughts, floods, retreating glaciers, migration and infrastructure development (C. Oberlack)



Susanne Wymann von Dach, Felicitas Bachmann, Irasema Alcántara-Ayala, Sven Fuchs, Margreth Keiler, Arabinda Mishra, Elisabeth Sötz

# Disasters threaten sustainable mountain development

Weekly market in a remote Hmong community in northern Vietnam (C. Oberlack)

Mountain people in rural and urban areas are highly exposed to multiple natural hazards. Often, they are vulnerable, also due to their precarious livelihoods, and may fail to cope with and recover from disasters. Dynamic changes have been increasing disaster risks in mountains. The Sendai Framework for Disaster Risk Reduction 2015–2030 offers opportunities to foster safer lives and livelihoods in mountains, if policy and practice consider the specific challenges of mountain regions and communities.

Living with natural hazards is a constitutive fact for mountain people. Geophysical and geomorphological processes have continuously formed mountain landscapes; however, as natural hazards they have limited the safe living space and threatened people's livelihoods in mountains and in the valleys downstream.

A 7.8 magnitude earthquake struck Nepal on 25 April 2015 and triggered more than 4 000 landslides, many of them in remote areas with difficult access. Nearly 9 000 people died, about 17 000 were injured and close to 500 000 houses were completely destroyed [1]. In Georgia, economic losses due to natural hazards total US\$ 115 million per year; nearly 60 percent of these are caused by some 500 mudflows and landslides in rural and urban areas [2]. In 2008, a heavy hailstorm occurred in the wine-growing area of Tarija, Bolivia, destroying the harvest of more than 1 000 smallholder families in just 30 minutes. In the Western Cape province, South Africa, an unexpected flash flood in 2013 affected 18 000 people

in informal settlements. And since August 2016, a series of earthquakes in the Abruzzo Mountains, Italy, have killed 300 people, left more than 25 000 without shelter and triggered massive snow avalanches that buried several dozen people in January 2017.

These devastating events demonstrate rural and urban mountain societies' exposure and vulnerability worldwide to natural hazards. Social and economic achievements are under threat if development activities are not implemented in a risk-informed and risk-reducing way.

### **Are mountains particularly prone to hazards?**

Mountains are certainly not the only context at risk of disaster linked to natural hazards. But mountains differ from other regions due to the frequent occurrence of a variety of hazards (see Stäubli et al., pp. 12–17) in one place – hazards that often also trigger secondary, cascading hazards. Moreover, hazards impact not only the area of occurrence but often also affect communities up- and downstream. This complex situation makes it challenging to predict hazards and their effects [3]. For example, earthquakes destabilize slopes and snow packs, leading to landslides, mudflows and avalanches that in turn can block waterways and increase flood risks downstream. The massive Atta Abad landslide in northern Pakistan in 2010 is a striking example of such cascading multidimensional and highland–lowland effects. The landslide blocked the narrow valley and led to flooding of 25 km of the Karakoram Highway. In the immediate disaster, 19 people died and more than 500 families were displaced. Subsequently, upstream communities experienced economic losses and social and emotional impacts due to disrupted mobility. Trade in cash crops and food supplies was blocked, access to health services was hindered, and it was challenging to maintain family ties [4].

### **Are mountain communities at increased exposure to risk?**

In mountain areas, land suitable for human use is very limited. It is often concentrated in valley floors where settlements, main transport routes, critical economic and social infrastructure (schools, hospitals and energy and industrial facilities) and productive agriculture compete for the limited land resources. Moreover, hazard-safe and hazard-prone areas are often very close – with areas susceptible to different hazards sometimes partly overlapping – thus making the clear demarcation of safe zones a challenge [3]. The competition for safe land is intensifying, as the worldwide population in mountain areas continues to increase – from 789 million people in 2000 to more than 915 million in 2012 (16 percent). This increase is even more pronounced in urban mountain areas, where population growth was up by 33 percent during the same period. In 2012, about 273 million people lived in urban mountain neighbourhoods. However, the share of urban residents differs significantly from one mountain region to the other: In Latin America and developed countries, more than 50 percent of mountain people live in cities; in Asia this figure is 21 percent and in Africa only 16 percent [5]. Overall, the increasing pressure on land tends to push vulnerable people into unsafe areas, exposing them to higher hazard risks; in many cities, for example, informal settlements have sprung up on steep and unstable slopes. Moreover, the dense concentration of housing, economic activities and infrastructure in urban areas – and, increasingly in rural areas with good access – means economic losses are intensifying when natural hazards cause destruction.



### Are people who live in mountains particularly vulnerable?

Whether the prevalent natural hazards eventually result in disasters is determined less by environmental conditions than by people's resilience and vulnerability – i.e. their capacity to anticipate, cope and recover from an event (Box 1). Mountain people's vulnerability to disaster is often too simply ascribed to their unstable and precarious livelihood base in mountains and the remoteness of their living space. Although these are important factors that possibly co-determine mountain people's vulnerability, they reflect only a part of the diverse and complex reality. Mountain people have always sought to minimize their risks by diversifying and adapting their livelihood strategies and institutional arrangements to changing conditions. In doing so, they were able to develop resilience to some extent. However, in the context of the development of modern statehood and globalization, the dynamics and dimension of socio-economic, environmental and climate changes in mountains and beyond have strongly increased during the last decades. Many processes and activities have taken place aimed at fostering the economic and social development in mountains: urbanization; construction of access and transit roads, hydropower plants and dams; intensification of agriculture; and development of infrastructure for tourism. But these infrastructural improvements have also had secondary effects, resulting in increased vulnerability of parts of the local population, undermining their social fabric and weakening traditional coping strategies [6].



People living in Eritrean mountains are vulnerable to droughts (P. Roden)

#### BOX 1 | A few indications of mountain people's ...

##### ... vulnerability

- About 40 percent of mountain people in developing and transition countries are vulnerable to food insecurity [5]
- Poverty is widespread. E.g. in the Andes, two-thirds of people live in poverty; in the Hindu Kush Himalayas, poverty rates are higher in the mountains than in the lowlands
- High outmigration, particularly of young men
- Livelihoods of people living in informal urban settlements are often insecure
- Rural communities are at the periphery of economic development and politically underrepresented
- Remoteness and difficulty of access hinder relief and recovery efforts
- Lack of hazard-resistant houses and infrastructure

##### ... resilience

- Diversified and adapted livelihood strategies to minimize risks
- Traditional institutional arrangements and social cohesion to cope with disasters
- Traditional local knowledge of hazard risks and risk management

### The Sendai Framework helps to mitigate risks in mountains

Since the start of the United Nations International Decade for Natural Disaster Reduction (1990–1999), international endeavours such as the Yokohama Strategy for a Safer World (1994) or the Hyogo Framework for Action 2005–2015 have aimed at reducing disaster risks and strengthening the resilience of nations. But despite these international efforts, disasters in mountains have further increased, affecting more and more people and bringing about higher human and economic losses. Up to now, mountains as a particularly challenging context have received little explicit attention by these international policy debates [3], nor have they been considered explicitly in global assessments of DRR achievements [7]. The latest agreement is the Sendai Framework for Disaster Risk Reduction, adopted in Japan in March 2015, as a follow-up to the Hyogo Framework (Box 2). But can it help to halt or even reverse the trend in mountains and enhance the resilience of mountain communities, including their capacity to anticipate natural hazard risks, to cope with and to recover from disaster?

The Sendai Framework for Disaster Risk Reduction sets forth four priorities for action: understanding risks, strengthening disaster risk governance, investing in disaster risk reduction (DRR) for resilience, and enhancing preparedness (Box 2). These priorities for action are imperative to reducing disaster risks in the mountains. However, to be fully effective, they must be adapted to the particular challenges faced by mountain people, also with regard to changes in risk patterns triggered by the effects of climate change and dynamic socio-economic developments.

#### BOX 2 | Sendai Framework for Disaster Risk Reduction 2015–2030

The Sendai Framework for Disaster Risk Reduction aims to achieve seven global targets by 2030 [8]. These are, to substantially reduce: disaster mortality, the number of people affected by disasters, economic losses, damage to critical infrastructure and disruption of basic services. The targets also call for a significant increase in the number of countries applying DRR strategies, the international cooperation fostering DRR and the implementation of multihazard early warning systems. To achieve these targets, the Sendai Framework sets forth four priorities for action at different levels, from local to global:

**Priority 1:** Understanding disaster risk.

**Priority 2:** Strengthening disaster risk governance to manage disaster risk.

**Priority 3:** Investing in disaster risk reduction for resilience.

**Priority 4:** Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation and reconstruction.

This insight was the impetus for preparing the present publication. We portray 15 good practices and applied research for DRR from mountains around the world, to illustrate how the priorities of the Sendai Framework can best be put into practice. Our case studies highlight the need for integrating DRR measures with development interventions driven by the 2030 Agenda for Sustainable Development [9] and climate change adaptation and mitigation measures. The studies are intended to provide guidance for policy-makers at the local, national and global levels, on how to make living in mountains and their lowlands safer, and secure development gains in the long term.



A new road boosted development of the market place of Dhaule Bazaar, Nepal, in a risk zone (T. Lennartz)



Anina Stäubli, Samuel U. Nussbaumer, Simon Allen, Christian Huggel, Susanne Wymann von Dach

# Diverse natural hazards – high human and economic losses

Mountain systems are very diverse and so is the pattern of natural hazards. Worldwide disaster databases show that associated human and economic losses are significant but vary greatly between and within mountain regions. Continued changes in climate, land use and socio-economic conditions are likely to lead to vastly altered mountain landscapes in the future, with associated implications for hazards and impacts on sustainable mountain development.

Mountains are high-risk environments and they experience multiple hazards, many of which are exclusive to mountain regions (Box 1). Seismic and volcanic activities, geology, topography, climate, vegetation and land use determine the variety, intensity and dimension of hazards. Multiple hazards can occur in one place, and one event can trigger others. The pattern can vary greatly from one mountain region to another, and from one valley to another. This makes it difficult to capture the diversity of hazard environments and to provide an overview of the enormity of hazard events in mountains worldwide. In the following, we draw on two global databases that register geophysical and hydrometeorological hazards with significant social and economic impacts. Nonetheless, the insights present only a part of the whole picture: The databases do not register small-scale but frequent events, nor do they reveal the socio-economic drivers of the disasters.

The Obishur watershed in Muminabad district, Tajikistan, experienced severe losses after a flood in spring 2012 (S. Odinaohev)

## BOX 1 | Natural hazards in mountains and lowlands

(categories adapted from [www.desinventar.net](http://www.desinventar.net))

| Hazard category       | Mainly in mountains                         | In mountains and lowlands                         | Mainly in lowlands |
|-----------------------|---|---|--------------------|
| <b>Geophysical</b>    | Rockfalls                                   | Earthquakes, volcanic activities                  | Tsunami            |
| <b>Hydrological</b>   | Landslides (debris / mud flows), avalanches | Floods (riverine and flash)                       | Coastal floods     |
| <b>Meteorological</b> |   | Cyclones, storms, hail, extreme temperatures, fog | Wave action        |
| <b>Climatological</b> | Glacial lake outburst floods                | Drought, wildfire                                 |                    |

### High seismic activity destabilizes mountains

Mountains are often located in zones with elevated seismic activity and a high risk of volcanic eruption. Although mountains cover only about 22 percent of the world's land surface, more than 37 percent of the 4 491 significant earthquakes since the year 1800, and more than 80 percent of the significant volcanic eruptions have occurred in the mountains (Figure 1) [1, 2]. Overall, 55 percent of mountain areas worldwide (compared to 36 percent of non-mountain areas) are susceptible to destructive earthquakes [3]. Through their destabilizing effects, earthquakes often trigger cascading hazards, such as landslides.

### Pattern and impacts of hydrometeorological hazards in five regions

Mountain regions are also highly prone to major hydrometeorologically induced disasters caused by mass movements (e.g. avalanches, landslides, debris flows), floods, storms, extreme temperatures and climatologically induced disasters (e.g. due to droughts and wildfires) (Figure 2). However, the following examples from five selected mountain regions (Hindu Kush Himalayas, Eastern African mountains, Andes, Central Asia and the European Alps) point out the heterogeneity of mountain "risksapes". The data presented are based on the Global Emergency Disaster Database (EM-DAT, see Box 2).

#### *Monsoon-triggered flooding in the Hindu Kush Himalayas*

More than half of the major disasters in the Hindu Kush Himalayas are due to floods, followed by mass movements that account for about 30 percent of the registered events causing damage. Floods often occur during the summer months due to the monsoon, and affect mainly the northern parts of Afghanistan and Pakistan, northwestern India and western China. For example, the 2013 Kedarnath disaster in northern India was linked to the early onset of heavy monsoon rainfalls triggering the catastrophic outburst of a small moraine-dammed glacial lake [4]. In Nepal alone, 21 glacial lakes out of the identified 1 466 glacial lakes were assessed as potentially critical [5], with the risk of exposure to such events intensified by increasing infrastructure and habitation in the high mountain regions of the Hindu Kush Himalayas [6].

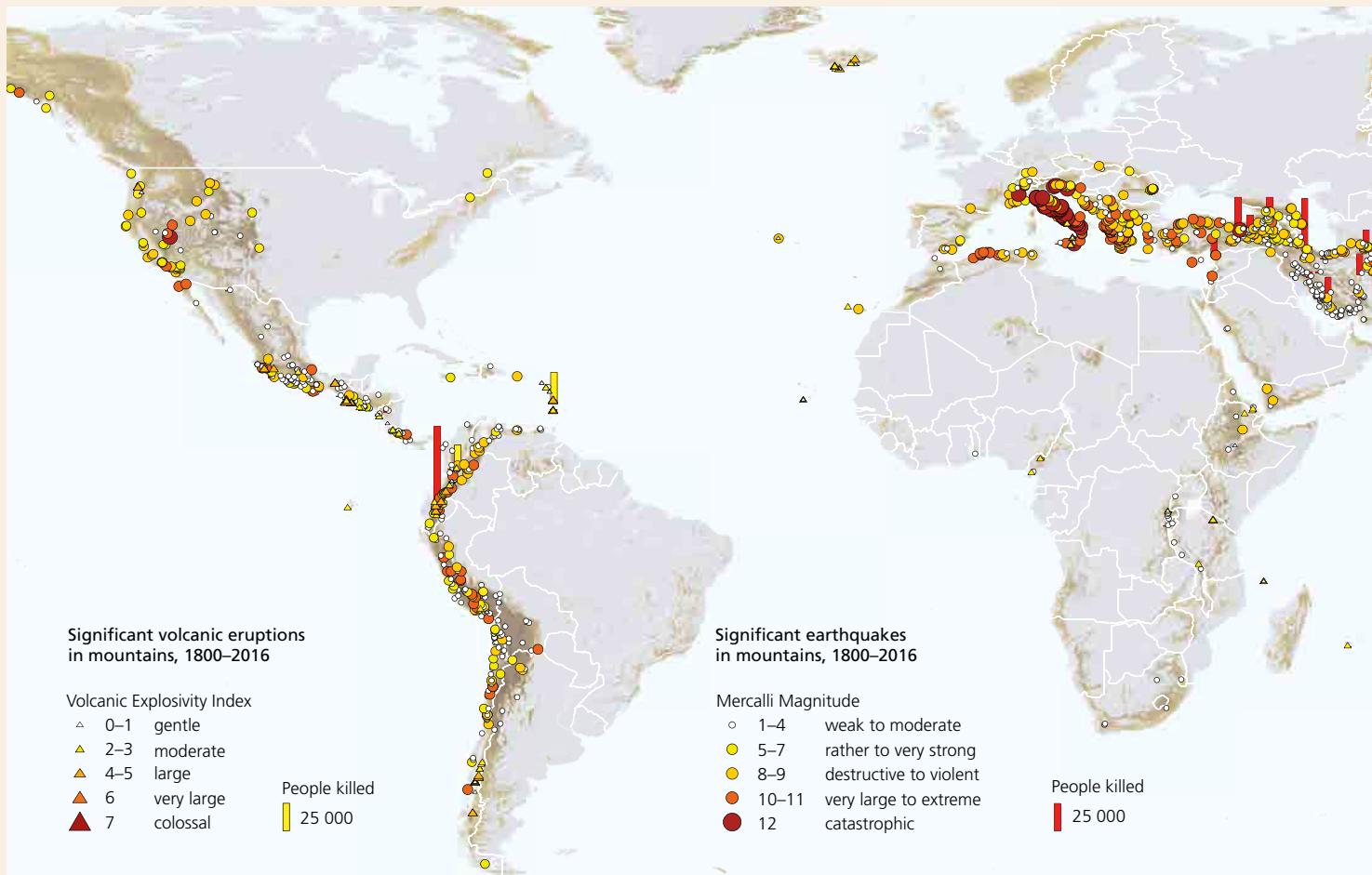
#### *Eastern African mountains hit by droughts and floods*

In the Eastern African mountains, disasters are most frequently triggered by floods (65 percent), followed by droughts (18.4 percent) and storms (8.6 percent). However, analysis of the registered disasters showed that drought-induced events affected about ten times more people than floods and storms. The frequency of drought events may be underestimated as they are more difficult to capture and do not destroy infrastructure. Experience from Kenya shows that droughts have a smaller impact in the highlands than in the lowlands because the topography

## BOX 2 | Global Emergency Disaster Database (EM-DAT)

The EM-DAT is the most complete public global database on disaster loss for large events at the national scale [7]. It covers natural and technological disasters from 1900 onwards and is based on various reliable sources. EM-DAT includes all disasters conforming to at least one of the following criteria:

- 10 or more people died;
- 100 or more people affected;
- Declaration of a state of emergency or a call for international assistance.





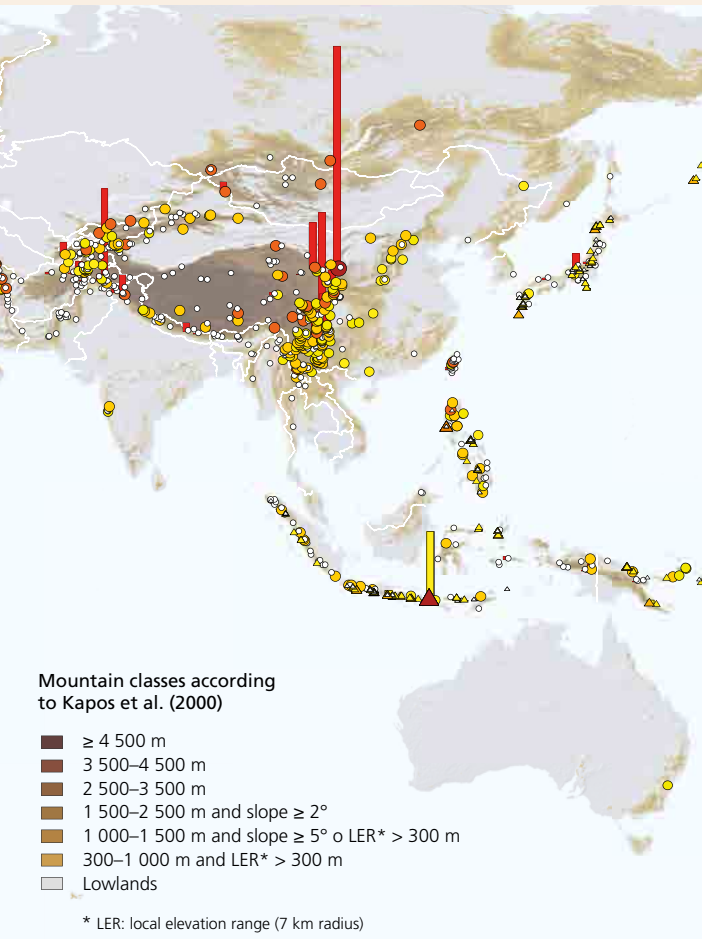


Figure 1. Map of significant earthquakes and volcanic eruptions that occurred between 1800 and the present in mountains. A significant earthquake is classified as one that meets at least one of the following criteria: moderate damage (ca. US\$ 1 million or more), ten or more deaths, magnitude 7.5 or greater, modified Mercalli Intensity X or greater, or the earthquake generated a tsunami. A significant eruption is classified as one that meets at least one of the following criteria: fatalities, moderate damage (ca. US\$ 1 million or more), Volcanic Explosivity Index (VEI) 6 or larger, the eruption caused a tsunami, or the eruption was associated with a significant earthquake. Definition of mountain areas according to [8]. Map by Juerg Krauer and Ulla Gämperli Krauer, Centre for Development and Environment, University of Bern. Data source: [1, 2]

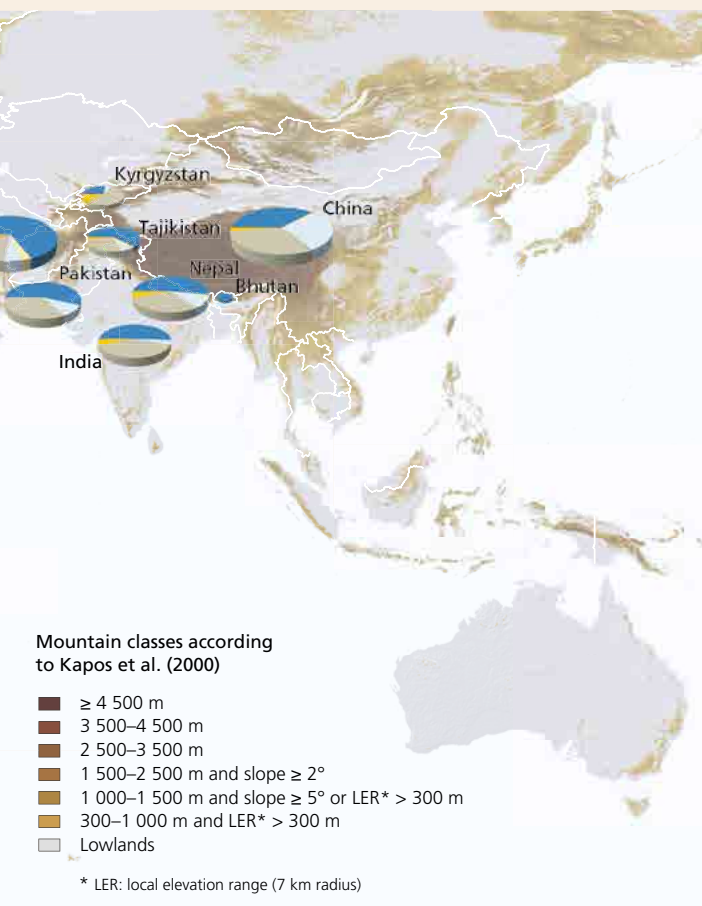


Figure 2. Occurrence of major disasters associated with six types of natural hazards between 1985 and 2014 in five selected mountain regions: the Andes, the European Alps, the Pamir Mountains and the Tien Shan in Central Asia, the North and Eastern African mountains and the Hindu Kush Himalayas. Definition of mountain areas according to [8]. Map by Anina Stäubli, Department of Geography, University of Zurich, Juerg Krauer and Ulla Gämperli Krauer, Centre for Development and Environment, University of Bern. Data source: [7]

generates some rain even in dry periods. Nonetheless, mountain areas are more vulnerable overall, as their population and its density are much higher than in the lowlands.

#### *Floods and mass movements affect the Andean region*

The orographic effects of the Andean Cordillera lead to abundant precipitation that is even more pronounced during El Niño years. This often results in severe floods (50 percent of the registered disaster events), causing damage in the densely populated foothills of the Andes and significant mass movements (28.7 percent). A closer look shows that the Central Andes of Peru and Bolivia are the most disaster-prone areas in the Andes – where natural hazards more often turn into disasters – due to their higher population density and vulnerability. Apart from these hydrometeorologically and climatologically induced disasters, the Andes are among the highest seismic-risk areas globally (cf. Figure 1).

#### *Mass movements and floods affect Kyrgyzstan and Tajikistan*

Rainfall is a main trigger of hazards in the mountainous areas of Kyrgyzstan and Tajikistan. More than 5 000 potential landslide sites have been identified in Kyrgyzstan [9], mainly in the south, in the foothills of the Fergana Basin. Tajikistan is most exposed to flood disasters, due to intense rainfalls in the high mountains and outbursts of some of the numerous glacial lakes. In contrast to the Hindu Kush Himalayas where there is a distinct monsoon influence, the climate in Central Asia is continental arid and semi-arid, with maximum precipitation in spring during the northward migration of the Polar front.

#### *Floods and avalanches predominant in the European Alps*

The European Alps are heavily affected by floods, while mass movements including avalanches account for a third and storms for a fifth of the major disasters as recorded in EM-DAT. Snowmelt in spring is an important contributing factor for floods and mass movements in the Alps, together with heavy rainfall events which occur also later in the year.

The impacts of these natural hazards on mountain people vary depending on their exposure, resilience and capacity for risk management. In the Hindu Kush Himalayas, significantly more people are affected by an average event than in Central Asia. An average event affects about the same number of mountain people in Eastern Africa as in the Hindu Kush Himalayas, and while livelihoods in both places were highly affected, economic losses in Eastern Africa were considerably lower (Table 1). However, the data reveal only a part of people's reality, as entry criteria for disaster databases are often biased towards economic and monetized loss (and there is less economic value to be lost in poorer countries). Moreover, the data do not capture the frequent small events that also threaten people's livelihoods. In Georgia, for example, more than 380 landslides were recorded per year between 1995 and 2010. Cumulatively, these landslides caused significantly higher economic losses than the fewer but bigger flood events [10, 11].

| Mountain region        | Number of disasters | Economic losses (in million US\$) | Number of people killed | Number of people affected | Mountain population, 2012 [12] |
|------------------------|---------------------|-----------------------------------|-------------------------|---------------------------|--------------------------------|
| Hindu Kush Himalayas   | 323                 | 44 690.4                          | 26 991                  | 165 694 879               | 286 019 683                    |
| Eastern & North Africa | 163                 | 1 246.8                           | 4 881                   | 76 127 779                | 146 108 040                    |
| Andes                  | 150                 | 3 138.4                           | 6 664                   | 13 006 871                | 73 090 954                     |
| Central Asia           | 39                  | 257.4                             | 700                     | 3 518 763                 | 4 012 359                      |
| European Alps          | 38                  | 7 245.0                           | 607                     | 33 011                    | 22 814 551                     |

Table 1. Major hydrometeorological hazards (mass movements such as avalanches, landslides and debris flows, as well as floods, storms, extreme temperatures, droughts and wildfires) and their impacts between 1985 and 2014 in five mountain regions based on EM-DAT [7]. Smaller events, even such affecting people and the local economy, are not included (criteria see Box 1).

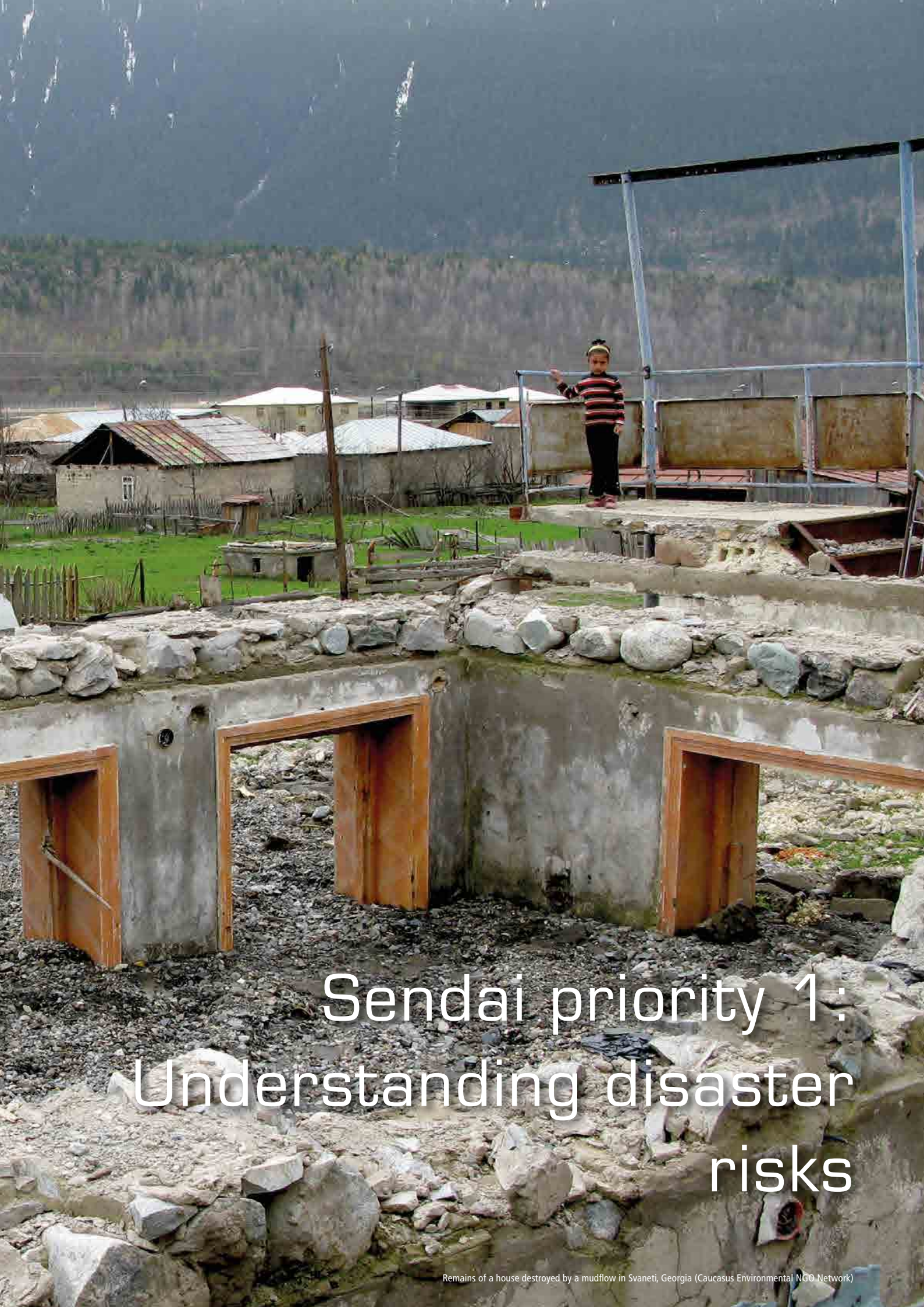


In 2013, debris flows devastated the village of Kedarnath and downstream settlements in Uttarakhand, India (V. Kaul)

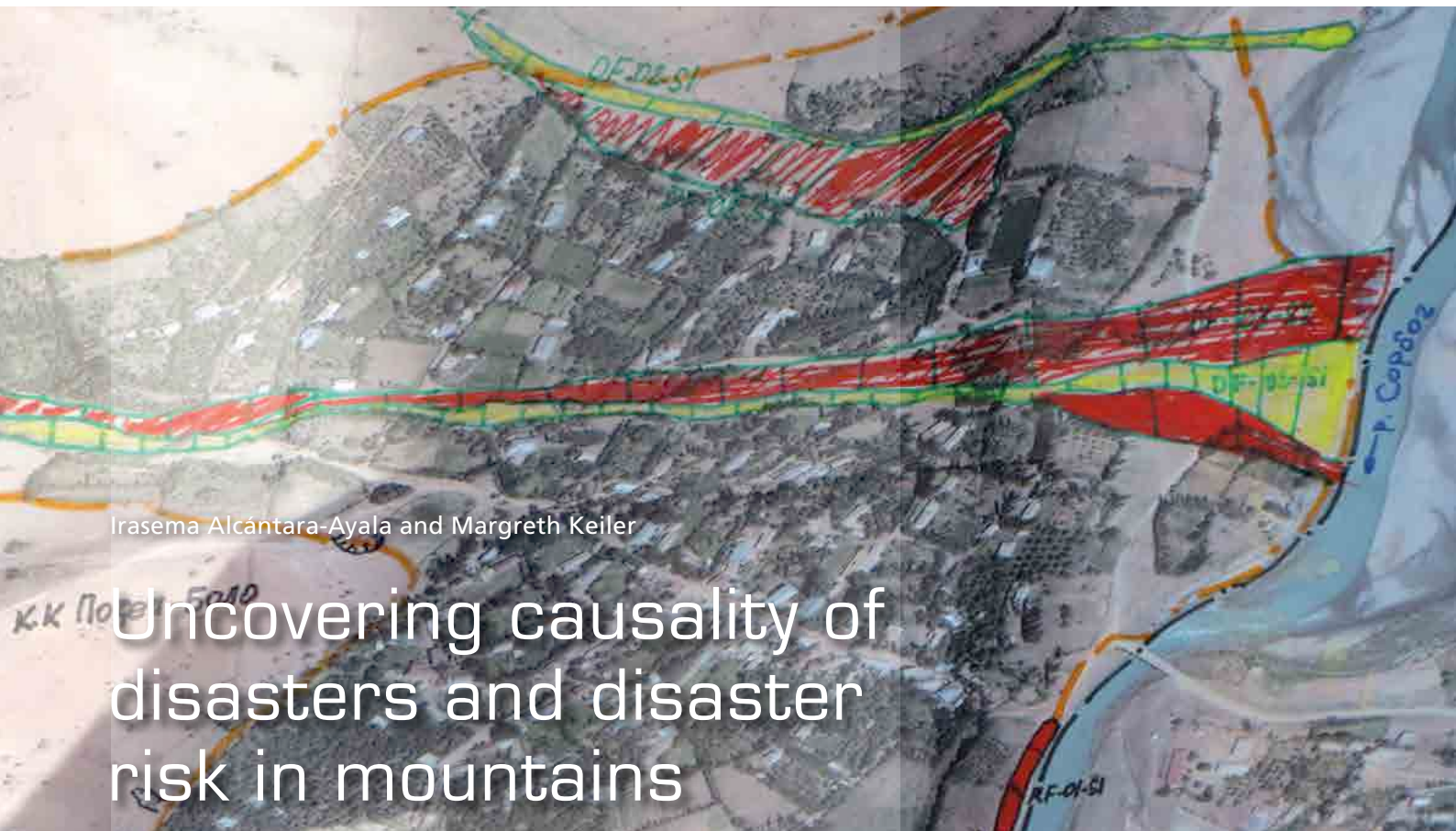
### **Global change is increasing natural hazard risks**

There is a high probability that the disaster risk associated with natural hazards will increase in the future as a consequence of projected climate change and additional stressors. These additional stressors include poor governance and land use practices, land use changes, growth of settlements and infrastructure in hazard-prone areas, tourism expansion and ecosystem degradation. Climate change is altering the magnitude and frequency of hydrometeorological hazards through observed and projected increases in extremes of temperature and precipitation in many mountain regions. While temperature extremes and related melt events (short- or long-term, e.g. snowmelt in spring, or extreme glacier melt during a summer heatwave) are projected to increase globally, there is greater uncertainty and variation in future projections of heavy rainfall events [13]. In general, climate models show a trend of currently wet regions becoming wetter, and dry regions becoming dryer. This means that flooding and landslides can be expected to increase, most significantly across tropical mountain regions. For glaciated catchments, the contribution of glacier melt to overall runoff is generally expected to increase due to greater ice melt in the near future, but to decrease afterwards when there is less ice. Irrespective of extremes, the current retreat of glaciers and degradation of permafrost in response to changes in the mean global temperature will lead to further destabilization of high mountain slopes [14]. As new glacial lakes continue to expand in response to warming, the threat of ice or rock avalanches impacting lakes and triggering catastrophic downstream flooding is thus of paramount concern across populated high mountain regions of Asia, North and South America and Europe [15].





# Sendai priority 1: Understanding disaster risks



Irasema Alcántara-Ayala and Margreth Keiler

# Uncovering causality of disasters and disaster risk in mountains

Fostering disaster risk reduction in mountains within a sustainable development framework goes beyond response or recovery from impacts. It requires a change in disaster perception, people's understanding of the social construction of risk, and the engagement of local stakeholders. Scientific knowledge on hazard processes must be complemented by in-depth knowledge of root causes of mounting exposure and vulnerability driven by globalization-related social changes.

Priority 1 of the Sendai Framework for Disaster Risk Reduction states that *"policies and practices for disaster risk management should be based on an understanding of disaster risk in all its dimensions of vulnerability, capacity, exposure of persons and assets, hazard characteristics and the environment"* [1]. In mountain areas, local knowledge and practices should be combined with scientific knowledge to assess disaster risk, to achieve the cross-sectoral implementation of policies and practice.

Mountains are diverse and complex systems where hazards are related to seismic and volcanic activity as well as instability of slopes under different tectonic, geological and climate conditions, and subjected to the influence of anthropogenic activities. Mountains are home to people of diverse sociocultural backgrounds. They are characterized by dynamic social and environmental processes, and face different conditions of exposure, vulnerability and risk.

The magnitude and frequency of disasters associated with mountain hazards have increased noticeably in the last decades. Nonetheless, people still do not fully understand that disasters are not caused by extreme natural events, but by human agency as the prime factor of the multidimensional dynamics of disaster risk [2, 3].

Hazard map of the Rasht valley, Tajikistan. Such maps were jointly developed by locals and engineers for decision-making in the community (M. Keiler)

*"Do not let it happen: understand why and how disaster risk is socially constructed, to avoid creating new disaster risks."*

Although in the past communication programmes were developed to improve information exchange on disaster risk reduction (DRR) in mountain areas, they have often fallen short of enhancing understanding about the underlying or root causes of disaster risks. Media information has induced the understanding of disasters as synonymous with emergency response. Hence, for developing effective DRR, these questions need to be answered: Why and how does exposure and vulnerability of mountain societies persist or continue to grow in the short, medium and long term, and lead to an enduring increase in losses and in disaster frequency and magnitude? The Forensic Investigations of Disasters approach addresses this deficiency (Figure 1). Based on the understanding that unfolding historical processes at different scales configure the particular circumstances in which disasters occur, it helps to reveal how human actions and choices can explain the magnitude of losses and damage [3].

Frequent occurrences of multiple hazards of both low and high magnitude, proximity of safe and hazard-prone areas, and climate variability and change are among the main issues faced by mountain communities. It is of primary importance to comprehend drivers of increasing inequalities [4, 5] and how these, together with other social processes, shape the diverse patterns of exposure and vulnerability of mountain people (see Bastide et al., pp. 28–30) – including the elderly, women, children and those with disabilities – and thus aggravate risks and/or create new forms of risk. Globalization and related social, economic, cultural, political and institutional changes lead to increasing interactions between highland and lowland, and become in some places more significant than dimensions of remoteness, isolation, relative inaccessibility and the extremely complex and difficult terrain of mountains.

The key point made in integrated research on disaster risk [2] is that sustainable practices by indigenous peoples and local communities in mountain areas can have positive effects for both decreasing vulnerability and exposure, and increasing resilience. The most appropriate mechanisms to understand disasters and disaster risk must be the identification and recognition of their underlying or root causes through effective multistakeholder engagement and a strong understanding of local conditions as shown by Padrón Chacón (pp. 24–25) and Stolz and Fleiner (pp. 26–27). Disaster risk reduction and management require better scientific and technical understanding of hazards (see Michellier et al., pp. 22–23) and, most importantly, strategies of development that directly address human pressures on resources and the use of the territory as critical components of the social construction of disasters.

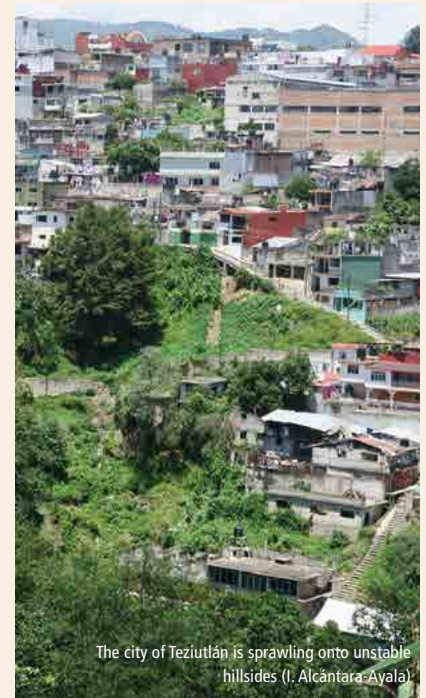


Figure 1. Understanding disaster risk: the key relationships and processes in the social construction of risk. Source: based on [2]

# From analysing geohazards to managing georisks



Caroline Michellier, François Kervyn, Olivier Dewitte

Recurrent conflicts and tensions in the mountain region around Lake Kivu, Democratic Republic of Congo, trigger migration towards rapidly growing urban centres. Natural hazards put this densely populated region under additional pressure. As a base for effective disaster prevention and risk management, the GeoRisCA project provides the relevant institutions with risk maps combining hazard and vulnerability assessments.

Studying and monitoring volcanic activity at Nyiragongo (N. d'Oreye, MNHN/ECGS)

A combination of seismic, volcanic and landslide hazards threatens the densely populated, mountainous area around Lake Kivu, Democratic Republic of Congo. This is further compounded by low scientific expertise and a dearth of geophysical and socio-economic data. Since 2012, the GeoRisCA project has analysed the geohazards and people's vulnerability, resulting in the first georisk assessment of the region. This € 1 million project funded by the Belgian Ministry of Research involves researchers from Belgium and Luxembourg, as well as local scientists.



The project focuses on the cities of Goma and Bukavu, which have populations of 670 000 and 750 000 respectively. In 2002, during the last eruption of the Nyiragongo volcano, 10 percent of Goma was destroyed by lava flows [1], causing long-term socio-economic impacts with about 120 000 homeless people and 50–150 fatalities. At the southern tip of Lake Kivu, Bukavu is built on steep and unconsolidated slopes, making it prone to landslides. These events, sometimes fatal, have dramatic impacts on infrastructure, with severe economic and/or sanitation-related consequences. In addition, human-induced environmental change (deforestation, urbanization) is linked to recent landslides [2].

By developing local risk maps as decision-support tools for the local authorities, GeoRisCA aims at improving disaster prevention, helping to reduce volcanic and landslide risk, and promoting long-term urban planning. The lack of accurate and reliable data was a main challenge and was addressed by an interdisciplinary approach combining satellite data, household surveys, intensive fieldwork and ground-based geophysical measurements. This resulted in an in-depth understanding of the spatiotemporal characteristics of the hazard risks [3, 4] and the socio-economic



## Lessons learned



situation, urban dynamics and people's risk perception. These latter aspects play a key role in the risk assessment equation: To assess the potential impacts of a risk, it is essential to understand the community and environment in which a hazard occurs.

Moreover, throughout the research process, local scientists, the Institute of Statistics, the Civil Protection, city and provincial authorities and non-governmental organizations were involved in numerous discussions and field activities to ensure the most appropriate vulnerability and risk assessment [5] (Box 1). In doing so, the project has strengthened the mandate and action of the Civil Protection in three ways: (1) by emphasizing the crucial role of this provincial institution in charge of disaster prevention and risk management, (2) by initiating collaboration with local scientists, whose knowledge regarding georisks was reinforced throughout GeoRisCA, and (3) through financial support of the Civil Protection, as the political authorities are now aware of the natural hazards issue.

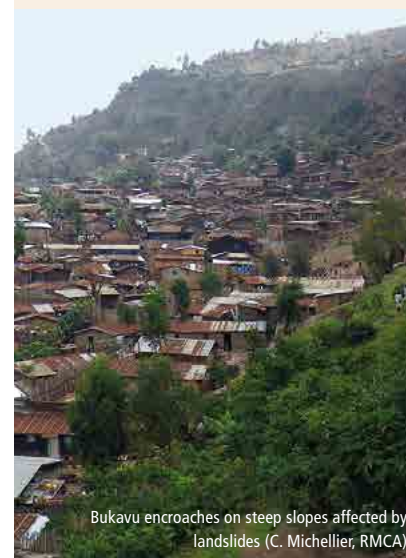
Finally, the project provides the stakeholders with administrative, hazard, vulnerability and risk maps, as well as with robust data sets and methodologies. And it has raised issues, such as capacity building and strengthening of monitoring techniques and networks (ground- and space-based), which are today addressed and implemented in new projects.

### BOX 1 | Understanding people's vulnerability

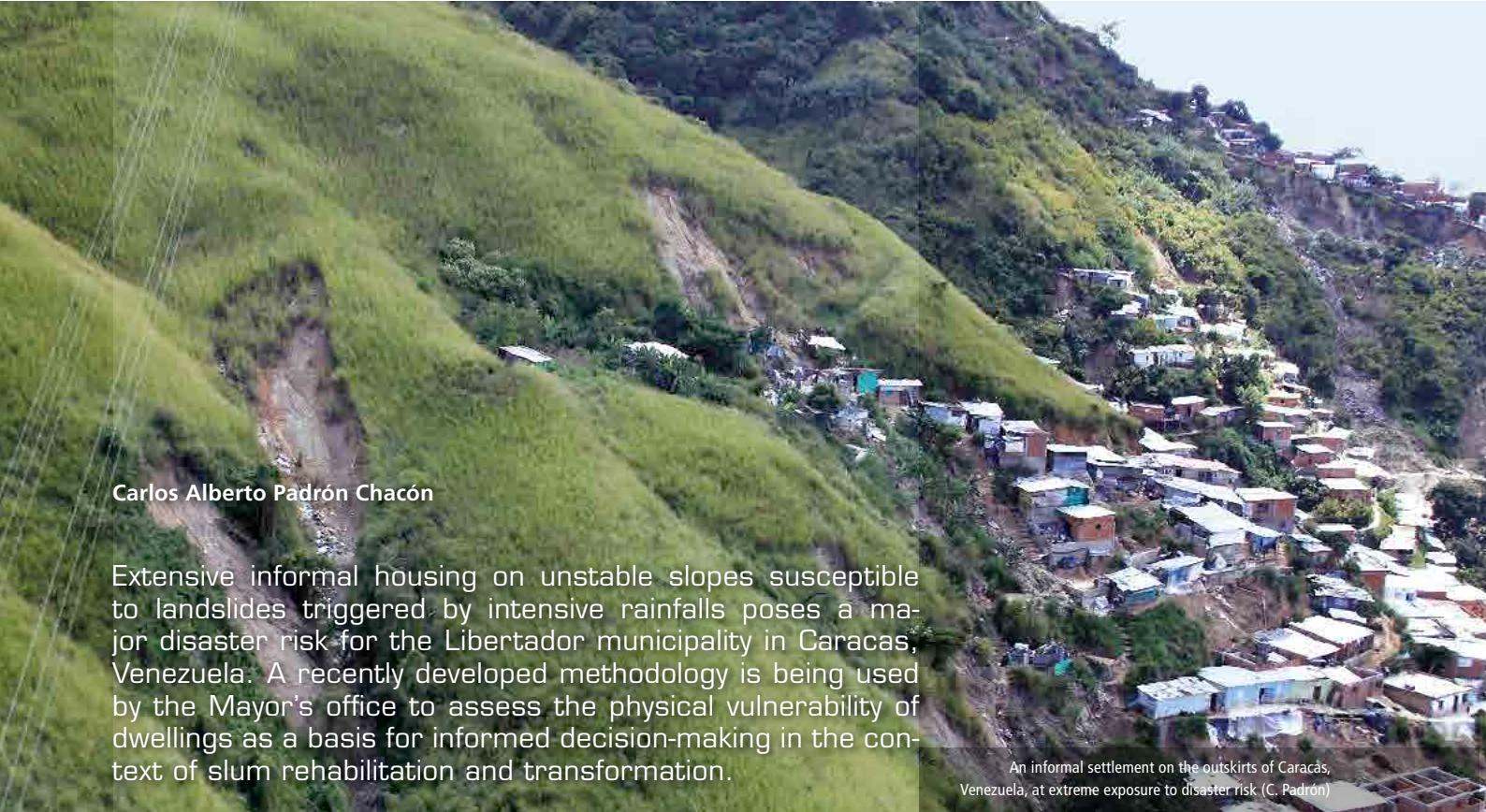
A local vulnerability index that considers the specific characteristics of a community and its environment increases the relevance, acceptance and effectiveness of disaster risk reduction (DRR) policies, particularly in times of local political unrest and severe poverty. Vulnerability assessment in the GeoRisCA project comprised the following steps:

- Semi-structured interviews with local institutions to understand their perception of vulnerability and their policies related to risk reduction.
- Working-group discussion based on an expert survey to agree on a local definition of vulnerability and define its relevant parameters.
- Household demographic survey to complement data scarcity, or data that are of limited quality, and develop spatial data layers on people's vulnerability.
- Involvement of the local scientists and DRR managers throughout the process, for an effective use of methods and results, and effective implementation of DRR strategies.

- Strengthening community resilience requires efficient and effective communication between scientists, civil authorities and the communities themselves.
- Modern technologies coupled with extensive fieldwork enable understanding and monitoring of socio-economic and hazard dynamics, and allow for risk-sensitive urban planning.
- Reducing the divide between scientific research and development cooperation is crucial to promoting understanding between the two sectors, thus enabling them to take their respective constraints into account for effective disaster risk reduction.
- Political unrest makes it more likely that low priority will be given to natural hazards.



# Identifying vulnerable dwellings in urban slums



Carlos Alberto Padrón Chacón

Extensive informal housing on unstable slopes susceptible to landslides triggered by intensive rainfalls poses a major disaster risk for the Libertador municipality in Caracas, Venezuela. A recently developed methodology is being used by the Mayor's office to assess the physical vulnerability of dwellings as a basis for informed decision-making in the context of slum rehabilitation and transformation.

An informal settlement on the outskirts of Caracas, Venezuela, at extreme exposure to disaster risk (C. Padrón)

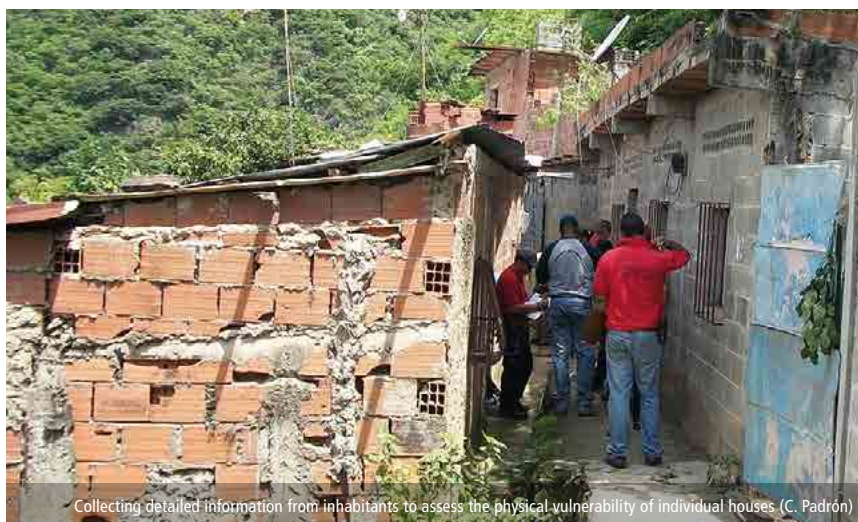
The economic and social policies implemented in Venezuela during the second half of the twentieth century had a negative impact on territorial planning. This was due to dependence on oil income on the one hand, and the concentration of public power in the capital on the other. As a result, rural workers migrated from other states to the city of Caracas in search of a better quality of life. There, soaring demand for housing led to the commodification of urban land, causing the poorest segments of the population to move to unstable slopes, where settlements developed without proper planning. Today, more than 1.25 million people – 60 percent of the population of Caracas – live in informal housing [1]. Over 90 percent of these slums occupy mountainous terrain prone to rainfall-induced mass movements. Reasons for this are geomorphological conditions as well as human factors such as poor construction quality and disregard of risky natural conditions.



A methodology developed to assess the physical vulnerability of informal dwellings to landslide risk supports the municipality in making informed decisions on slum rehabilitation and prevention measures [2]. The physical vulnerability analysis estimates the potential damage to or loss of housing, and people exposed to landslide risk. Physical vulnerability is understood as the susceptibility of a dwelling to damage resulting from shear stresses and axial loads imposed by mass movements. The landslide risk is assessed on the basis of a geospatial model based on the measurement and evaluation of various physiographic variables. The following four factors determine the susceptibility of the dwellings: the number of floors and thus the load produced by a dwelling, static design and construction material used, pre-existing damage or weaknesses in regard to construction, and signs of past mass movements in and around the dwelling.

## Lessons learned

- The systematic vulnerability assessment in urban slums provides the authorities with detailed information on the number of houses and people exposed to landslide risk, and thus contributes to targeting investments for disaster risk reduction in priority areas.
- Actively involving the inhabitants in the information-collection process is crucial for raising their awareness on which places are safe to live in and which are risk-prone. This process will discourage them from continuing to occupy territories in an uncontrolled and illegal way.



Data to assess the susceptibility of dwellings are collected in collaboration with the inhabitants of the affected neighbourhoods by means of a questionnaire, checking a number of indicators associated with the aforementioned susceptibility factors. Supported by geographic information systems, map algebra operations are carried out to obtain the degree of physical vulnerability of each dwelling, evaluated on a cadastral scale (1 : 2 500). The tool distinguished four levels of vulnerability (low, medium, high, very high).

Currently, the method is being applied successfully in Caracas, where the information collection will be completed by 2018. By the end of 2016, 130 000 dwellings (70 percent of the slums) had been evaluated. In some areas, physical vulnerability was found to be extreme. As an example, in *Carretera Vieja Caracas – La Guaira*, at 280 hectares one of the biggest slums in Caracas, 96 percent of the 6 654 dwellings assessed were found to be highly or very highly vulnerable. The national government uses the vulnerability assessment to develop comprehensive intervention strategies in the context of urban slum transformation programmes. The programmes aim at improving the quality of life of slum dwellers through development of urban infrastructure, implementation of risk mitigation works and eviction of high-risk dwellings.

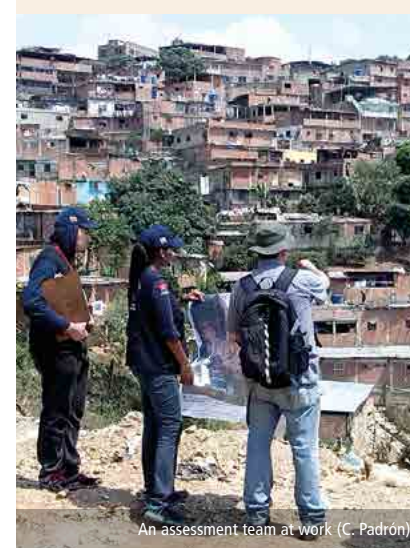
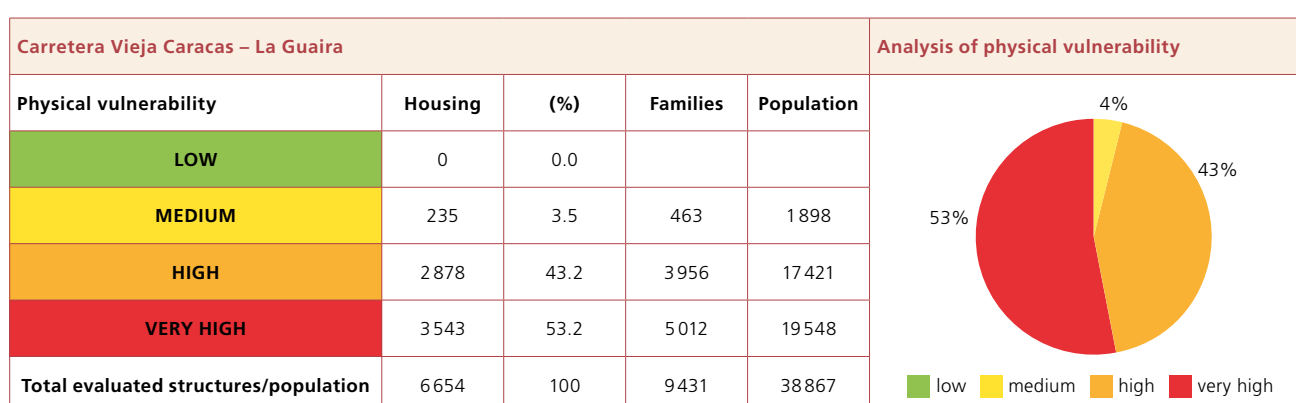


Figure 1. Physical vulnerability in the Carretera Vieja Caracas – La Guaira slum: number of dwellings potentially affected by mass movements.



# Participatory risk assessment for priority setting



Nicole Stolz and Renate Fleiner

In a mountainous country such as Tajikistan, prone to natural hazards but with extremely limited resources to reduce disaster risk, obtaining a quick overview of the most susceptible and vulnerable communities is crucial. Participatory rapid local risk assessments provide a solid understanding of the risk situation. They enable communities to proactively address risks, and decision-makers to allocate resources based on evidence.

River bank erosion destroys farmland and puts settlements at risk (N. Stolz)

Over 90 percent of Tajikistan's territory is mountainous, making the country highly susceptible to natural hazards. The most frequent such hazards are floods (47 percent), landslides (21 percent) and earthquakes (17 percent), causing an average annual economic loss of US\$ 112 million in 2005–2014 [1]. Mounting economic pressure on natural resources is leading to extensive soil erosion, increasing the risk of floods, mudflows, debris flows and landslides. The situation is exacerbated by climate change, excessive deforestation (to meet demand for firewood, currently the only fuel available in the mountains), unsustainable land management and overgrazing. This means that even natural disasters of a medium scale can have big impacts, especially as disaster risk management capacities of both the population and the government are very limited.



The security of people's livelihoods and socio-economic well-being are closely linked to the prevailing disaster risks and how well they can be mitigated. Too often, local communities are not sufficiently aware of the diverse aspects that determine the outcome of a disaster, and the impacts of their action or inaction on the environment. To protect themselves and their livelihoods, it is essential that they have a comprehensive understanding of the disaster risk situation they are living in.

The participatory MECO Risk Assessment Tool (MECO-RAT) addresses this need and facilitates local and national priority setting in a multihazard context. It was developed in 2009 by the MECO alliance (Mission East, Caritas Switzerland/Luxembourg and Oxfam GB) in collaboration with the Committee for Emergency Situations and Civil Defence (CoES) of the Republic of Tajikistan. The tool aims at

## Lessons learned



- How vulnerable is a certain community to disaster risk? Participatory rapid assessment can support priority setting and decision-making in a multirisk and limited-resources context.
- Seeking and ensuring continuous engagement of local key stakeholders including communities and government is key for enhancing ownership and long-term commitment in disaster risk management.

quickly assessing the conditions and factors that put communities at risk of disaster, to help identify suitable mitigation strategies together with concerned stakeholders. It has been applied in hundreds of communities in Tajikistan and Nepal.

MECO-RAT helps communities to enhance their understanding by observing and analysing their hazard situation. It generates a data and knowledge repository relevant to different actors such as local communities, authorities and organizations working in disaster risk reduction. It provides a quick overview on vulnerability and capacity data in contexts where data are scarce or missing. While the tool's standardized process and norms across communities allow the scale of risk to be compared among different communities, the tool does not provide in-depth analysis of the causes of risk or vulnerability. It also lacks accuracy, resulting in a general understatement of the estimated damage caused by a disaster.

As risk perceptions vary from women to men and from the elderly to youth, successful application of MECO-RAT greatly depends on a well-instructed, multidisciplinary and gender-balanced assessment team. Capturing the full picture requires involving the full range of participants as well as inclusive engagement and active participation of the community being assessed.

### The tool in short

MECO-RAT facilitates participatory assessment of disaster risks at the community level, and requires relatively low technology and expertise.

Main steps:

1. Community meeting: Determining risk zones in the community's territory
2. Interviewing households in identified risk zones: Determining assets at risk and capacity to recover

Main outputs:

1. A local hazard and vulnerability map
2. An overall vulnerability score per community
3. An estimate of economic vulnerability as a basis for decision-making
4. A data and knowledge base to develop a community disaster risk management plan

# Identifying and targeting vulnerable communities



Joan Bastide, Stéphanie Jaquet, Melia Ungson, Michael Epprecht

The Lao People's Democratic Republic is prone to natural hazards that continuously threaten vulnerable communities. With limited resources, the Lao government is challenged to effectively target policies and interventions to the most vulnerable communities. A country-wide tool, developed by researchers and non-governmental organizations, helps decision-makers identify such communities and target disaster risk reduction efforts accordingly.

Village in a shifting cultivation area in the uplands of Lao PDR (C. Hett)

While large-scale disasters are relatively rare in the Lao People's Democratic Republic (PDR), the increasing frequency of smaller events is a constant threat to fragile development gains. With few public resources available for disaster risk reduction (DRR), the government must ensure that investments benefit the communities most in need.

Livelihood structures, customs and natural environment vary greatly between lowlands and uplands in Lao PDR. The level and nature of people's vulnerability to natural hazards is shaped by the geographic, socio-economic and institutional characteristics of the place in which they live. Vulnerability is context-specific, dynamic in time and multidimensional in terms of the variety of underlying causes. Assessing and comparing vulnerability consistently is therefore very challenging. Moreover, the normative dimension of vulnerability means that multistakeholder dialogues are required to select variables and negotiate their respective weighting.

To address this challenge – and to provide sound evidence for planning and allocating resources that prioritize the communities most in need – a village vulnerability assessment toolbox was developed by a consortium of researchers from the University of Bern and international non-governmental organizations, funded by the European Commission's Civil Protection and Humanitarian Aid Operations [1]. The tool is of use to decision-makers within governmental and non-governmental organizations, as it helps to identify communities for implementation of projects on vulnerability. The tool would also help to speed up the assessment after a disaster to define the needs of the communities.

The tool, available online, was designed in line with the following principles: It was to be a) broadly accepted by multiple stakeholders, meeting their respective information needs; b) cost-effective; and c) technically feasible.



## Lessons learned



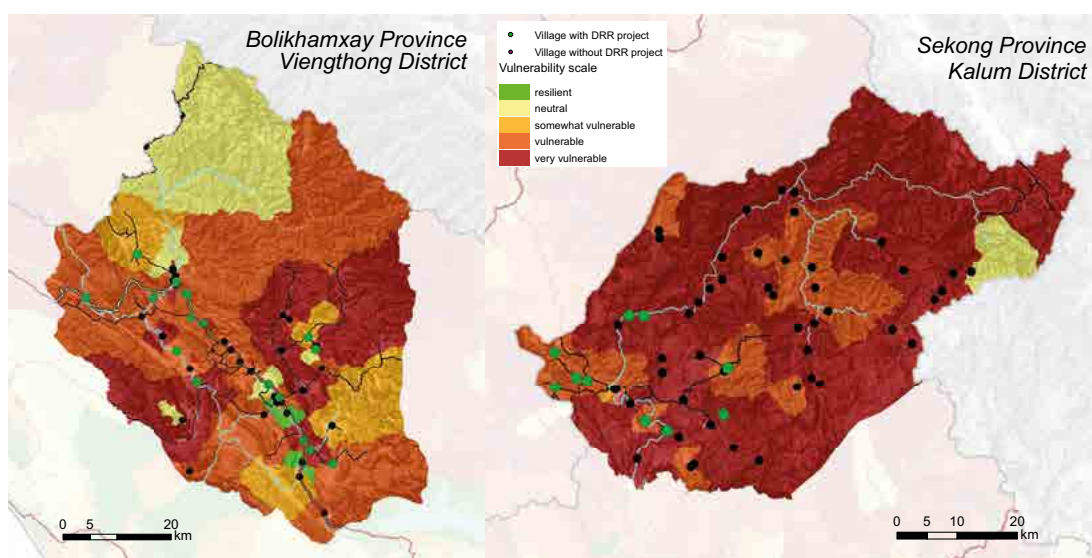
Flash flood in Luang Prabang province, September 2015 (Save the Children)

Accordingly, the tool uses mainly publicly available census data [2] and common, open-source software (OpenOffice and QGIS). It includes variables on hazard exposure, socio-economic conditions of households and access to infrastructure such as a health centre or a school. Tool users can customize their own vulnerability indices according to their requirements, by selecting and integrating the relevant variables and assigning them a weighting. Based on user settings, the tool then calculates a multidimensional vulnerability index for each village of the Lao PDR and ranks them across the whole country. The results provide a first-tier analysis that helps to identify the most vulnerable villages in which more comprehensive community-level processes such as vulnerability and capacity assessments (VCAs) should be undertaken.

To assess the effectiveness of the targeting, a georeferenced database of the location of DRR activities was developed. Results suggest that the spatial correlation between vulnerability level and concentration of projects is almost non-existent. For example, almost three-quarters of the targeted villages are located in easily accessible areas such as the village of Viengthong District (Figure 1). About half of the currently targeted villages are among the most well-off in their respective province. In addition, while upland communities often face a greater level of vulnerability, they receive far less support than lowland communities.

- A tool that assesses vulnerability in a spatially explicit way – and is based on indicators jointly defined by stakeholders – allows for more targeted DRR that considers the specific needs of mountain communities.
- Combining spatial vulnerability assessments with a database of development activities helps to reveal inconsistencies between current activities and truly vulnerable communities, e.g. mountain communities that are difficult to access.
- The tool can facilitate more effective use of scarce resources. It also fosters synergies between different projects, with a view to mainstreaming DRR into broader development initiatives.

Figure 1. In Viengthong District and Kalum District (upland areas of central and southern Laos), communities with the highest vulnerability and those with no access to roads are also the ones who benefit least from DRR.



FIRMA DEL ACUERDO SOLIDARIO PARA LA  
PROTECCION CIVIL DEL GOBIERNO DEL  
ESTADO DE CHIAPAS

TUXTLA GUTIERREZ, CHIAPAS, 18 DE MARZO DE 2010.







# Sendai priority 2: Strengthening governance



Elisabeth Sötz and Arabinda Mishra

# Enhancing governance capacities and collaboration to manage disaster risks in mountains

Stakeholders from European countries discuss joint strategies to prevent disasters associated with natural hazards in the Alps (E. Sötz)

Safe space in mountains for settlements, agriculture, industries and infrastructure is limited. Often people end up using hazard-prone and remote, inaccessible areas. Spatial planning and coordination of disaster risk reduction and development efforts between different sectors and governance levels are key to consolidating the interests of various users with the need to protect people and goods from disasters. They are also key to protecting nature from human activities, to prevent deterioration that would further increase the disaster risk.

Sendai priority 2 gives emphasis to disaster risk governance that fosters collaboration and partnership.

Disaster risk management in mountain regions is highly complex due to mountain-specific challenges such as, first, the multitude of hazard risks; second, the multiple interests of stakeholders and demand for land uses (settlement, agriculture, infrastructure, tourism, etc.) in a limited space; third, mountain people's different exposure and often low adaptive capacity; fourth, the geographical interdependences between upstream and downstream ecosystems and communities; fifth, the

transboundary issues arising out of mountain ecosystems crossing administrative borders and nations; and sixth, the global dimension of drivers of disasters such as climate change. Disaster risk reduction (DRR) entails several aspects, from prevention of disaster to increasing resilience of ecosystems and communities, enhancing preparedness and “Building Back Better”.

There is no one-size-fits-all solution to every risk. Each hazard situation in any given governance context has to be assessed for the best response option considering the available financial, technical and human resources. In addition, the multi-dimensional challenges require the involvement of many stakeholders from different sectors and government levels in identifying, coordinating and implementing appropriate measures to reduce disaster and enable sustainable development [1]. This calls for coherent and well-informed planning and management, and sometimes requires priorities to be set (see Chichinadze, pp. 38–39).

Collective actions can only succeed if risk communication mechanisms and institutional arrangements at different levels for DRR-related decision-making and monitoring are in place that allow for the active participation of all people concerned. This is especially important for marginalized and vulnerable groups, e.g. elderly people that are left behind when younger men or women migrate to urban centres. Further, strong leadership by an organization with a clear mandate and adequate resources is necessary to strategize and coordinate such efforts (see Cardona et al., pp. 34–35). Such lead organizations would need to be equipped with adequate authority and competence to overview and monitor the processes, and to react quickly and effectively in an emergency. It is the public government – on the local, national as well as regional levels – which must have the competency, capacities and will to play this leading role; it must also have the strength to shed conventional functioning and adopt a partnership approach with communities and community organizations.

If this crucial point is given, the different stakeholders will be able to contribute to disaster reduction and sustainable development in specific ways. Research institutions or intergovernmental organizations may offer background data and experiences from other countries as inspiration for national or local planning and design. The latter can also play a role in promoting transboundary cooperation. Local stakeholders often have in-depth knowledge about a certain landscape, hence participatory planning should lead to a result in spatial management which suits “daily use” as well as the disaster case. Moreover, they are the first to spot signs of an upcoming hazard, so they could be entrusted with local monitoring as part of an early warning system. Indigenous people’s experience and traditional knowledge can be invaluable assets in this regard. It is also important to have environmental organizations to provide stewardship of nature, as degradation of natural ecosystems, especially forests or wetlands, can further increase disaster risk or provoke a new type of hazard. Non-governmental organizations can also successfully act as interlocutors between the public government and the local people (see Sötz, pp. 40–41). Since multiple stakeholders are involved, a shared understanding is a necessity that can be facilitated through science, policy and practice engagements using transdisciplinary heuristics [2].



Including local knowledge in DRR is imperative, not only in Venezuela (C. Padrón)

# Effective risk management requires political will



Omar-Dario Cardona, Dora Catalina Suarez, María del Pilar Perez

Effective investments in disaster risk reduction were implemented in Manizales, Colombia, following a successful combination of political will, scientific-technical inputs and community acceptance. Measures included hazard risk assessments for land use planning, early warning systems, public information and awareness creation, collective insurance and risk mitigation structures.

Aerial view of Manizales (O.D. Cardona)

The Colombian city of Manizales, capital of the Department of Caldas, is located on the steep and unstable slopes of the central Colombian Andes, at an altitude of 2 100 metres above sea level. Since the end of the nineteenth century, the city has been repeatedly affected by fires, strong earthquakes and volcanic lahars. Frequent landslides and flash floods have occurred in the last decades, triggered by the urban expansion to currently 370 000 inhabitants. The low-income population inhabiting the hills has become even more vulnerable, as population pressure, social exclusion, poverty and a lack of adequate spatial planning has increasingly forced families to settle in hazard-prone zones. The recurrent disasters have led to a local culture of earthquake-proof construction, including a traditional unique building technique called “bahareque”.



Political will in Manizales to improve people’s quality of life and resilience is strong, and a cross-sectoral approach coupled with high investments have borne fruit. Since the 1970s, the city has implemented an integrated and innovative disaster risk management approach that combines enhancing scientific knowledge, increasing inter-institutional collaboration and building community capacity. After the national policy on disaster risk management was updated in 2012 [1], Manizales established the intersectoral Municipal Council for Disaster Risk Management. The council is led by the mayor and comprises government authorities such as development planning, finances, environment, public works, housing, education, health, water services, community development and emergency preparedness. Nonetheless, disaster risk management in Manizales faces political challenges: Mayors are elected for four-year terms, resulting in frequent changes in priority and political agenda setting. Risk reduction might not always be a priority for new local governments.

## Lessons learned



- Disaster risk management is not a single discipline that can be reduced to a sector or department: It requires political will and a comprehensive cross-sectoral approach coordinated by a unit with authority.
- Structural and non-structural measures must consider the vulnerability and needs of poor households whose homes and land are located on steep and unstable slopes.
- Disaster risk management – including risk reduction and strengthening resilience and preparedness – must be an integral part of development strategies.

In addition to strengthening disaster risk governance, the city has significantly invested in structural and non-structural measures to reduce risks and enhance preparedness. An automatic online early warning system assesses hydrometeorological, volcanic and seismic risks. Regulations for earthquake-resistant construction were implemented based on detailed seismic microzoning to guide retrofitting of key buildings [2]. The regional environment authority carried out more than 970 measures for slope stabilization and erosion protection in collaboration with the engineering faculty of the National University, and several housing relocation projects were implemented in a participatory way. The social programme “Guardians of the Hillsides” pays women of female-headed households living in hazard-prone areas for maintaining the protection structures. The women, who are the “guardians”, also inventory risk-exposed households to help assess their susceptibility to hazards as well as physical and social risks [3]. The inventory is instrumental for spatial planning and public investment plans. Based on probabilistic risk models, the design and implementation of a risk transfer instrument to cover the private buildings of the city was developed. This voluntary collective instrument provides financial protection to both estate-tax payers and low-income households through a cross-subsidy strategy; it promotes not only the insurance culture but also community solidarity [4].



Manizales has invested close to US\$ 52 million in disaster risk reduction since 2002 (Table 1), with money stemming from governmental budgets as well as from a supplementary environmental tax and a disaster risk management tax (0.15 and 0.05 percent of the property value respectively). From 2009 to 2015, these two types of tax generated approximately US\$ 23.6 million [5, 6].

| Disaster risk management (DRM) investments (US\$), 2002–2015 |  |   |                       |
|--|--|---|-----------------------|
| Year   | Risk reduction investments (structural measures) | Other DRM investments (non-structural measures) | Total DRM investments |
| 2002–2008  | 7 442 208  | 1 092 112                                       | 8 534 320             |
| 2009   | 8 139 048  | 108 990   | 8 248 038             |
| 2010   | 1 305 772  | 233 768   | 1 539 540             |
| 2011   | 19 337 100                                       | 218 234   | 19 555 335            |
| 2012   | 5 440 237  | 248 325   | 5 688 562             |
| 2013   | 2 650 666  | 915 555   | 3 566 221             |
| 2014   | 2 132 969  | 451 679   | 2 584 647             |
| 2015   | 1 976 973  | 202 636   | 2 179 609             |
| <b>TOTAL</b>   | <b>48 424 974</b>                                | <b>3 471 299</b>                                | <b>51 896 272</b>     |

Table 1. Disaster risk management investments (2002–2015). Sources: [5, 6]

# Strengthening disaster risk governance from the bottom up



Rafaël Van Dyck

Disaster risk governance is particularly challenging in a context of social, institutional and economic vulnerability – and in spatially scattered communities as found in the mountains of the state of Chiapas, Mexico. The United Nations Development Programme (UNDP) Risk Management Programme is focused on strengthening disaster risk management in community development planning, starting at the bottom and working towards disaster risk reduction in state policies.

Two municipalities were left without road access following landslides and flooding (L. Roblero)

The mountain regions of Chiapas are among the most vulnerable regions of Mexico, posing specific challenges for disaster risk reduction (DRR). They are highly exposed to multiple hazards such as cyclones, intensive rains, floods, landslides, droughts, earthquakes, forest fires and volcanic activity. With 78 percent of the population living in poverty, Chiapas has the highest poverty rate in the country [1]. Demographic dispersion, typical for mountain areas, is a particular challenge. The region is home to more than 14 000 rural and indigenous communities with fewer than 100 inhabitants, many of whom are located in rather inaccessible areas, lacking basic services and attention from the central government [2]. Local and even state governance are weak, and conflicts between the communities and local government are frequent. Municipal governments as well as their priorities and staff change every three years, making it difficult to ensure continuity of DRR strategies and implementation. Thus, prevention often does not get enough attention, and risk situations may remain unresolved.



The United Nations Development Programme (UNDP) worked from 2008 to 2014 in Chiapas with approximately 230 communities in some 30 municipalities and an estimated total budget of US\$ 1 million. The programme's objective was to reduce local vulnerabilities, to increase territorial, community and institutional resilience and to strengthen public policy on DRR. The programme started with organizing subregional assemblies to identify committed municipal and community leaders, who were trained and employed by UNDP as local DRR experts. They had various tasks, including replicating the capacity building programme at the local level and – in collaboration with local authorities and villagers – establishing community and municipal risk committees. These local committees developed DRR plans and

## Lessons learned



A local DRR expert and the community assembly jointly develop the DRR community plan (UNDP)

- Building local capacity and governance through committed local DRR committees is of utmost importance where spatial dispersion of mountain communities complicates coordination and communication between the state government and the local communities.
- Consideration of local good practices in policy-making processes ensures more context-specific policies and instruments.
- Weak governance and frequent changes in government priorities endanger the effective implementation of DRR.

executed risk analysis. Involving the population in these activities strengthened the social organization of the community, as well as local DRR capacities, and improved collaboration between the community, state leaders and civil society organizations such as the coffee alliances. Some changes in municipal policies were effected – for example, in some cases, risk analysis was integrated in the municipal development plan. And, in consensus with the local communities, modifications in terms of integrating risk reduction or adaptation measures were made in the municipal “rules of good governance”.

The outcomes of the programme – the early warning system through community leaders, the damage assessments completed within 48 hours after a disaster and the risk analysis methodology – captured the attention of the Civil Protection Director of Chiapas and other government officials. Besides replication of this model in other municipalities through extensive collaboration with the State Government and Civil Protection of Chiapas, the programme also influenced the federal law and stimulated changes in the public policy of the state of Chiapas such as implementation of a new law on Civil Protection and Integrated Risk Management focusing on prevention and capacity building. In 2014, the state of Chiapas was granted the National Award for Civil Protection.

### Applying the risk analysis tool in Jaltenango

Jaltenango is a poor municipality located in a mountain region of Chiapas. In the past, a road and a water pipeline built across a riverbed were affected almost annually by floods and landslides, leaving around 4 000 families without water and road access. The recurrent events affected the living conditions and health of the population. To seek remediation, the local DRR expert, accompanied by local leaders and government officials, visited the affected pipeline and applied the participatory, easy-to-use risk analysis questionnaire developed by UNDP. The tool designed for assessing the risk level of public infrastructure helped to identify the main risks and assess the vulnerability of the pipeline and the road. Thereafter, the government implemented mitigation measures with a minimal investment, ensuring for Jaltenango the availability of water and road access and thereby increasing the municipality’s resilience.

# Analysing costs and benefits to set the right DRR priorities



David Chichinadze

The High Caucasus region of Georgia is an area affected by multiple natural hazards. To ensure more effective disaster risk reduction (DRR), local authorities have recently been assigned greater responsibility, under the ongoing decentralization process. However, financial resources at the local level are scarce. Detailed hazard mapping combined with a cost-benefit analysis of DRR measures have helped local governments to set meaningful DRR priorities.

Construction of the water retention reservoir as one of the components of the flood and mudflow protection measures in Mestia (G. Japaridze)

In the last 40 years, natural hazards such as earthquakes, mass movements, avalanches, heavy weather storms, but also drought affected about 70 percent of the mountainous country of Georgia and caused economic losses of more than US\$ 14 billion [1]. While big events such as earthquakes contributed significantly to this figure, the highest total costs were caused by numerous landslides and mudflows [2, 3, 4]. In Georgia, natural hazards are a driver forcing people to leave their homes. As there is no mandatory property insurance system in place, relocation of affected families causes additional expenditure for central and local governments.

The multiple disaster risks in the mountain regions of Georgia call for effective management of these risks at the national as well as local levels. The self-governance reform, under way since 2013, has enabled such efforts by delegating more authority and financial resources to local government. But financial resources remain limited, and local authorities are under pressure to make the most of them.

A project financed by the Swiss Agency for Development and Cooperation (SDC) between 2013 and 2016 has aimed at improving disaster management capacities at the national and local levels. Experts trained over 20 specialists of the National Environmental Agency, the Emergency Management Department of the Ministry of Internal Affairs and the Ministry of Regional Development and Infrastructure in the hazard mapping methodology developed in Switzerland, and in cost-benefit analysis of hazards and preventive measures. Subsequently, the Georgian specialists adapted the approach to the Georgian context, to be able to use the localized methodology throughout the country.



*"... with the support of hazard maps we were able to avoid future mistakes, as we employed the maps while creating the development plan of our municipality."*

Kapiton Jorjoliani, head of Mestia municipality





A pilot project was tested in Mestia, the administrative capital of the Georgian municipality of Upper Svaneti. Mestia is home to 14 000 people and has the fastest-growing tourism sector in Georgia. The municipality is exposed to a multitude of hazards, with more than 136 families currently considered ecomigrants (Box 1).

The Georgian specialists developed hazard maps (1 : 5 000 scale) for six communities, considering the five most relevant hazards: landslide, mudflow, stone fall, flooding and avalanche. They calculated the costs of the risks based on probable extent of damage in material assets under different scenarios, and compared them with the benefits due to reduced risks after implementation of preventive measures. This allowed the local government to set priorities for preventive measures and determine the necessary funds for implementation. Eventually, the project implemented slope stabilization, flood and mudflow prevention measures.

The experience revealed that a lack of historical data of hazard patterns (frequency, strength, etc.) and the limited technical capacities affect the accuracy of predictions and the quality of the maps. Moreover, it showed that the mapping process can become highly sensitive, particularly when future development planning is affected by the classification of territory. At present, Georgia lacks a legal basis for regulating the roles and responsibilities with regard to hazard maps.

Nonetheless, the mapping methodology has proved effective and can be applied to other regions of Georgia, including urban areas and specifically the capital, Tbilisi, which faces environmental hazards of its own.

#### BOX 1 | Ecomigrants in Georgia

The Ministry of Internally Displaced Persons from the Occupied Territories, Accommodation and Refugees of Georgia has recorded about 2 437 families as ecomigrants resettled by the government [5]. Moreover, estimates show that about 37 000 families are in need of resettlement for environmental reasons [6, 7].

The term “ecomigrant” is used in Georgia to describe environmental migrants, who are “persons ... who, for compelling reasons of sudden or progressive changes in the environment that adversely affect their lives or living conditions, are obliged to leave their habitual homes, or choose to do so, either temporarily or permanently, and who move either within their country or abroad.” [8]

## Lessons learned

- In a context of multiple hazards and scarce financial resources, the combination of hazard maps and cost–benefit analysis is an effective tool to decide on risk reduction measures.
- Evidence-based planning of preventive measures can help to address the cause of environmental migration and eventually reduce relocation costs.
- Hazard maps can become highly political in the framework of planning processes; rules regarding the legal status of such maps could help to prevent conflicts.

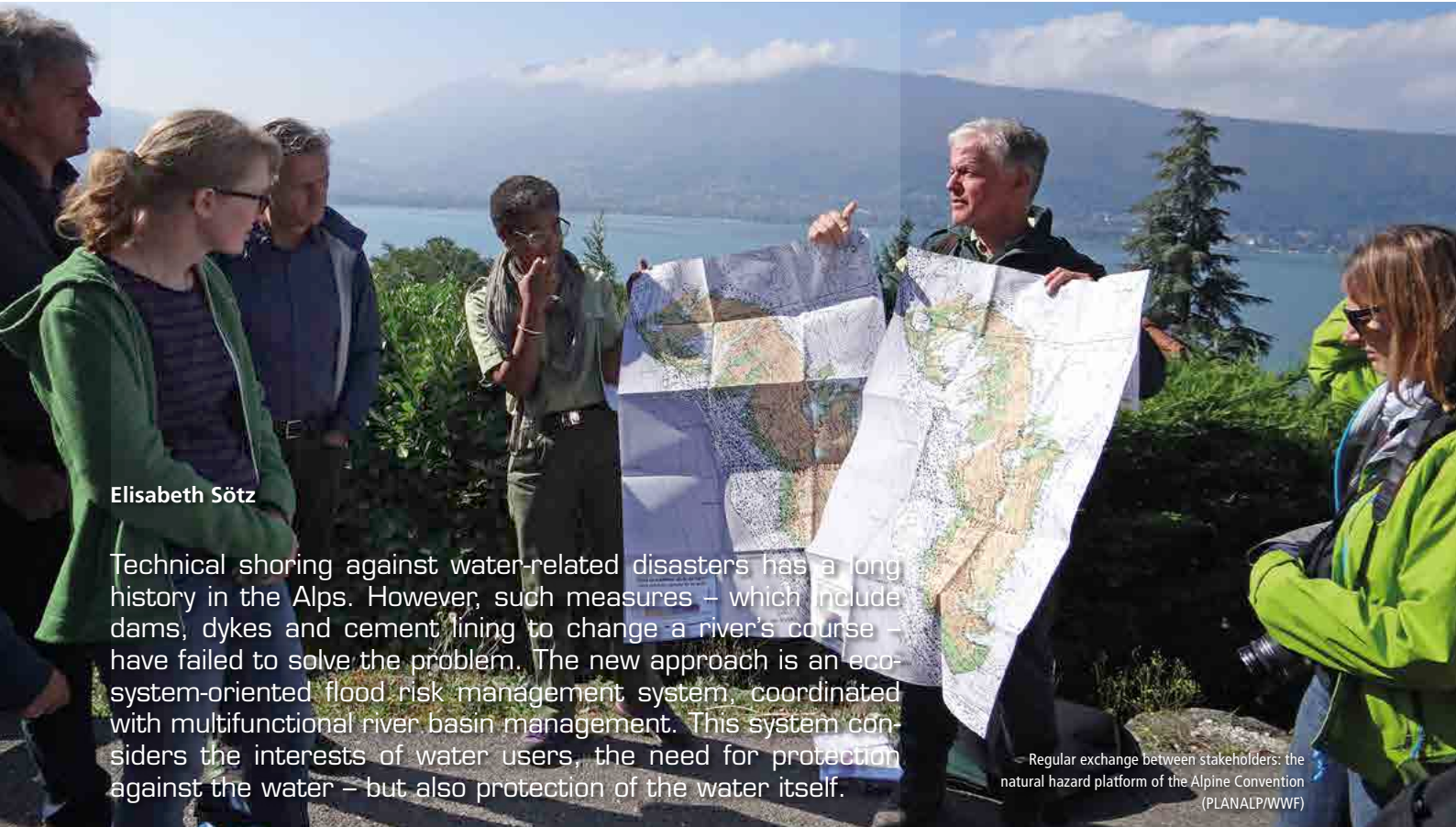
### Cost–benefit analysis of preventive measures

The cost–benefit analysis calculates collective risk based on probable extent of damage in material assets for different scenarios, and the benefit of reduced risk after implementation of preventive measures. The benefit–cost ratio is calculated with the following formula:

$$B/C = \frac{R(\text{init}) - R(\text{init} - \text{res})}{C(y)} = \frac{R(r)}{C(y)}$$

B/C = benefit–cost rate of measure(s)  
 R(init) = initial risk  
 R(res) = residual risk  
 R(r) = yearly risk decrease  
 C(y) = yearly cost of planned measure(s)

# Preventing water disasters: Different interests, common goals



Elisabeth Sötz

Technical shoring against water-related disasters has a long history in the Alps. However, such measures – which include dams, dykes and cement lining to change a river's course – have failed to solve the problem. The new approach is an ecosystem-oriented flood risk management system, coordinated with multifunctional river basin management. This system considers the interests of water users, the need for protection against the water – but also protection of the water itself.

Regular exchange between stakeholders: the natural hazard platform of the Alpine Convention (PLANALP/WWF)

In summer 2016, heavy rainfalls in the Eastern Alps caused floods, mudflows and landslides all over Austria, southern Germany and neighbouring regions. This is nothing new. For many decades, the Austrian spatial planning system has defined "red zones" for construction due to the high disaster risk, and millions of euros have been invested in technical shoring of Alpine rivers. Technical shoring refers to "grey infrastructure": engineering and construction works intended to change a river's course. But far too often this is insufficient, or even worsens the problem downstream. Typically, mountain rivers are characterized by a quick, roaring flow which only becomes more ferocious if restrained, leading to increased damage in the lowlands. The only effective way to soften it is to give it space – to broaden the riverbed, wherever possible, and to foresee retention areas where the water can romp around without causing severe damage. And that's the catch – there is little space in narrow valleys, and the spatial pressure is often so high that even the aforementioned "red zones" are contested by different actors, or disrespected. There are multiple stakeholders with competing claims, among them municipalities, agriculture, fishermen or hydropower companies. Increasingly, integrated local river management requires multifunctional planning and multistakeholder platforms that take into account different actors' interests, use scenarios, as well as flood and drought risk issues.



Hence, the Alpine Convention – an international treaty of the eight countries in the Alpine Arc – has established working groups such as the "Water Management Platform" or the "Natural Hazards Platform", to support dialogue, facilitate knowledge exchange and solve transboundary questions. Technicians and



Floods are a common threat to Alpine communities (I. Roblek, PSAC)

## Lessons learned

- Transboundary, macroregional, multi-stakeholder platforms addressing upstream and downstream challenges require more effort than national ones, but often lead to better and more widely accepted results.
- Flood protection cannot be dealt with in isolation but must be embedded in integrated river management approaches to ensure ecosystem functions and address societies' interests and needs.
- Disaster prevention considering the natural characteristics of rivers can often be more sustainable and cost-effective than applying blueprint technical solutions.



Successful revitalization of the upper Drau river, Austria (E. Sötz)

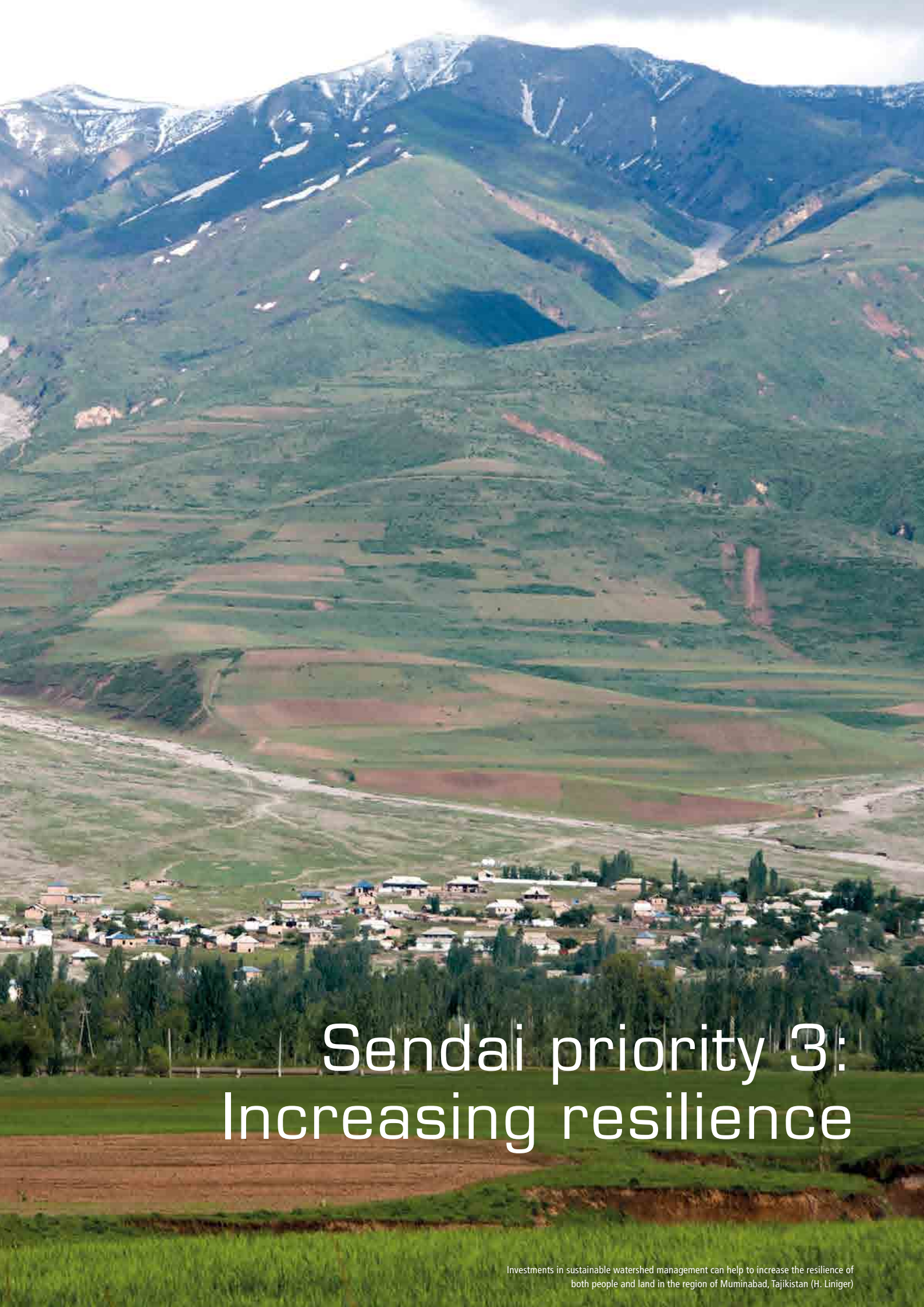
representatives from national governments meet regularly to discuss current issues and publish guidelines and recommendations for practical implementation. Environmental non-governmental organizations such as the Worldwide Fund for Nature (WWF) are members of those platforms too, to lend a voice to nature and ecosystem services: Damming for hydropower and flood protection already causes hydromorphological alterations for 81 percent of Austrian watercourses [1]. It is the key threat for healthy river ecosystems today – a loss not only for nature, but also for local fisheries. Further, it enhances deepening of the riverbed, which might lead to a drop in the groundwater level, with severe consequences for agriculture and water supply systems.

The best flood buffering effect is provided by riparian wetlands and alluvial forests, which also contribute to mitigating the converse risk of water stress – hitherto a lesser concern in the Alps, but predicted to gain importance due to climate change. Today, only 8 percent (4 670 km) of the Alpine rivers are still bordered by floodplains or wetlands. Thus, priority should be given to protecting the few remaining river stretches which are not hydromorphologically restrained. The project “Save the Alpine Rivers” analysed ecologically sensitive river stretches to identify “no-go areas” for infrastructure construction.

### Watershed management supplementing macroregional efforts

In the Alpine Arc, engagement on a strategic, macroregional level is matched by specific engagement in selected river catchments. Several activities have already been initiated on the river Inn in the Federal State of Tyrol, Austria, in cooperation between the provincial government, the Federal Ministry for Agriculture, Forestry, Environment and Water Management, the Worldwide Fund for Nature (WWF), private enterprises and the fisherpeople's association. In the steering committee, all stakeholders agreed upon specific local measures – such as restoration of riparian forests, broadening of the riverbed or deepening of shores to allow a re-connection to nearby wetlands – while implementation and monitoring were assigned to specific actors. The WWF vision ahead is a holistic, transboundary river basin management concept from the source of the river Inn in Switzerland to the estuary on the German–Austrian border [1].





# Sendai priority 3: Increasing resilience

Investments in sustainable watershed management can help to increase the resilience of both people and land in the region of Muminabad, Tajikistan (H. Liniger)



Margreth Keiler and Arabinda Mishra

# Linking risk reduction and development

Splitting wedges protect the church (built in 1603) and modern houses (2002) against avalanches in Davos, Switzerland (S. Fuchs)

Changing environmental and social conditions in mountain areas are leading to ever greater risks of multiple hazards for communities. Disasters have long-term effects on rural and urban livelihoods and sustainable development. Investments in disaster risk reduction by governments – with public–private partnerships and community participation – can be a driver for development, increase the resilience of communities, save lives and reduce losses during the next disasters.

Sendai priority 3 aims to increase resilience of people, assets and the environment through investments in structural and non-structural measures for disaster risk prevention and reduction. This is especially important for mountain communities – both rural and urban – and their economic development, which is strongly affected by, and in turn affects, risks of diverse hazards. Changes in climate and socio-economic conditions are introducing greater uncertainty as well as new risks in mountain regions. According to Alexander [1], the causes of vulnerability and low resilience are found in poverty, marginalization of social groups and the hazardousness of certain locations. These characteristics are found in many mountain areas, which are remote, distant from centres of power and home to indigenous peoples and cultures who are often socio-economically and politically marginalized.

The resilience of mountain communities exposed to multiple hazards is especially challenged by steep slopes and high variability of precipitation and runoff, infrastructural constraints and limited safe space for living and economic activities [2]. Less developed and poor communities, many of which are located in mountain areas, have endured a larger proportion of disaster impacts than those in other regions, related also to their higher vulnerability and lower resilience [3]. However, there are also assets to be found in mountain regions: A significant diversity of plants, animals and geology provides valuable ecosystem services. If sustainably managed, these can contribute not only to the resilience of mountain areas, but also to that of the lowlands.

Disaster risk reduction (DRR) aims to avoid a further rise in risks, and to reduce the vulnerability and increase the resilience of communities. The global DRR frameworks for action emphasize the crucial role of information, infrastructure and institutions. They also emphasize a fourth element: the need for insurance to take care of the risks that could not be eliminated before a disaster occurs. Investing in DRR for building resilience of mountain communities would need to take into consideration these four elements. Importantly, the financial investment – often related to political commitment and will – would need to be accompanied by appropriate institutional arrangements and capacity building at the local level.

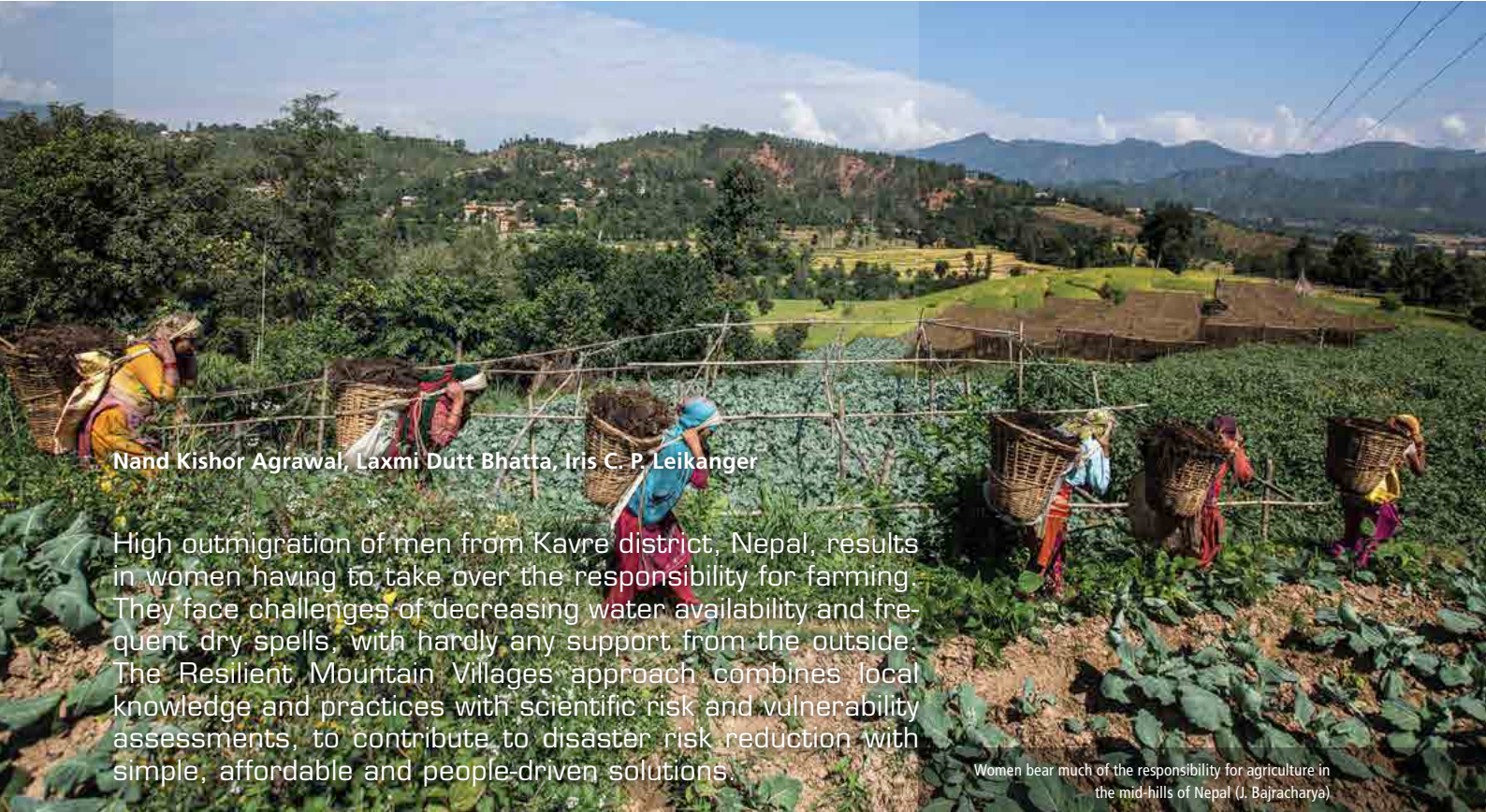
DRR incorporates public and private investments through structural, non-structural and functional disaster risk prevention and reduction measures for settlements, critical facilities (health services, schools) and infrastructure (see Fuchs and Thaler, pp. 50–51). Mainstreaming DRR in land use policy to identify safe settlement areas (risk maps) and livelihood programmes that focus on preserving a well-functioning ecosystem through sustainable land management, will help to reduce risks and improve resilience (see Agrawal et al., pp. 46–47). Recent studies [4, 5] indicate that empowering rural and urban mountain communities to take ownership of these processes is of high importance in enhancing the capacity of communities to adapt. This is especially true because mountain communities have traditional knowledge and strategies to cope with disasters that are sometimes not in line with, or recognized by, national guidelines [2, 4]. However, as environmental conditions and socio-economic contexts change, especially those driven by outside forces, so too do the abilities of communities to adapt to new conditions [6].

Rural communities are often dependent on their own resources and capacities because of remoteness and long duration of cut-off after an event, and because of special local conditions that have to be considered in the development of a DRR strategy. Social networks and social capital have often acted as local insurance mechanisms in the immediate aftermath of a disaster. The government may also suitably incentivize private insurers to offer innovative risk insurance products that should not replace but complement the traditional informal safety net (see Paz and Méndez, pp. 48–49). National mechanisms for disaster risk transfer and insurance may help to reduce the financial impact of disasters on mountain governments and societies. In this context, DRR in general, but especially in mountain communities, is a cross-cutting and multistakeholder issue allowing and securing sustainable development.



Elevated and reinforced platform for a power pylon in a floodplain, Taiwan (M. Keiler)

# Women-centric approach to enhance resilience



Nand Kishor Agrawal, Laxmi Dutt Bhatta, Iris C. P. Leikanger

High outmigration of men from Kavre district, Nepal, results in women having to take over the responsibility for farming. They face challenges of decreasing water availability and frequent dry spells, with hardly any support from the outside. The Resilient Mountain Villages approach combines local knowledge and practices with scientific risk and vulnerability assessments, to contribute to disaster risk reduction with simple, affordable and people-driven solutions.

Women bear much of the responsibility for agriculture in the mid-hills of Nepal (J. Bajracharya)

In the past 20–30 years, an increase in hazard risk due to changes in rainfall patterns was observed in Kavre district, in the mid-hills of Nepal. Drought is the most severe challenge impacting agricultural production, the livelihood mainstay for over two-thirds of the population. In addition, crops are being affected by higher incidences of insect pest attacks. This in turn is forcing farmers to apply higher doses of “red-labelled” chemical pesticides, leading to severe health hazards to people and the environment.

The Resilient Mountain Villages (RMV) approach was developed by the International Centre for Integrated Mountain Development (ICIMOD) [1]. Since 2014, the approach has been applied in a pilot project in eight villages by the Center for Environment and Agricultural Policy Research, Extension and Development (CEAPRED). The project has directly benefited 1 089 households, out of which 13 percent are *dalit* and 21 percent are ethnic minorities. Female participation was high (83 percent), partly because the project encouraged women to join, but also because of the high level of male outmigration – in almost 40 percent of the households in the mid-hills, at least one man had migrated. Based on a risk assessment and participatory planning, the project addresses water scarcity, soil nutrition, crop productivity, information gaps, risk reduction and institutional linkages. The actions were deliberately kept simple and affordable to ensure easy uptake for farmers, and to enable practices to be shared by word of mouth among the communities not directly participating. Average investment per household was less than US\$ 100 in the first two years. District and village-level governments, district line agencies (e.g. agriculture, forest, soil and watershed management) and agroveterinary centres are the main stakeholders that support the project partly



*“These smart practices helped me farm better, and added to my income. People now recognize me for my actions.”*

Sita Neupane, who applies *Jholmal* – a biofertilizer and biopesticide made from cattle urine – combined with straw mulches, to address the risk of yield loss in times of drought [2].



## Lessons learned



Village-level meeting (U. Bajracharya)

- People-centric climate change adaptation (CCA) and DRR practices need to be integrated into long-term development planning to enhance mountain people's resilience.
- Promote simple, affordable and replicable solutions that address villagers' key concerns and do not add additional risks for or burdens on women. Enable them to take charge of change without having to wait for external assistance.
- CCA and DRR activities that involve communities for shared responsibilities and decision-making and have the full ownership of local institutions are more likely to see wide uptake and effective results.

from their own resources, and are key to scaling up the approach at the national level. A project management committee has been formed representing all stakeholders, ensuring approval, monitoring and networking with other organizations.

Smallholder farmers are often conservative in their practices, and it took time to convince the participants to experiment with alternative approaches as they already face many risks due to changes such as natural hazards, climate change and reduced labour availability due to migration: If the trials failed, their risks would increase. However, an open-dialogue process engaging the community and local governments in decision-making helped the project to progress, and most of the farmers are now enthusiastically adopting the recommended practices.

The project takes a holistic approach to simultaneously address various aspects of resilience enhancement. A number of technologies and practices based on farmers' traditional as well as scientific knowledge are tested, demonstrated and disseminated.

| Action Areas  | Key Interventions  | Results  |
|---|--|--|
| <b>Climate Resilience and Disaster Risk Reduction (DRR)</b> |  |  |
| Farming systems   | <ul style="list-style-type: none"> <li>– Cowshed management and introduction of <i>Jholmal</i>, a cattle-urine-based biopesticide and fertilizer</li> <li>– Improved cropping practices such as crop rotation, mixed cropping, intercropping</li> <li>– Testing of crop varieties for different rainfall patterns and climatic conditions</li> <li>– Manure and mulching to maintain soil nutrients</li> </ul> | High rate of adoption; <i>Jholmal</i> autonomously outscaled to other areas; 10–15% increase in productivity |
| Energy  | <ul style="list-style-type: none"> <li>– Promotion of biogas and solar energy through other schemes</li> <li>– Practices to reduce the amount of energy required for agriculture</li> </ul>  | Shared ownership of line departments   |
| Water   | <ul style="list-style-type: none"> <li>– Harvesting of rain- and wastewater using plastic ponds</li> <li>– Affordable drip and sprinkler irrigation</li> </ul>   | Water conservation and productivity increase   |
| <b>Socio-Economic Resilience</b>                            |  |  |
| Gender equality   | <ul style="list-style-type: none"> <li>– Improve women's access to knowledge, tools and resources to sustainably manage households and farms</li> </ul>  | 83% of participants are women  |
| Institutional development                                   | <ul style="list-style-type: none"> <li>– Strengthen women's and farmers' groups for peer sharing and decision-making</li> <li>– Work closely with village- and district-level governments to institutionalize practices and ensure ownership</li> </ul>  | Shared ownership of community and government   |
| <b>Future Resilience</b>                                    |  |  |
| Digital services and disaster preparedness                  | <ul style="list-style-type: none"> <li>– Phone-based crop, weather and market advisories</li> <li>– Equipping schools with meteorological stations to gather weather data while providing students with an opportunity to learn about climate change</li> </ul>  | Increase in farmers' bargaining capacity   |

# Microinsurance to reduce impacts of climatic hazards



**Ximena Jáuregui Paz and Roberto Méndez**

The PROFIN Foundation generates innovative financial mechanisms for vulnerable small-scale producers to cope with the adverse effects of weather events. Its Risk Transfer Funds are an agricultural microinsurance that give producers in the highlands and valleys of the Bolivian Andes access to an adequate and accessible protection mechanism.

Peach growers in the High Valley of Cochabamba  
(Fundación PROFIN)

In Bolivia, 94 percent of producer families work on plots smaller than 5 hectares, and most of these are settled in valley and mountain areas. Climate risks in Bolivia are mainly associated with hazards such as floods, droughts, frost and hailstorms. The increase in frequency and intensity of such events means greater destruction to the investments made by the small-scale rural producers, damaging their productive activity and putting their livelihoods at risk.



Against this background, the development cooperation agencies of Switzerland and Denmark, SDC and DANIDA, supported the PROFIN Foundation in developing and implementing microinsurance or risk transfer mechanisms. These mechanisms are targeted at resource-poor, small-scale, rural producers, and provide them with economic compensation in case of losses due to natural hazards, especially climate hazards. To this end, a Risk Transfer Fund has been set up with resources from international donors and supplemented with the membership premiums paid by the producers. The fund is invested in regulated financial entities so as to generate returns, and is activated only if the amount collected from the membership premiums is not sufficient to meet indemnities to the producers.

The Risk Transfer Fund seeks to provide small-scale agricultural producers with protection against the occurrence of climatic events, by joining forces with agricultural advisory services to contribute to integrated risk management. Pilot schemes for potato, grape, peach and corn crops have been implemented in four of Bolivia's nine departments (La Paz, Tarija, Chuquisaca and Cochabamba), covering 24 municipalities. The schemes operate either by performance index (i.e. if the yield is lower than expected) or based on damage incurred through specific climatic events.

## Lessons learned



- Microinsurance schemes are an effective means to reduce the risk of economic loss associated with climate hazards, also for vulnerable small-scale farmers in remote mountain areas.
- Agricultural microinsurance supports adaptation to climate change. It strengthens the resilience of people unable to access mainstream commercial insurance schemes, and allows them to transfer their production risk and indemnify their investment costs against the adverse effects of extreme weather events.

If a producer wants to protect his crops against losses caused by frost, hail or drought, he pays a membership premium proportional to the size of the farm and the type of crop. Examples of premium / compensation per hectare are: grapes (US\$ 243 / US\$ 1 714), corn (US\$ 98 / US\$ 857), peaches (US\$ 220 / US\$ 2 142). The main difficulties in implementing the Risk Transfer Fund are the lack of data on climate and crop yields necessary for designing the insurance; low awareness of rural producers about the risk transfer mechanism; and the geographic dispersion of rural communities, resulting in high costs for advisory services, marketing and expertise work.

The agricultural insurance pilot schemes covered 24 of the 339 municipalities in Bolivia, insuring 2 460 families. The families benefited from risk reduction, and received training on insurance and having their claims paid in the event of crops affected by an adverse climatic event. This has enabled them to continue their productive activity.

Complementary actions such as financial education on insurance to create a culture of protection, and strengthening the early warning network, have provided the basis for generating a commercial agricultural insurance product that promotes communities' resilience to climate change.

| Risk Transfer Fund pilot schemes 2006–2015 |         |                    |
|--|---------|--------------------|
|  | Total   | Average per family |
| Number of families with insurance          | 2 460   | –                  |
| Number of hectares insured                 | 1 456   | 0.59               |
| Amount collected in premiums (US\$)        | 255 258 | 104                |
| Amount of compensation paid (US\$)         | 356 754 | 145                |
| Number of families compensated             | n/a     | –                  |

### The Risk Transfer Fund in Uriondo [1]

If a family wishes to insure its vineyard, they call the insurance office. The insurance office makes the appointment with the evaluation expert who, in a first step, conducts an inspection to decide whether the general condition of the plants suffices to qualify for insurance. If the plants pass the inspection, the client can directly pay the corresponding premium at a branch of the Microfinance Cooperative. To improve production techniques as well as risk prevention and mitigation practices, the evaluation experts regularly offer technical assistance to clients. In case of a hail event, the client calls the insurance hotline, which sends its evaluation expert to measure the damage directly on-site. The indemnity amount is then calculated as a percentage of the damage applied to the insured sum. To encourage microsavings, the indemnity payment is transferred to a client savings account opened for this purpose.

### Risk transfer schemes offer two different types of compensation

#### By performance index

- The trigger is a given percentage of (average) expected yield in the zone.
- Expert evaluation is carried out only once, at the end of the harvest.
- Compensation corresponds to yield losses due to weather events covered by the insurance, compared to the trigger.

#### By damage

- It covers damage caused by specified events (frost, hail, etc.).
- The amount of compensation depends on the scale of the damage caused to the crop due to specified climatic events.
- Expert evaluation is carried out once an event is reported.
- Partial compensation is paid out immediately.

# Preventing the “White Death”: More than an avalanche dam



Sven Fuchs and Thomas Thaler

In mountain areas of Austria, recurring heavy snowfalls have resulted in disastrous avalanches with high losses for local communities and the people affected. In response, the Austrian government has promoted natural hazard management systems. The aim of these multifunctional protection schemes, often community-led, is to reduce the overall risk of future losses.

This wall, 345 m long and 19 m high, protects Galtür from avalanches and forms the rear wall of the Alpinarium, a multifunctional building (G. R. Wett)

Major snow avalanches affecting settlements and traffic infrastructure occurred throughout the European Alps in 1951, 1954, 1999 and 2009 [1]. Their destruction is such that they are also known as the “White Death”.

The municipality of Galtür, 1 580 metres above sea level, lies 35 km southwest of the Austrian city of Landeck, near the Swiss border. The municipality covers an area of 121 km<sup>2</sup> and was inhabited by 772 people in 2016. In winter, the population swells by about 4 000, with tourists staying in Galtür’s hotels and guest houses. Overall, 26 avalanche paths endanger the municipality – nine of them equipped with defence structures. Around one-third of the building stock is exposed to snow avalanches [2], the result of the typical pressure on local land use (agriculture, settlement, infrastructure and tourism) in Alpine settlements [3].



On 23 February 1999, Galtür was hit by a 50-metre-high powder avalanche travelling at a speed of 290 kilometres per hour [4]. It buried 57 people, killing 31. Following the disastrous event, a dam was constructed to protect the village under the “Alpinarium” project, initiated by the Austrian Service for Torrent and Avalanche Control (known by its Austrian initials as WLW) [5]. The limited living space, proximity of safe and hazard-prone areas, and continuous land use pressure – but also increasing financial limitations – sparked strong community engagement to use the dam for additional purposes. Eventually, the construction was designed in a multifunctional way to include an exhibition room, a panorama café, an indoor and outdoor climbing wall, conference facilities and the local civil protection centre. The multifunctional construction was a highly complex and innovative project with strong citizen participation in the decision-making process. Many efforts were in-

## Lessons learned

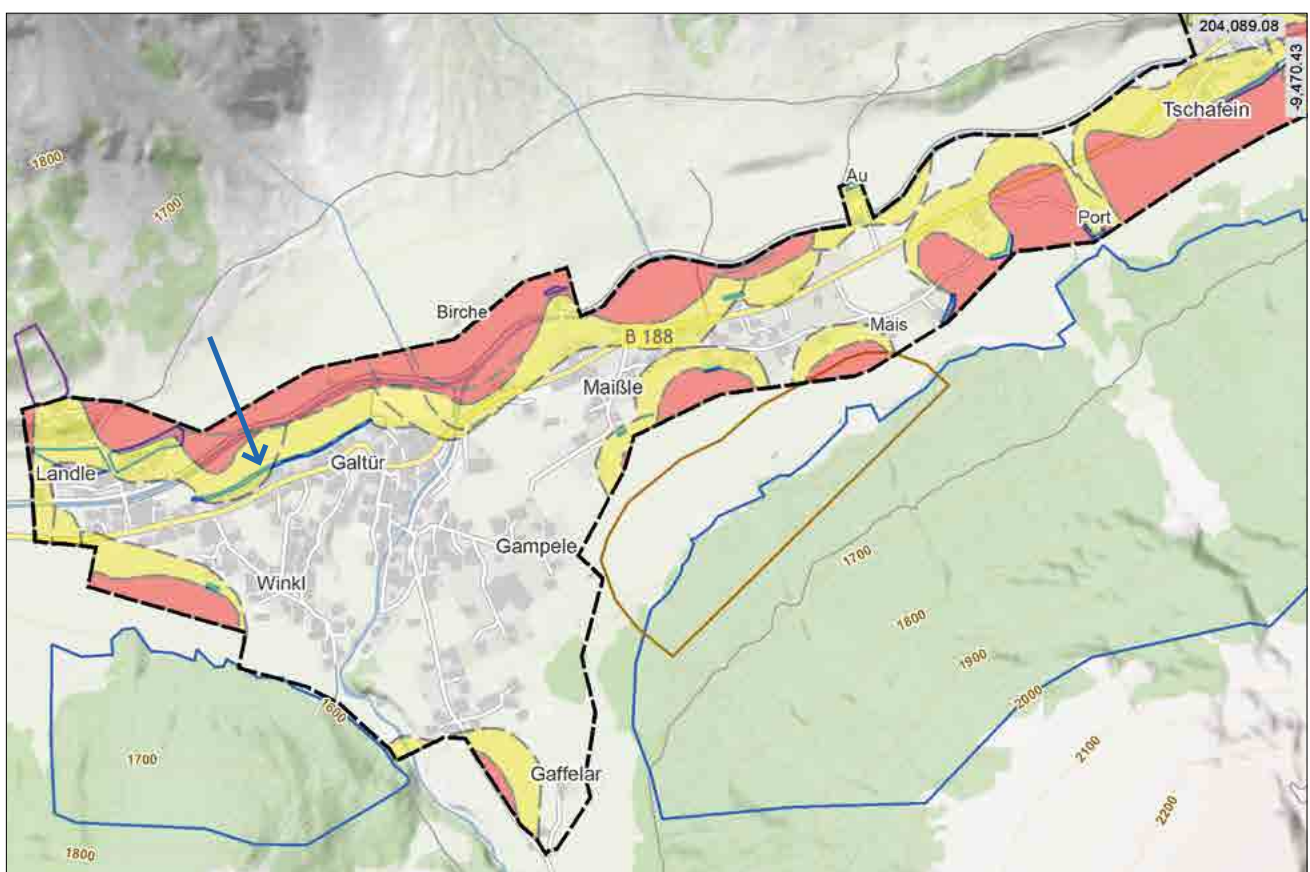
vested in developing new administrative arrangements to settle responsibilities and liabilities between the municipality, citizens and the WLV – as well as in securing new financial resources to develop and maintain structural protection schemes [6].

The key players in implementing the Alpinarium were the WLV and the Federal State of Tyrol, which both led the discussions in Galtür. Tyrol was powerful because of its importance regarding funding sources, while the WLV was responsible for designing and constructing the dam. The national, regional and local governments provided € 9.5 million towards the project, receiving additional funds from international donors who supported reconstruction following the 1999 disaster, such as the Autonomous Province of Bolzano, Italy.

The leadership at the local and regional levels was key in driving the strong community engagement. It was also powerful enough to influence the current policy discourse, due to its technical knowledge and expertise. The main challenges identified were the gap between policy guidelines, regulations and the implementation process at the local level. Inhabitants showing higher risk awareness were more likely to participate in the process. Another challenge was the shift of legal responsibilities between the different public authorities involved and their regulatory power, such as planning regulation (municipality) or permission to carry out the construction (WLV). Moreover, a central aspect was the question of responsibility for potential damage from future natural hazard events, which was finally transferred to the municipality. Thus, the avalanche dam contributed to improving social capacity building of the community of Galtür – increasing risk perception, risk communication and risk education, with respect to sustainable mountain development.

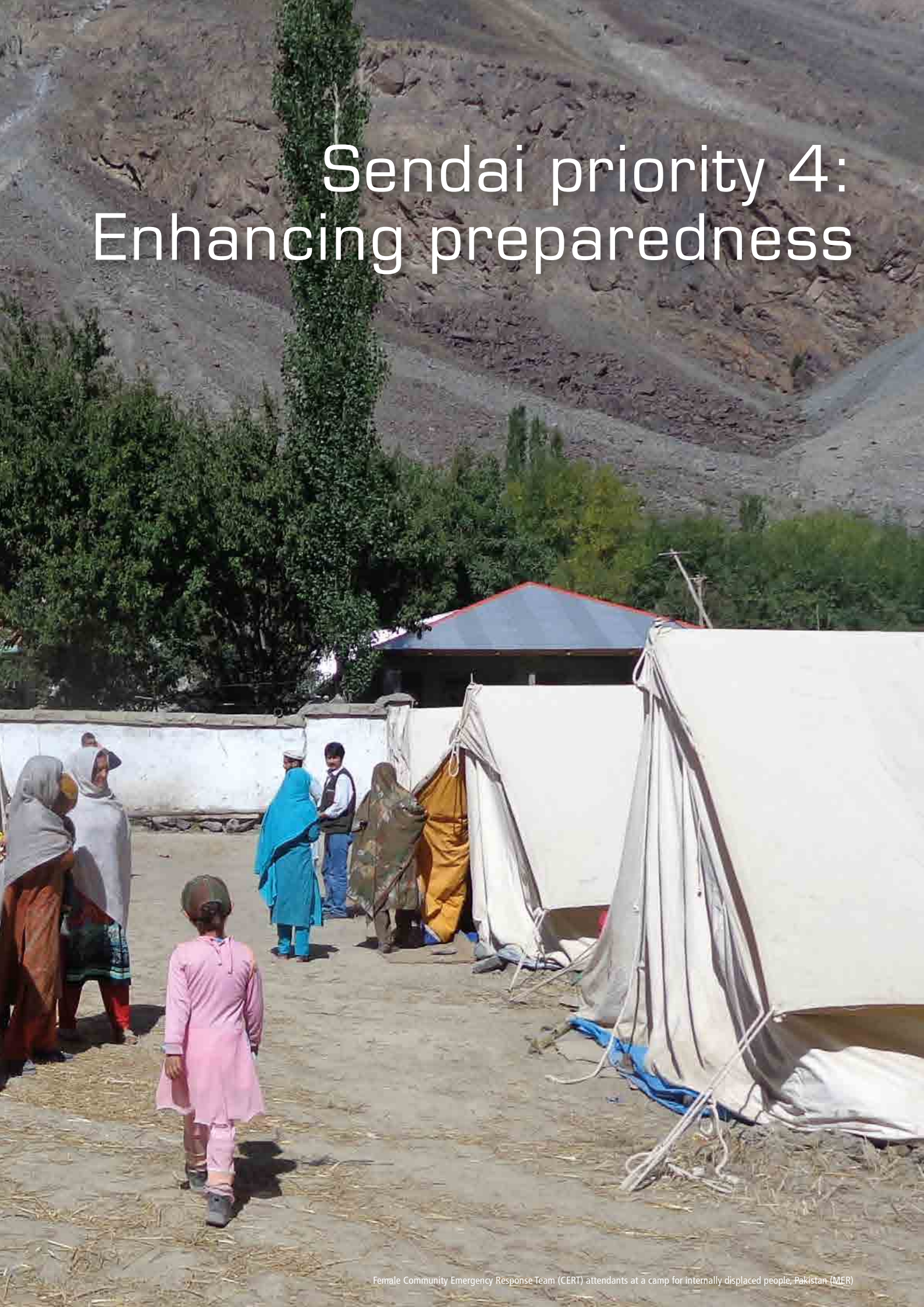
- The community-based initiative encouraged citizens to actively engage in risk management and ensured that local interests and well-being were met.
- Multifunctional protection schemes provide multiple benefits. Such schemes reduce pressure on limited land and thus mitigate land use conflicts. They can attract investors, providing new financial resources to complement scarce public finances. And they can be used for risk communication and education in promoting local resilience.
- Major investments in disaster risk reduction often require collaboration between local, regional and national authorities – and a new division of responsibility.

Section of the hazard map of Galtür, showing the high (red) and moderate (yellow) hazard zones and the locations of protective elements (blue), including the Alpinarium (arrow).  
(Cartography: M. Wenk, based on BMLFUW)





# Sendai priority 4: Enhancing preparedness





Sven Fuchs and Maria Papathoma-Köhle

# Strengthening local capacities for effective response

Training women in packing “go-bags” to be prepared in case of a flood event (J. Bajracharya, ICIMOD)

Changes in climate and socio-economic context of mountain areas indicate the need to strengthen risk governance through better disaster preparedness. This involves improving the role allocation of stakeholders, risk communication, community participation and risk reduction activities. Ensuring the participation of local communities in decision-making and planning is paramount for effective response – and to reduce their vulnerability.

The main goal of Sendai priority 4 is to enhance disaster preparedness for effective response and reconstruction of communities. To do so, it calls for community participation, enhancing resilience, promotion of public awareness and exercises, and better cooperation of institutions at local, national and international levels.

In mountain areas, however, sensitivity to climate change, limited space for settlement and remoteness pose a number of specific challenges to disaster risk preparedness. The proximity of hazard-prone to safe areas often leaves only a short time to respond to events, which makes it difficult to coordinate action. In temperate mountain areas, for example, urban agglomerations and critical infrastructure are concentrated in broader valleys and mountain basins that have been subject to



human intervention in flood risk mitigation for decades [1]. By contrast, in tropical mountains, small and medium-sized towns are often located in the uplands and roads often cross ridge-top locations [2], making them prone to landslides and requiring adequate actions for risk reduction. A re-scaling of risk governance to the regional and even local level often remains fragmented, even if traditional local knowledge to avoid losses exists.

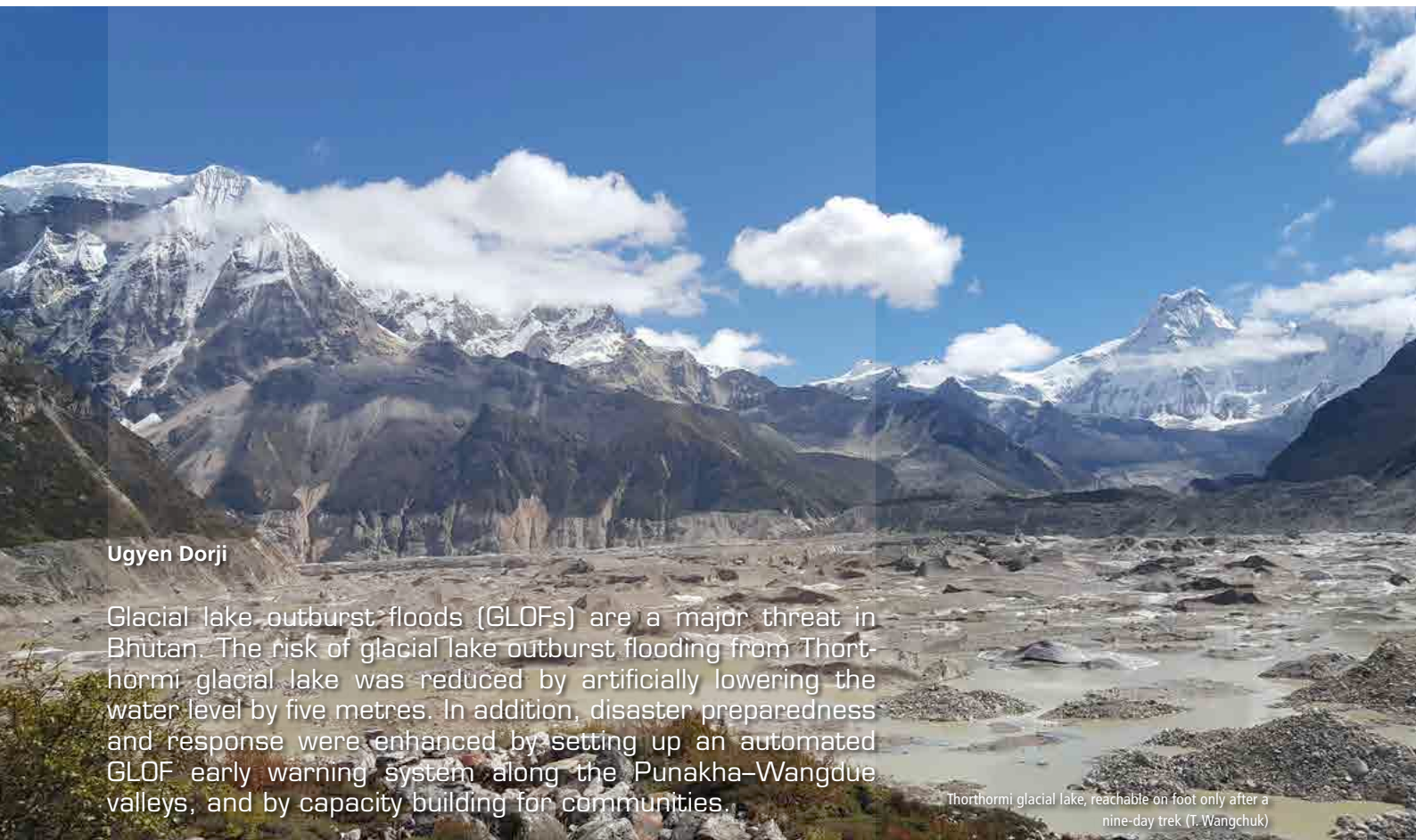
Regarding local disaster-response capacity, there is often no framework for risk governance, such as amendments in land-use planning laws and delineation of hazardous areas or safe zones that may serve as shelter in case of an event. Furthermore, many mountain areas have experienced a strong and often uncontrolled increase in population and economic development over the last decades [3]. Without proper exposure and vulnerability management and multistakeholder participation, reviewing and updating disaster preparedness is not possible, and coordinated social and economic recovery may fail. Additionally, natural hazard impacts in mountain areas may be amplified by unsustainable development and, conversely, poor disaster management practices may set back sustainable development goals.

Preparedness and emergency plans have to encourage participation of all relevant stakeholders, including local communities. Interactions between highland and lowland must be considered, and climate and socio-economic change should be taken into account. People-centred early warning systems may support sustainable development, with their special focus on risk communication and capacity building, and by reaching all vulnerable groups (see Aga Khan Agency for Habitat, pp. 60–61). In this way, early warning systems contribute to reducing inequalities due to gender, health condition or age in mountain communities, in line with the Sustainable Development Goals of the United Nations' Agenda 2030. Land use planning may restrict development in hazardous areas and reduce adverse consequences. Reconstruction should include the concept of "Building Back Better" [4] (see Posch and Mackner, pp. 62–63). Rebuilding within hazard zones should be prohibited, and relocation or reinforcement of existing buildings may be considered. Reinforcement of schools and critical infrastructure should be a priority. Appropriate land use planning may reduce deforestation, overexploitation of the flood plain and soil degradation. Finally, preparedness and reconstruction efforts may contribute directly to the battle against poverty by improving housing or, indirectly, by safeguarding livelihoods and food security, and reducing hunger in substantial parts of the mountain world.

Consideration of local knowledge and practices has also been an important tool in disaster reduction through traditional weather forecasting, selection of housing locations, mirror signaling as well as earthquake-resistant traditional housing [5]. Early warning systems have been developed in mountain areas for the timely evacuation of hazardous areas. For example, the early warning system for floods caused by glacial lake outbursts in Bhutan covers the majority of households but also critical infrastructure such as health facilities and schools, and is accompanied by capacity building activities that encourage participation and make use of local knowledge and experience (see Dorji, pp. 56–57). Collaborative approaches in South Africa aiming at preparedness and response to flash floods promote partnerships and cooperation among multiple stakeholders (see Holloway et al., pp. 58–59).



# Enhancing preparedness for glacial lake outburst floods



Ugyen Dorji

Glacial lake outburst floods (GLOFs) are a major threat in Bhutan. The risk of glacial lake outburst flooding from Thorthormi glacial lake was reduced by artificially lowering the water level by five metres. In addition, disaster preparedness and response were enhanced by setting up an automated GLOF early warning system along the Punakha–Wangdue valleys, and by capacity building for communities.

Thorthormi glacial lake, reachable on foot only after a nine-day trek (T. Wangchuk)

Bhutan, a landlocked and least developed country located in a fragile mountain ecosystem in the Eastern Himalayas, is dependent on climate-sensitive sectors such as agriculture, hydropower and forestry. It is thus highly vulnerable to the impacts of climate change. While the country is exposed to multiple hazards including landslides, flash floods, forest fires, droughts and windstorms, retreating glaciers and the formation of supraglacial lakes are among the most significant climate change impacts observed in recent years.



From 2008 to 2013, the United Nations Development Programme (UNDP) and the Global Environment Facility (GEF) implemented a US\$ 4.67 million project for reducing glacial lake outburst flood (GLOF) risks from the Thorthormi glacial lake, located at 4 300 metres above sea level. Reachable after a nine-day trek from the nearest road, the lake is only accessible during 3–4 months a year due to extreme weather conditions. Thus, the project faced huge logistical challenges in terms of transportation of equipment, project staff and workers, and to secure health and safety of all staff. The glacial lake is an important source of the Punatshangchu river system flowing along the Punakha–Wangdue valleys, where urban settlements and cultural heritage sites are located, and the country's biggest hydropower plants are under construction.

After elaborating engineering and safety plans and environmental impact assessments, some 350 staff including workers, armed forces and a multidisciplinary team of experts – engineers, geologists and seismologists – were involved in lowering the

*"I still remember that October morning in 1994, when I saw many of my community members being suddenly swallowed by the GLOF from Lugge tsho that came without warning. I could do nothing but stand there and witness my friends and neighbours disappear with the flood. I wish the early warning system developed by the project had been in place back then. Things would not have ended the way they did."*

Dophu, 82-year-old farmer and village head from Samdingkha, Punakha

## Lessons learned

- Capacity building and early warning systems are instrumental for enhancing preparedness of communities living downstream from glacial lakes, as these communities are often oblivious of risk from climate-change-induced GLOFs.
- Early warning systems together with adequate evacuation plans and procedures can reduce potential losses and vulnerability of mountain communities.
- A disaster risk reduction project that responds to national priorities and addresses risks that endanger sustainable development is likely to enjoy strong country ownership.



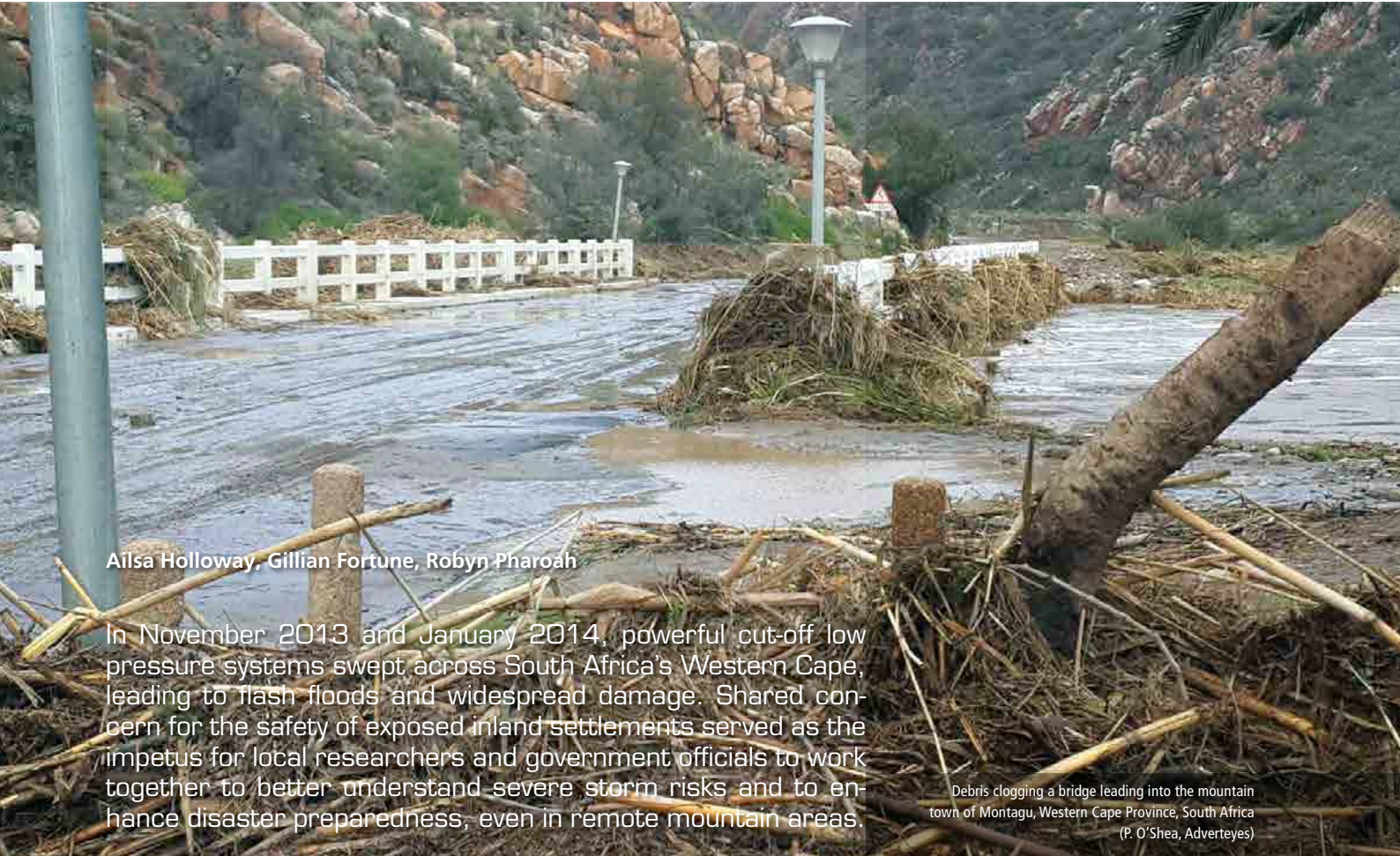
water level of the Thorthormi glacial lake. The work was done under extremely difficult conditions since heavy machinery could not be used due to the risk of weakening the already weak moraine dam of the lake. Thus, ice and boulders had to be removed by shovel and pickaxe to dig a drainage channel. Providing income to many local workers, the project contributed to local enterprise development through their savings.

A GLOF early warning system comprising several automated water-level monitoring stations, weather stations, early warning sirens and a 24-hour manned flood warning control station was established. The station is linked with the flood warning system of Bhutan, and shares data with neighbouring Indian states. The system covers 875 households – more than 90 percent of all households of the 21 vulnerable communities downstream – infrastructure (schools, health centre), as well as thousands of staff of the Department of Roads and the Punatshangchu hydropower plants. The installation of the early warning system was accompanied by capacity building and awareness raising activities in the communities. Based on GLOF hazard zonation mapping, red zone areas and safe evacuation sites were demarcated in all vulnerable communities. Combining an early warning system and awareness creation provides a positive long-term impact on the lives of communities along the Punakha–Wangdue valleys as villagers are now able to move to safe sites when the sirens are activated.



The 2001 inventory [1] made in Bhutan reported 677 glaciers and 2 674 glacial lakes, out of which 25 pose a risk of flooding through the phenomenon known as glacial lake outburst flood (GLOF). In addition, numerous supraglacial ponds were counted, which were becoming large and interconnected. The Thorthormi glacial lake was considered as one of the most critically growing glacial lakes with GLOF threat in the near future.

# “Why this storm ... this flood ... this hospital?”



Ailsa Holloway, Gillian Fortune, Robyn Pharoah

In November 2013 and January 2014, powerful cut-off low pressure systems swept across South Africa's Western Cape, leading to flash floods and widespread damage. Shared concern for the safety of exposed inland settlements served as the impetus for local researchers and government officials to work together to better understand severe storm risks and to enhance disaster preparedness, even in remote mountain areas.

Debris clogging a bridge leading into the mountain town of Montagu, Western Cape Province, South Africa (P. O'Shea, Adverteyes)

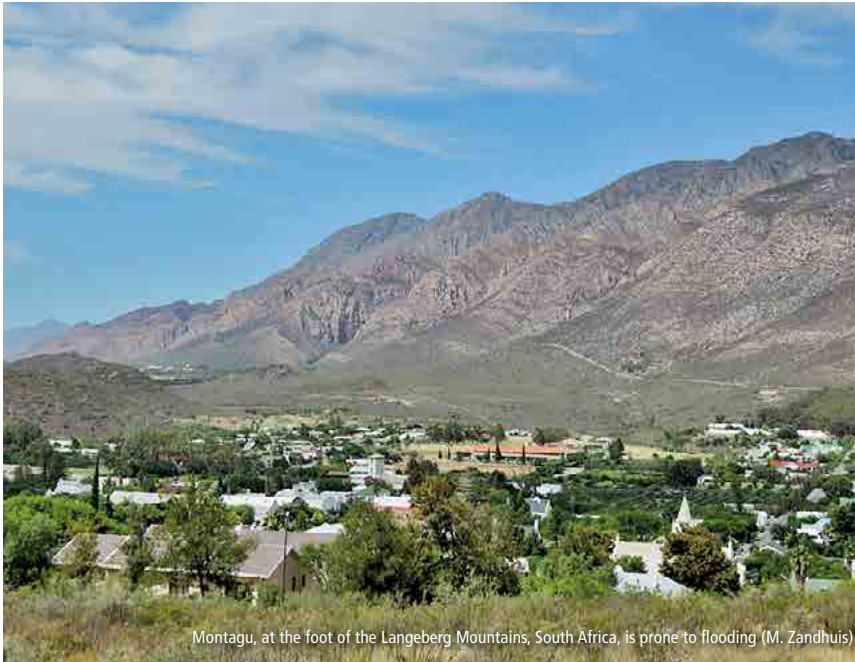
South Africa's Western Cape, home to over 5 million people, is known as “the Cape of Storms”. High-impact weather events increase the prospects of flash flooding and isolation for mountain communities in this province, which has many towns scattered inland beyond Cape Town.

The 2013 flash flood forced the night-time evacuation of an entire hospital under precarious conditions, and led to significant agricultural loss and infrastructure damage [1]. As the flood was not predicted by South Africa Weather Service's (SAWS) flash flood guidance system, practitioners were taken by surprise, later asking: “Why this storm ... this flood ... this hospital?”

A collaborative research project, funded by the Western Cape Provincial Government and USAID's Office of Foreign Disaster Assistance, was initiated to better understand the risks of flash floods and to enhance disaster preparedness for effective response, especially in mountain areas. The initiative represented an enabling government–university partnership, in which the Western Cape's Disaster Management Centre ensured ongoing multistakeholder engagement. Together with colleagues from Stellenbosch University's Research Alliance for Disaster and Risk Reduction (RADAR), the research team conducted more than 100 interviews with local officials, farmers, residents of poor communities, weather analysts and emergency responders, to capture essential local knowledge about flash flood risks throughout the province [1].



## Lessons learned



- Recurring flash flood disasters in mountain catchments can result in costly damage to essential roads, water and other public infrastructure, undermining local development prospects.
- Complex mountain topography can constrain the accuracy of broad-based flash flood warnings, especially in small, remote catchments, limiting preparedness actions.
- Integrated post-disaster studies that actively include researchers, civil-society representatives and committed government officials can produce context-specific and vital information that improves flood risk management planning in areas with complex mountainous topography.

Combining local insights with detailed rainfall and flooding analyses [2, 3, 4, 5], and drawing on RADAR's decade-long research on severe storms and their impacts, the study team pieced together the factors that increased the likelihood of flash flood danger, especially in mountain areas. The study led to the staggering realization that, contrary to the perceptions of emergency responders and disaster managers, the SAWS flash flood guidance system was not fully operational in inland areas. This was because the province's mountainous topography blocked the reach of the existing weather radar, leading to generic flood warnings (Figure 1). These proved insufficiently precise to guide protective action – especially in towns located in remote, mountainous catchments – constraining the effectiveness of preparedness efforts.

The study also revealed a counter-intuitive finding that storms triggered by summer cut-off low pressure systems were twice as damaging as those that occurred in cooler seasons. This crucial – but unexpected – discovery has been essential for improving preparedness planning in mountain zones, where rainfall is particularly intense in summer storms due to their increased convective activity, leading to fast-flowing runoff and prospects of life-threatening flash floods [6]. It is particularly reflected in increased attention by SAWS to improve the quality of flash flood warnings issued for inland areas.

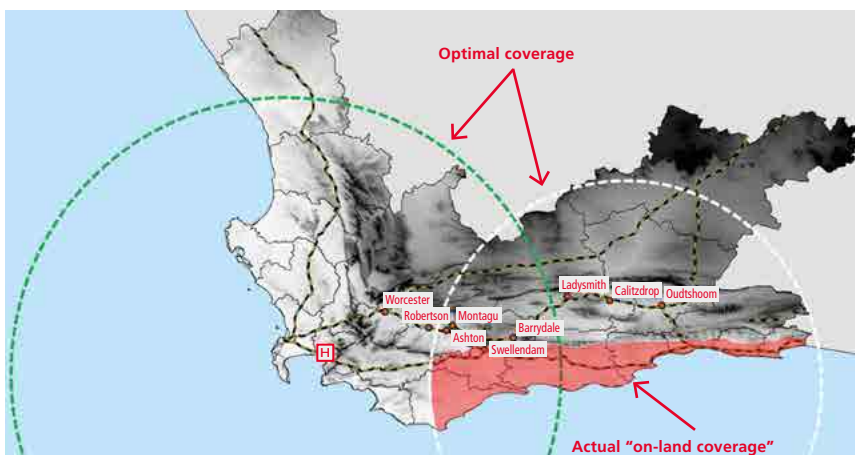
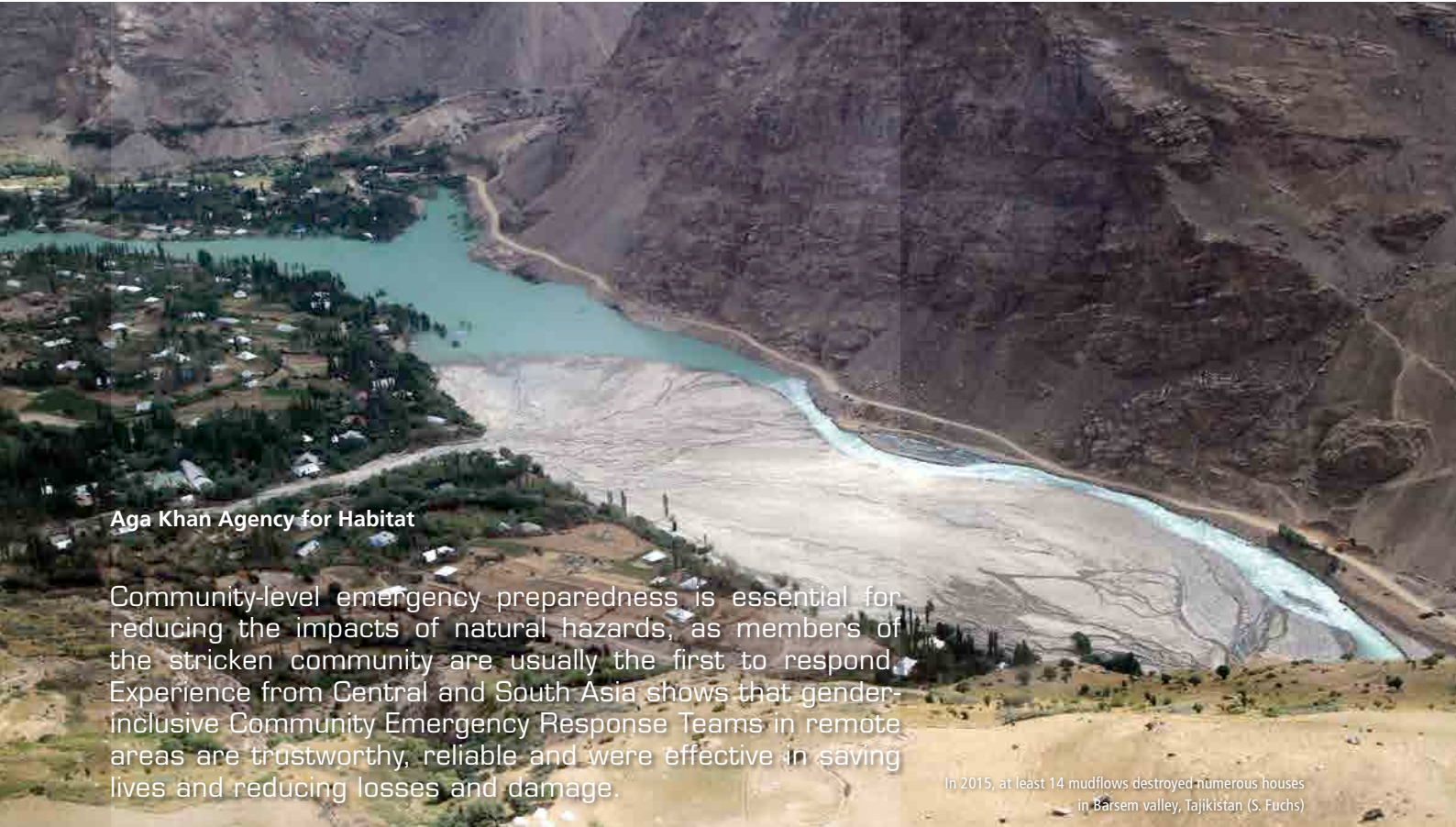


Figure 1: Map of the Western Cape, South Africa, showing the discrepancy between optimal weather radar coverage (green and white circles) and actual weather radar coverage (red shading). Source: [1]

# Fostering gender-inclusive emergency preparedness



## Aga Khan Agency for Habitat

Community-level emergency preparedness is essential for reducing the impacts of natural hazards, as members of the stricken community are usually the first to respond. Experience from Central and South Asia shows that gender-inclusive Community Emergency Response Teams in remote areas are trustworthy, reliable and were effective in saving lives and reducing losses and damage.

In 2015, at least 14 mudflows destroyed numerous houses in Barsem valley, Tajikistan (S. Fuchs)

The Aga Khan Agency for Habitat (AKAH) has established an expansive network of Community Emergency Response Teams (CERTs) across Central and South Asia, in order to increase the ability of vulnerable and isolated communities to respond to emergencies associated with natural hazards. Overall, more than 20 000 CERT members (11 879 volunteers in Afghanistan, 2 100 in Tajikistan, 2 500 in India and 5 200 in Pakistan) have been trained in emergency management. The training included the following contents: conduct basic search and rescue operations, activate emergency evacuation, provide first aid and shelter, and communicate effectively with professional responders. To maintain their readiness, CERTs also receive periodic refresher training and conduct practice drills, often in coordination with the local and national government emergency response mechanisms. Women play an indispensable role on all CERTs, and at least 40 percent of the CERT members in the four countries are female (Box 1).

The timely response to the disastrous mudflows in the Shugnan District of Tajikistan by the local CERT is a powerful demonstration of the team's effectiveness. With support from the Swiss Agency for Development and Cooperation (SDC), AKAH conducted risk assessments of the mountainous hamlets of Barsem, Kolkhozabad and Berdibekobod, in close consultation with relevant stakeholders, including local villagers, civil society and government authorities. These stakeholders then created disaster management plans and were taught how to evacuate to designated safe havens during a hazardous event; what to pack in their "Grab-&-Go Bag"; and what to do before, during and after a disaster. Finally, volunteers were selected, trained and equipped to serve as local CERTs.



*"I noticed that the colour and direction of the water had changed two days before the huge floods. I alerted the team, and we immediately took early action."*

Dilkusho Muborakshoev,  
Community Emergency Response  
Team volunteer, aged 31, from  
Boghev village in Shugnan

## Lessons learned



Female CERT member evacuating an injured person in a simulation session (Training Officer, Gilgit)

- Participatory disaster planning and emergency training in remote settlements helps communities learn how to prevent and respond to disasters, and at the same time integrate local knowledge.
- Trained female first responders can make a pivotal contribution to community emergency management; they are the most reliable stakeholder group and trusted by both female and male community members.
- AKDN's inclusiveness approach can lead the way in developing much-needed gender-inclusive policies and systems for disaster risk management that recognize women's often informal contributions to disaster risk reduction and strengthen their position in disaster risk reduction decision-making.

In July 2015, an unprecedented heatwave accelerated the melting of a large glacier in the area, resulting in a series of catastrophic mudflows that hit three remote villages. Despite the destructive force of the mudflows, which partially or totally destroyed or damaged over 85 homes and blocked the country's link to China, not a single life was lost thanks to the previous training of the volunteering emergency team.

That process of engagement made all the difference during the 2015 event. Not only did the CERTs successfully evacuate all at-risk households before they were hit – but also afterwards, by providing camp management. Moreover, working in close coordination with the local government, Aga Khan Development Network (AKDN) staff and CERTs helped to construct some of the houses at the new site allocated by the Government to residents whose houses had been damaged by the Barsem mudflows.

### BOX 1 | Gender-inclusive CERT, Pakistan

*“Training of females as CERT members may seem unbelievable considering the strict social norms in our Pakistani society. Over time, not only are the communities amazed to see us work with males, but they are also developing trust that female CERT members can plan and provide a timely response in emergencies.”*

Gul Noori, female CERT member,  
Jutial village, 45 years old

*“Surrendering to the floods was the only thought we had amidst darkness and the roaring rain. But then a woman hurried to our home and led us to a safe place. Had it been a man, we may not have been comfortable to follow him. Later we found that the woman was a CERT member.”*

Bibi Sharifa, female resident of  
Brep village, 52 years old

CERTs are normally composed of one male and one female captain, and 50 percent female team membership. Although this team composition is challenging in a region where the traditional role of women is quite restrictive, female first responders are often first on the scene in mountain disasters, and are often perceived as more honourable and trustworthy than their male counterparts.

The design of CERTs and their capacity building programmes take into account gender sensitivity and cultural aspects of mountain communities. Female members attend training sessions and drills or simulations often jointly with men and seldom separately. Women contribute throughout the “disaster cycle” (preparedness, response, recovery and mitigation), in fields traditionally considered to be predominantly “men’s work”, and actively participate in disaster risk reduction decision-making.

# Earthquake-proof reconstruction



Eva Posch and Elisabeth Mackner

Outmigration is one of the many challenges faced by mountain communities in Nepal. After the major earthquakes in 2015, skilled workers for reconstruction were scarce. To counter this and strengthen resilience to future disasters, EcoHimal organized capacity building for disadvantaged and young people. This enabled them to acquire technical knowledge and practical skills to rebuild infrastructure in an earthquake-proof way.

Training in earthquake-proof construction creates income opportunities (EcoHimal)

The catastrophic earthquake in April 2015 and its subsequent aftershocks devastated wide parts of Nepal: Nearly 9 000 people died, thousands were displaced and countless buildings destroyed. Earthquake-hit districts in mountain areas faced immense challenges due to their remoteness, exposure to natural hazards, limited economic opportunities and outmigration of young people. Among the affected areas were the mountainous districts Solukhumbu and Khotang. While access to development resources in these districts was already limited before the earthquake, people's living conditions have undoubtedly deteriorated even further since the disaster. An urgent response was required to the loss of livelihood assets and income opportunities, and the destruction of infrastructure. However, the lack of capacity for reconstruction was a major challenge as skilled workers were needed immediately to guarantee earthquake-resilient reconstruction of schools, private houses, health posts and drinking water systems.



Awareness raising and capacity development were crucial in a reconstruction and rehabilitation project that was conducted by EcoHimal Austria and Nepal in coordination with the Nepalese government (2015–2017), and funded by the Austrian Development Agency. In addition to activities such as supporting local radio broadcasts on the topics of emergency response measures and earthquake-proof construction, the project organized three-month training courses in masonry, carpentry and plumbing for local disadvantaged and young people. The future trainees had to pass qualifying examinations and a selection process supported by local community committees, set up for this purpose, that tested their aptitude in terms of literacy and basic mathematical skills as well as motivation and personality traits. To enhance ownership by local communities, the committees were





Many private houses and community infrastructure were destroyed in the 2015 earthquakes (EcoHimal)

## Lessons learned

- Preparedness for future disasters was enhanced by raising awareness and constructing earthquake-proof houses and community infrastructure.
- Developing local capacities and practical skills of young people within the disaster risk reduction framework can contribute to securing livelihoods and reducing outmigration. Locally available capacities enhance the resilience of remote communities.
- Giving local communities an active role in reconstruction ensures continuous knowledge sharing as well as the creation of the community's ownership of infrastructure.

involved in managing the courses and monitoring construction activities. During their apprenticeships, the trainees supported local reconstruction efforts by constructing earthquake-proof community buildings such as schools, which were later managed by the local communities.

The awareness raising and capacity development efforts had multiple positive outcomes in terms of preparedness and sustainable mountain development. In addition to the valuable skills desperately needed for reconstruction, awareness of the importance of earthquake-proof construction methods was raised through specialized training courses and other activities, strengthening the capacity of local communities to act. The new earthquake-proof infrastructure together with the newly acquired qualifications contribute to improving the communities' preparedness to future disasters. In addition, local income-generating opportunities were created as the young newly trained professionals can offer their services beyond reconstruction. This is of utmost importance for the sustainable development of mountain communities, as they are particularly affected by outmigration of young people to the cities in Nepal or countries in Asia and the Middle East.





# Enabling safer livelihoods in and beyond mountains



Irasema Alcántara-Ayala, Felicitas Bachmann, Sven Fuchs, Margreth Keiler, Thomas Kohler, Arabinda Mishra, Elisabeth Sötz, Susanne Wymann von Dach, Markus Zimmermann

# Messages for policy-makers

The increase in disasters associated with natural hazards is putting communities and their sustainable development in and beyond mountains at risk. Disasters undermine poverty alleviation efforts, jeopardize growing economic assets and critical social infrastructure and affect the environment. The Sendai Framework for Disaster Risk Reduction 2015–2030 [1] offers leverage to halt or even reverse the trend, provided policy-makers succeed in tackling the specific challenges of mountain communities and environments, and addressing root causes of disaster risks.

Mountains require special and coherent policy attention

## **Recognize mountains as specific, disaster-prone areas in international, national and local policies**

To successfully reduce the high disaster risk in mountains, they require special policy attention. This is, firstly, because mountains are multihazard environments where disasters affect mountain communities, critical social and economic infrastructure, the environment and the adjacent lowlands; secondly, because the last decades have seen a noticeable increase in the frequency and magnitude of disasters; and thirdly, because disaster risk reduction (DRR) is particularly challenging where high-magnitude processes are concerned. If global policies, such as the Sendai Framework, and national policies explicitly refer to disaster-related challenges in mountains, this will spur policy- and decision-makers to support mountain-specific implementation strategies. It will also trigger urgently needed investments for effective DRR, for the benefit of mountain and adjacent lowland communities.

Natural resource management and fostering of rural economic development help to address the vulnerability of families in Rustaq, Afghanistan (B. Wolfgramm)

### **Bring DRR, climate change adaptation and sustainable mountain development together**

Achievements of development efforts in mountains recurrently risk being eroded by disasters and climate change. However, alleviating poverty and enhancing gender equality and the adaptive capacity of women, men and children living in mountains can help to enhance their resilience and reduce their vulnerability to hazards. Moreover, building multifunctional social and economic infrastructure in a risk-informed way is key to improving people's livelihoods and well-being and reducing future losses – as well as making the most of limited financial and scarce land resources.

#### Priority 1: Understanding risks

##### **Uncover underlying mountain-specific risk drivers**

In most mountain areas, poverty rates are higher than in lowlands, and economic opportunities more limited. Population growth, urbanization, climate change and effects of globalization tend to increase inequalities in mountains, and they add to competition for the limited safe space and to a spatial concentration of essential infrastructure. This results in greater exposure to hazards of more vulnerable people and of critical infrastructure. Investing in an in-depth understanding of mountain-specific drivers of disaster risk is key to tackling root causes and effectively reducing risk and preventing losses.

##### **Invest in fine-scaled, integrative assessments for site-specific DRR**

Changing topography, upstream–downstream dynamics, site-specific environmental, economic and institutional conditions, as well as high sociocultural diversity and dynamic global change shape the highly diverse “riskscapes” in mountain watersheds. The complex interactions of these factors make it challenging to assess the risk situation of a specific area and require fine-scaled systematic assessment. In addition, mountains are data-scarce regions, but local people possess pertinent knowledge about nature, hazards and the local socio-economic situation. Only upfront investments in fine-scaled disaster risk assessments that integrate local and scientific knowledge can help to overcome these challenges and allow for planning effective DRR and risk-informed development interventions.

#### Priority 2: Strengthening risk governance

##### **Reinforce local DRR institutions to manage risks and disasters, particularly in remote mountain regions and in times of isolation**

Mountain communities often live in remote and scattered settlements that are difficult to access and only weakly linked to and supported by national governmental institutions. It is therefore vital that the capacity, leadership and ownership of local DRR organizations are strengthened and their financial resources enhanced, to guide and organize activities across different DRR-relevant sectors, and to take full advantage of the local DRR knowledge. This is especially important in the case of a hazardous event, when immediate response is crucial.

##### **Establish inclusive and transboundary multistakeholder platforms to negotiate DRR priorities of mountain and lowland communities**

Safe space is limited in mountain areas but there are manifold land use and conservation claims by different stakeholders. Moreover, natural hazards and process dynamics in the upper parts of watersheds can affect downstream communities in and outside mountain areas. Institutionalized processes are needed to negotiate stakeholder interests and priorities, make best use of the limited resources and coordinate activities in a holistic approach across sectors and administrative boundaries. These processes must be inclusive – with special attention given to disadvantaged social groups – and can be scaled up to a transboundary dimension in the watershed, if needed.



Community members in Kabale District, Uganda, conduct a vulnerability assessment (K. Twinamasiko)



Trial of different bioengineering technologies for slope stabilization in the community of Dulce Nombre de Culmi, Olancho, Honduras (Swiss Red Cross)

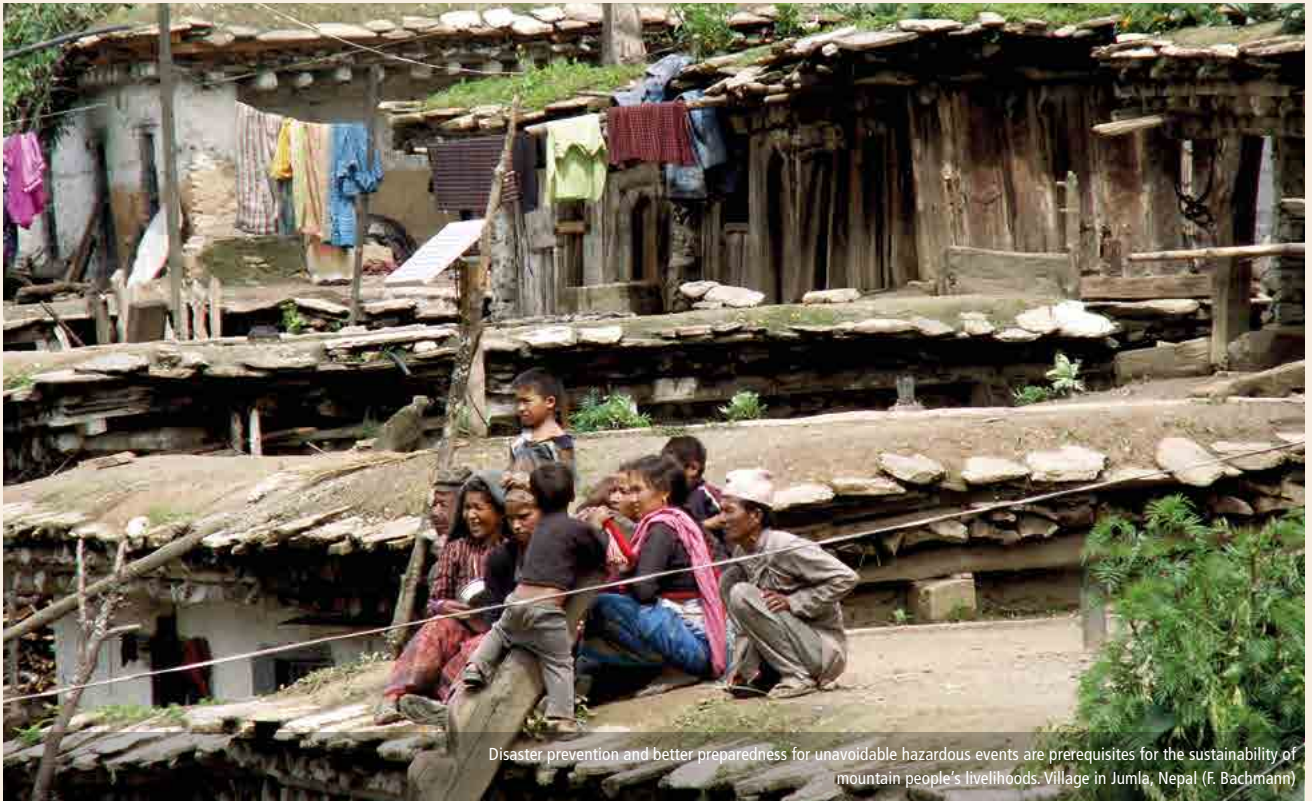
### Priority 3: Increasing resilience

#### **Foster innovations that expand livelihood options and build mountain people's resilience**

Poverty in mountains is high; livelihood options and public resources are limited. Innovations tailored to mountain-specific challenges serving multiple purposes – e.g. to prevent or mitigate disaster, increase economic opportunities and enhance adaptation to climate change – can go a long way in increasing mountain people's resilience. Private–public partnerships can help to increase scarce financial resources and trigger innovative solutions, such as multifunctional structural measures or microinsurance schemes for smallholder farmers.

#### **Enhance sustainable land management in watersheds to secure key mountain ecosystem services**

Population growth as well as climate and socio-economic change are putting ever greater pressure on mountain lands. Risk-conscious urbanization and land use planning in rural areas as well as sustainable land and watershed management are key to moderating extreme events, protecting settlements and infrastructure and safeguarding services of mountain ecosystems. This would also help to adapt to climate change, as well as to ensure food security and livelihood options for mountain communities and the population of adjacent lowlands.



#### Priority 4: Enhancing preparedness

##### **Set up decentralized early warning systems based on scientific and traditional knowledge**

Prevention is cheaper than recovery and reconstruction. Early warning systems are an effective means when an event occurs. Wherever possible, early warning systems should be set up to be locally manageable. Given the data scarcity in mountains, and to strengthen local ownership, early warning systems should capitalize on traditional knowledge and combine it with information increasingly made available by science and modern technology.

##### **Develop the capacity of mountain women and men to act autonomously**

In the event of a disaster, prompt and effective response is pivotal to save lives and assets. In areas with traditionally different gender roles and responsibilities, gender-mixed emergency teams are particularly important to respond effectively also to female needs. Far-sighted local capacity building in risk-conscious planning, response and (re)construction facilitates effective and sustainable recovery. It can also provide new income opportunities for trained women and men in mountains, e.g. in construction of earthquake-resistant buildings.

Safer livelihoods for people living in mountains and downstream in lowlands can become a reality, provided that policy-makers are committed to promoting and investing in a holistic DRR approach. Such an approach should not only combine measures across the Sendai Framework's four priorities, but also integrate DRR and climate change adaptation efforts with sustainable development initiatives tailored to the challenges and needs of mountain communities. In this way, the Sendai Framework for Disaster Risk Reduction could contribute to achieving the Sustainable Development Goals in mountain regions and adjacent lowlands [2] and address the United Nations General Assembly's plea and concerns put forward in its resolution on sustainable mountain development [3].

## Authors

### Dynamic mountains – vulnerable communities

#### Disasters threaten sustainable mountain development

Susanne Wymann von Dach, Felicitas Bachmann  
Centre for Development and Environment  
University of Bern, Switzerland  
susanne.wymann@cde.unibe.ch  
felicitas.bachmann@cde.unibe.ch

Irasema Alcántara-Ayala  
Institute of Geography  
National Autonomous University of Mexico (UNAM)  
Mexico City, Mexico  
irasema@igg.unam.mx

Sven Fuchs  
Institute of Mountain Risk Engineering  
BOKU University of Natural Resources and Life Sciences  
Vienna, Austria  
sven.fuchs@boku.ac.at

Margreth Keiler  
Institute of Geography  
University of Bern, Switzerland  
margreth.keiler@giub.unibe.ch

Arabinda Mishra  
International Centre for Integrated Mountain Development  
(ICIMOD)  
Kathmandu, Nepal  
arabinda.mishra@icimod.org

Elisabeth Sötz  
WWF Austria  
Innsbruck, Austria  
elisabeth.soetz@wwf.at

#### Diverse natural hazards – high human and economic losses

Anina Stäubli, Simon Allen, Christian Huggel  
Department of Geography  
University of Zurich, Switzerland  
a.staebli@gmx.ch  
simon.allen@geo.uzh.ch  
christian.huggel@geo.uzh.ch

Samuel U. Nussbaumer  
Department of Geography,  
University of Zurich, Switzerland  
Department of Geosciences,  
University of Fribourg, Switzerland  
samuel.nussbaumer@geo.uzh.ch

Susanne Wymann von Dach  
Centre for Development and Environment  
University of Bern, Switzerland  
susanne.wymann@cde.unibe.ch

### Sendai priority 1: Understanding disaster risks

#### Uncovering causality of disasters and disaster risk in mountains

Irasema Alcántara-Ayala  
Institute of Geography  
National Autonomous University of Mexico (UNAM)  
Mexico City, Mexico  
irasema@igg.unam.mx

Margreth Keiler  
Institute of Geography  
University of Bern, Switzerland  
margreth.keiler@giub.unibe.ch

#### From analysing geohazards to managing georisks

Caroline Michellier, François Kervyn, Olivier Dewitte  
Earth Sciences Department  
Royal Museum for Central Africa  
Tervuren, Belgium  
caroline.michellier@africamuseum.be  
francois.kervyn@africamuseum.be  
olivier.dewitte@africamuseum.be

#### Identifying vulnerable dwellings in urban slums

Carlos Alberto Padrón Chacón  
Dirección de Gestión de Riesgos  
Alcaldía de Caracas, Venezuela  
carlospadron2502@gmail.com

#### Participatory risk assessment for priority setting

Nicole Stolz, Renate Fleiner  
Caritas Switzerland  
Lucerne, Switzerland  
nstolz@caritas.ch  
rfleiner@caritas.ch

#### Identifying and targeting vulnerable communities

Joan Bastide, Stéphanie Jaquet, Michael Epprecht  
Centre for Development and Environment  
University of Bern, Switzerland  
joan.bastide@cde.unibe.ch  
stephanie.jaquet@cde.unibe.ch  
michael.epprecht@cde.unibe.ch

Melia Ungson  
School of Global Policy and Strategy  
University of California  
San Diego, USA  
melia.ungson@gmail.com

### Sendai priority 2: Strengthening governance

#### Enhancing governance capacities and collaboration to manage disaster risks in mountains

Elisabeth Sötz  
WWF Austria  
Innsbruck, Austria  
elisabeth.soetz@wwf.at



Arabinda Mishra  
International Centre for Integrated Mountain Development  
(ICIMOD)  
Kathmandu, Nepal  
arabinda.mishra@icimod.org

#### **Effective risk management requires political will**

Omar-Dario Cardona, Dora Catalina Suarez  
Instituto de Estudios Ambientales (IDEA),  
Universidad Nacional de Colombia and  
INGENIAR Consultants  
Manizales, Colombia  
odcardonaa@unal.edu.co  
doritasuarez@hotmail.com

María del Pilar Perez  
Secretary of Planning of Manizales and  
INGENIAR Consultants  
Manizales, Colombia  
pilarperezr@yahoo.com

#### **Strengthening disaster risk governance from the bottom up**

Rafael Van Dyck  
Consultant  
Oaxaca de Juárez, Mexico  
rafael.vandyck@gmail.com

#### **Analysing costs and benefits to set the right DRR priorities**

David Chichinadze  
Swiss Cooperation Office for the South Caucasus  
Tbilisi, Georgia  
david.tchitchinadze@eda.admin.ch

#### **Preventing water disasters: Different interests, common goals**

Elisabeth Sötz  
WWF Austria  
Innsbruck, Austria  
elisabeth.soetz@wwf.at

### **Sendai priority 3: Increasing resilience**

#### **Linking risk reduction and development**

Margreth Keiler  
Institute of Geography  
University of Bern, Switzerland  
margreth.keiler@giub.unibe.ch

Arabinda Mishra  
International Centre for Integrated Mountain Development  
(ICIMOD)  
Kathmandu, Nepal  
arabinda.mishra@icimod.org

### **Women-centric approach to enhance resilience**

Nand Kishor Agrawal, Laxmi Dutt Bhatta, Iris C. P. Leikanger  
International Centre for Integrated Mountain Development  
(ICIMOD)  
Kathmandu, Nepal  
nandkishor.agrawal@icimod.org  
laxmi.bhatta@icimod.org  
iris.leikanger@icimod.org

### **Microinsurance to reduce impacts of climatic hazards**

Ximena Jáuregui Paz  
Fundación PROFIN  
La Paz, Bolivia  
xjauregui@fundacion-profin.org

Roberto Méndez  
Swiss Cooperation Office  
La Paz, Bolivia  
rmendezt1@gmail.com

### **Preventing the “White Death”: More than an avalanche dam**

Sven Fuchs, Thomas Thaler  
Institute of Mountain Risk Engineering  
BOKU University of Natural Resources and Life Sciences  
Vienna, Austria  
sven.fuchs@boku.ac.at  
thomas.thaler@boku.ac.at

### **Sendai priority 4: Enhancing preparedness**

#### **Strengthening local capacities for effective response**

Sven Fuchs, Maria Papatoma-Köhle  
Institute of Mountain Risk Engineering  
BOKU University of Natural Resources and Life Sciences  
Vienna, Austria  
sven.fuchs@boku.ac.at  
maria.papatoma-koehle@boku.ac.at

#### **Enhancing preparedness for glacial lake outburst floods**

Ugyen Dorji  
United Nations Development Programme (UNDP)  
Thimphu, Bhutan  
ugyen.dorji@undp.org

#### **“Why this storm ... this flood ... this hospital?”**

Ailsa Holloway, Gillian Fortune, Robyn Pharoah  
Research Alliance for Disaster and Risk Reduction (RADAR)  
Stellenbosch University  
Stellenbosch, South Africa  
ailsaholloway@sun.ac.za  
gillianfortune@sun.ac.za  
robynpharoah@sun.ac.za

#### **Fostering gender-inclusive emergency preparedness**

Aga Khan Agency for Habitat  
<http://www.akdn.org/webform/contact-us>

## Earthquake-proof reconstruction

Eva Posch, Elisabeth Mackner  
EcoHimal  
Salzburg, Austria  
office@ecohimal.org

## Enabling safer livelihoods in and beyond mountains

### Messages for policy-makers

Irasema Alcántara-Ayala  
Institute of Geography  
National Autonomous University of Mexico (UNAM)  
Mexico City, Mexico  
irasema@igg.unam.mx

Sven Fuchs  
Institute of Mountain Risk Engineering  
BOKU University of Natural Resources and Life Sciences  
Vienna, Austria  
sven.fuchs@boku.ac.at

Margreth Keiler  
Institute of Geography  
University of Bern, Switzerland  
margreth.keiler@giub.unibe.ch

Arabinda Mishra  
International Centre for Integrated Mountain Development  
(ICIMOD)  
Kathmandu, Nepal  
arabinda.mishra@icimod.org

Elisabeth Sötz  
WWF Austria  
Innsbruck, Austria  
elisabeth.soetz@wwf.at

Markus Zimmermann  
NDR Consulting GmbH  
Thun, Switzerland  
markus.zimmermann@ndr.ch

Felicitas Bachmann, Thomas Kohler, Susanne  
Wymann von Dach  
Centre for Development and Environment  
University of Bern, Switzerland  
felicitas.bachmann@cde.unibe.ch  
thomas.kohler@cde.unibe.ch  
susanne.wymann@cde.unibe.ch

## Editors

Susanne Wymann von Dach, Felicitas Bachmann  
Centre for Development and Environment  
University of Bern, Switzerland  
susanne.wymann@cde.unibe.ch  
felicitas.bachmann@cde.unibe.ch

Irasema Alcántara-Ayala  
Institute of Geography  
National Autonomous University of Mexico (UNAM)  
Mexico City, Mexico  
irasema@igg.unam.mx

Sven Fuchs  
Institute of Mountain Risk Engineering  
BOKU University of Natural Resources and Life Sciences  
Vienna, Austria  
sven.fuchs@boku.ac.at

Margreth Keiler  
Institute of Geography  
University of Bern, Switzerland  
margreth.keiler@giub.unibe.ch

Arabinda Mishra  
International Centre for Integrated Mountain Development  
(ICIMOD)  
Kathmandu, Nepal  
arabinda.mishra@icimod.org

Elisabeth Sötz  
WWF Austria  
Innsbruck, Austria  
elisabeth.soetz@wwf.at

## Sounding board

Markus Zimmermann  
NDR Consulting GmbH  
Thun, Switzerland  
markus.zimmermann@ndr.ch

Thomas Kohler  
Centre for Development and Environment  
University of Bern, Switzerland  
thomas.kohler@cde.unibe.ch

## References and further reading

Note: URLs were last checked on 28 February 2017.

### Dynamic mountains – vulnerable communities

#### Disasters threaten sustainable mountain development

- [1] ICIMOD. Nepal earthquake 2015. *Resources*. Kathmandu, Nepal, International Centre for Integrated Mountain Development. <http://www.icimod.org/nepalearthquake2015>. (Web page)
- [2] IFRC. 2016. *How preparedness pays off: Evolution, costs, benefits and prospects of disaster risk management in Georgia*. Geneva, Switzerland, International Federation of Red Cross and Red Crescent Societies. <http://www.preventionweb.net/publications/view/48021>.
- [3] Zimmermann, M. & Keiler, M. 2015. International frameworks for disaster risk reduction: Useful guidance for sustainable mountain development? *Mt. Res. Dev.*, 35(2): 195–202. <http://dx.doi.org/10.1659/MRD-JOURNAL-D-15-00006.1>.
- [4] Cook, N. & Butz, D. 2013. The Atta Abad landslide and everyday mobility in Gojal, northern Pakistan. *Mt. Res. Dev.*, 33(4): 372–380. <http://dx.doi.org/10.1659/MRD-JOURNAL-D-13-00013.1>.
- [5] FAO. 2015. *Mapping the vulnerability of mountain peoples to food insecurity*, by R. Romeo, A. Vita, R. Testolin & T. Hofer, eds. Rome, Italy, Food and Agriculture Organization of the United Nations. <http://www.fao.org/3/a-i5175e.pdf>.
- [6] Hewitt, K. & Mehta, M. 2012. Rethinking risk and disasters in mountain areas. *J. Alp. Res. | Rev. géogr. alpine*, 100(1). <http://dx.doi.org/10.4000/rga.1653>.
- [7] UNISDR. 2015. *Making development sustainable: The future of disaster risk management*. Global Assessment Report on Disaster Risk Reduction. Geneva, Switzerland, United Nations Office for Disaster Risk Reduction. [http://www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/GAR2015\\_EN.pdf](http://www.preventionweb.net/english/hyogo/gar/2015/en/gar-pdf/GAR2015_EN.pdf).
- [8] UNISDR. 2015. *Sendai framework for disaster risk reduction 2015–2030*. Geneva, Switzerland, United Nations Office for Disaster Risk Reduction. [http://www.preventionweb.net/files/43291\\_sendai-frameworkfordrren.pdf](http://www.preventionweb.net/files/43291_sendai-frameworkfordrren.pdf).
- [9] UN. 2015. *Transforming our world: The 2030 agenda for sustainable development*. A/RES/70/1. New York, NY, USA, United Nations. <https://sustainabledevelopment.un.org/post2015/transformingourworld/publication>.

#### Diverse natural hazards – high human and economic losses

- [1] NGDC/WDS. *Global significant volcanic eruptions database, 4360 BC to present*. National Geophysical Data Center/World Data Service, National Oceanic and Atmospheric Administration. <http://dx.doi.org/10.7289/V5JW8BSH>.
- [2] NGDC/WDS. *Global significant earthquake database, 2150 BC to present*. National Geophysical Data Center/World Data Service, National Oceanic and Atmospheric Administration. <http://dx.doi.org/10.7289/V5TD9V7K>.
- [3] UNEP–WCMC. 2002. *Mountain watch: Environmental change & sustainable development in mountains*. Cambridge, UK, United Nations Environment Programme–World Conservation Monitoring Centre. <https://www.unep-wcmc.org/resources-and-data/mountain-watch--environmental-change-sustainable-development-in-mountains>.
- [4] Allen, S.K., Rastner, P., Arora, M., Huggel, C. & Stoffel, M. 2016. Lake outburst and debris flow disaster at Kedarnath, June 2013: Hydrometeorological triggering and topographic predisposition. *Landslides*, 13(6): 1479–1491. <http://dx.doi.org/10.1007/s10346-015-0584-3>.
- [5] ICIMOD. 2011. *Glacial lakes and glacial lake outburst floods in Nepal*. Kathmandu, Nepal, International Centre for Integrated Mountain Development. [http://www.icimod.org/dvds/201104\\_GLOF/reports/final\\_report.pdf](http://www.icimod.org/dvds/201104_GLOF/reports/final_report.pdf).
- [6] Schwanghart, W., Worni, R., Huggel, C., Stoffel, M. & Korup, O. 2016. Uncertainty in the Himalayan energy–water nexus: Estimating regional exposure to glacial lake outburst floods. *Environ. Res. Lett.*, 11(7). <http://dx.doi.org/10.1088/1748-9326/11/7/074005>.
- [7] Guha-Sapir, D., Below, R. & Hoyois, P. 2015. *EM-DAT: The international disaster database*. Brussels, Belgium, Université Catholique de Louvain. <http://www.emdat.be/database>.
- [8] Kapos, V., Rhind, J., Edwards, M., Price, M.F. & Ravilious, C. 2000. Developing a map of the world's mountain forests. In M.F. Price & N. Butt, eds. *Forests in sustainable mountain development: A state-of-knowledge report for 2000*, pp. 4–9. Wallingford, UK, CAB International.
- [9] UNISDR. 2009. *Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRMI): Risk assessment for Central Asia and Caucasus desk study review*, by S. Gupta. Washington, DC, USA, Geneva, Switzerland & Manila, The Philippines, The World Bank, International Strategy for Disaster Reduction & Central Asia Regional Economic Cooperation. [http://www.unisdr.org/files/11641\\_CentralAsiaCaucasusDRManagementInit.pdf](http://www.unisdr.org/files/11641_CentralAsiaCaucasusDRManagementInit.pdf).
- [10] IFRC. 2016. *How preparedness pays off: Evolution, costs, benefits and prospects of disaster risk management in Georgia*. Geneva, Switzerland, International Federation of Red Cross and Red Crescent Societies. <http://www.preventionweb.net/publications/view/48021>.
- [11] CENN & ITC, eds. 2013. *Atlas of natural hazards & risks of Georgia*. Tbilisi, Georgia, Caucasus Environmental NGO Network & Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente. <http://drm.cenn.org/index.php/en/background-information/paper-atlas>.
- [12] Mountain Partnership. 2014. 2012 mountain population. *Food security in mountains*. <http://www.mountainpartnership.org/our-work/focusareas/foodsecurity/en/>. (Download XLSX file)
- [13] Seneviratne, S.I., Nicholls, N., Easterling, D., Goodess, C.M., Kanae, S., Kossin, J., Luo, Y., Marengo, J., McInnes, K., Rahimi, M., Reichstein, M., Sorteberg, A., Vera, C. & Zhang, X. 2012. Changes in climate extremes and their impacts on the natural physical environment. In IPCC. *Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change*, by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgley, eds, pp. 109–230. Cambridge, UK & New York, NY, USA, Cambridge University Press. [https://www.ipcc.ch/pdf/special-reports/srex/SREX\\_Full\\_Report.pdf](https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf).

- [14] Korup, O. 2014. Mountain hazards and climate change. In T. Kohler, A. Wehrli & M. Jurek, eds. *Mountains and climate change: A global concern*. Sustainable Mountain Development Series. Bern, Switzerland, Geographica Bernensia. [http://boris.unibe.ch/61540/1/LOW\\_Fullversion\\_Mountain\\_CC%281%29.pdf](http://boris.unibe.ch/61540/1/LOW_Fullversion_Mountain_CC%281%29.pdf).
- [15] Haeblerli, W., Buetler, M., Huggel, C., Lehmann Friedli, T., Schaub, Y. & Schleiss, A.J. 2016. New lakes in deglaciating high-mountain regions – opportunities and risks. *Clim. Chang.*, 139: 201–214. <http://dx.doi.org/10.1007/s10584-016-1771-5>.

## Sendai priority 1: Understanding disaster risks

### Uncovering causality of disasters and disaster risk in mountains

- [1] UNISDR. 2015. *Sendai framework for disaster risk reduction 2015–2030*. Geneva, Switzerland, United Nations Office for Disaster Risk Reduction. [http://www.preventionweb.net/files/43291\\_sendai\\_frameworkfordrren.pdf](http://www.preventionweb.net/files/43291_sendai_frameworkfordrren.pdf).
- [2] Cutter, S.L., Ismail-Zadeh, A., Alcántara-Ayala, I., Altan, O., Baker, D.N., Briceño, S., Gupta, H., Holloway, A., Johnston, D., McBean, G.A., Ogawa, Y., Paton, D., Porio, E., Silbereisen, R.K., Takeuchi, K., Valsecchi, G.B., Vogel, C. & Wu, G. 2015. Global risks: Pool knowledge to stem losses from disasters. *Nature*, 522(7556): 277–279. <http://dx.doi.org/10.1038/522277a>.
- [3] Oliver-Smith, A., Alcántara-Ayala, I., Burton, I. & Lavell, A.M. 2016. *Forensic Investigations of Disasters (FORIN): A conceptual framework and guide to research*. IRDR FORIN Publication No. 2. Beijing, China, Integrated Research on Disaster Risk. <http://www.irdrinternational.org/wp-content/uploads/2016/01/FORIN-2-29022016.pdf>.
- [4] Blaikie, P., Cannon, T., Davis, I. & Wisner, B. 1994. *At risk: Natural hazards, people's vulnerability and disasters*. New York, NY, USA, Routledge.
- [5] Tierney, K. 2006. Social inequality, hazards, and disasters. In R.J. Daniels, D.F. Kettl & H. Kunreuther, eds. *On risk and disaster lessons from hurricane Katrina*, pp. 109–128. Philadelphia, PA, USA, University of Pennsylvania Press.

### From analysing geohazards to managing georisks

- [1] Syavulisembo, A.M., Michellier, C. & Kervyn, F. Submitted. Temporal evolution of the potential impacts of 2002-like lava flows on Goma city (Democratic Republic of Congo). *J. Afr. Earth Sci.*
- [2] Mugaruka Bibentyo, T., Kulimushi Matabaro, S., Muhindo Sahani, W. & Dewitte, O. In press. Anatomy of Nyakavogo landslide (Bukavu, DR Congo): Interplay between natural and anthropogenic factors. *Geo-Eco-Trop*.
- [3] Maki Mateso, J.-C. & Dewitte, O. 2014. Towards an inventory of landslides and the elements at risk on the Rift flanks West of Lake Kivu (DRC). *Geo-Eco-Trop*, 38: 137–154.
- [4] Smets, B., Kervyn, M., d'Oreye, N. & Kervyn, F. 2015. Spatio-temporal dynamics of eruptions in a youthful extensional setting: Insights from Nyamulagira Volcano (D.R. Congo), in the western branch of the East African Rift. *Earth-Sci. Rev.*, 150: 305–328. <http://dx.doi.org/10.1016/j.earsci-rev.2015.08.008>.
- [5] Michellier, C., Pigeon, P., Kervyn, F. & Wolff, E. 2016. Contextualizing vulnerability assessment: A support to geo-risk management in central Africa. *Nat. Hazards*, 82: 27–42. <http://dx.doi.org/10.1007/s11069-016-2295-z>.

### Identifying vulnerable dwellings in urban slums

- [1] Fundacaracas. No date. Transformación integral de barrios. *Plan de Caracas socialista*. [http://www.fundacaracas.gob.ve/?module=pages&op=displaypage&page\\_id=1&format=html](http://www.fundacaracas.gob.ve/?module=pages&op=displaypage&page_id=1&format=html). (Project pages on Alcaldía de Caracas website)
- [2] Padrón, C.A. 2015. *Propuesta metodológica para el análisis de vulnerabilidad física ante movimientos en masa. Caso estudio: asentamientos urbanos populares de la Carretera Vieja Caracas-La Guaira*. Caracas, Venezuela, Universidad Central de Venezuela. [http://comisiones.ipgh.org/CARTOGRAFIA/Premio/Tesis\\_MSc\\_2016/Tesis\\_completa\\_Carlos\\_Padron.pdf](http://comisiones.ipgh.org/CARTOGRAFIA/Premio/Tesis_MSc_2016/Tesis_completa_Carlos_Padron.pdf).
- Du, Y. & Nadim, L. 2013. Quantitative vulnerability estimation for individual landslides. In P. Delage, J. Desrues, R. Frank, A. Puech, F. Schlosser. *Proceedings of the 18th International Conference on Soil Mechanics and Geotechnical Engineering*. Paris, France, Presses des ponts, pp. 2181–2184. <http://www.cfms-sols.org/sites/default/files/Actes/2181-2184.pdf>.
- Uzielli, M., Nadim, F., Lacasse, S. & Kaynia, A.M. 2008. A conceptual framework for quantitative estimation of physical vulnerability to landslides. *Eng. Geol.*, 102(3–4): 251–256. <http://dx.doi.org/10.1016/j.enggeo.2008.03.011>.

### Participatory risk assessment for priority setting

- [1] UNISDR. No date. Tajikistan: Disaster & risk profile. *UNISDR prevention web*. <http://www.preventionweb.net/countries/tjk/data/>. (Web page)
- Belperron, C., Kempf, M., Kelly, C., Vlieghe, P. & Stolz, N. 2010. *The MECO risk assessment tool manual*. Dushanbe, Tajikistan, MECO Consortium. [https://www.caritas.ch/fileadmin/user\\_upload/Caritas\\_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/tadschikistan/2009\\_MECO\\_RAT\\_Manual\\_eng.pdf](https://www.caritas.ch/fileadmin/user_upload/Caritas_Schweiz/data/site/was-wir-tun/engagement-weltweit/country-programme/tadschikistan/2009_MECO_RAT_Manual_eng.pdf).
- CARITAS Switzerland. 2017. Country programme of Tajikistan. *What we do worldwide: Country programmes*. <https://www.caritas.ch/en/what-we-do/worldwide/country-programmes/country-programme-of-tajikistan.html>. (Web page)

### Identifying and targeting vulnerable communities

- [1] CDE. 2015. *Improving vulnerability targeting for disaster risk reduction projects in the Lao PDR*. Policy brief. Vientiane, Lao PDR, Centre for Development and Environment.
  - [2] Messerli, P., Heinemann, A., Epprecht, M., Phonesaly, S., Thiraka, C. & Minot, N., eds. 2008. *Socio-economic atlas of the Lao PDR: An analysis based on the 2005 Population and Housing Census*. Bern, Switzerland & Vientiane, Laos, Swiss National Centre of Competence in Research (NCCR) North-South, University of Bern & Geographica Bernensia. <http://www.laoatlas.net/links/PDF%20download.html>.
- Bastide, J. 2016. *L'espace des projets de développement au Laos: pour une géographie relationnelle et contextualisée du système de l'aide*. Geneva, Switzerland, University of Geneva. (PhD dissertation)
- NDMO, ADPC, UNISDR. 2012. *Lao PDR national assessment report on disaster risk reduction: Linkages between poverty and disaster risk*. Vientiane, Lao PDR, National Disaster Management Office, Asian Disaster Preparedness Center & The United Nations Office for Disaster Risk Reduction. [http://www.adpc.net/igo/category/ID416/doc/2013-ptk8Nb-ADPC-Publication\\_LNAReportWEB\\_\(2\).pdf](http://www.adpc.net/igo/category/ID416/doc/2013-ptk8Nb-ADPC-Publication_LNAReportWEB_(2).pdf).

## Sendai priority 2: Strengthening governance

### Enhancing governance capacities and collaboration to manage disaster risks in mountains

- [1] Zeidler, A., Stickler, T., Kleemayr, K., Lexer, W., Gerhardt, E., Dobesberger, P., Huber, A., Adams, M. & Siegel, H. 2011. *Guidance paper for risk governance in spatial planning*. Vienna, Austria, CLISP – Climate Change Adaptation by Spatial Planning in the Alpine Space. [http://www.alpine-space.org/2007-2013/uploads/tx\\_txrinningprojects/CLISP\\_Risk\\_Governance\\_Guidance\\_01.pdf](http://www.alpine-space.org/2007-2013/uploads/tx_txrinningprojects/CLISP_Risk_Governance_Guidance_01.pdf).
  - [2] Varma, N. & Mishra, A. 2017. Discourses, narratives and purposeful action – unraveling the social-ecological complexity within the Brahmaputra Basin in India. *Environ. Policy Gov.*, Online first. <http://dx.doi.org/10.1002/eet.1745>.
- Tierney, K. 2012. Disaster governance: Social, political, and economic dimensions. *Annu. Rev. Environ. Res.*, 37: 341–363. <http://dx.doi.org/10.1146/annurev-environ-020911-095618>.

### Effective risk management requires political will

- [1] Banco Mundial. 2012. *Análisis de la gestión del riesgo de desastres en Colombia: un aporte para la construcción de políticas públicas*, by A. Campos G., N. Holm-Nielsen, C. Díaz G., D.M. Rubiano V., C.R. Costa P., F. Ramírez C. & E. Dickson, eds. Bogotá, Colombia, Banco Mundial. <http://www.cridlac.org/digitalizacion/pdf/spa/doc19103/doc19103.htm>.
- [2] Birkmann, J., Chang Seng, D. & Suarez, D.-C. 2011. Manizales, Colombia. In German Committee for Disaster Reduction, ed. *Adaptive disaster risk reduction: Enhancing methods and tools of disaster risk reduction in the light of climate change*, pp. 34–39. DKKV Publication Series 43. Bonn, Germany, German Committee for Disaster Reduction (DKKV). [http://www.dkkv.org/fileadmin/user\\_upload/Veroeffentlichungen/Publikationen/DKKV\\_43\\_Adaptive\\_Disaster\\_Risk\\_Reduction.pdf](http://www.dkkv.org/fileadmin/user_upload/Veroeffentlichungen/Publikationen/DKKV_43_Adaptive_Disaster_Risk_Reduction.pdf).
- [3] PREDECAN. 2009. *La gestión local del riesgo en una ciudad andina: Manizales, un caso integral, ilustrativo y evaluado*. Experiencias significativas de desarrollo local frente a los riesgos de desastres, Colombia 2. Lima, Peru, Proyecto Apoyo a la Prevención de Desastres en la Comunidad Andina (PREDECAN). <http://www.cridlac.org/digitalizacion/pdf/spa/doc17849/doc17849-contenido.pdf>.
- [4] Marulanda, M.C., Cardona, O.D., Mora, M.G. & Barbat, A.H. 2014. Design and implementation of a voluntary collective earthquake insurance policy to cover low-income homeowners in a developing country. *Nat. Hazards*, 74: 2071–2088. <http://dx.doi.org/10.1007/s11069-014-1291-4>.
- [5] CORPOCALDAS. 2015. *Construcción obras de reducción del riesgo: Municipio de Manizales (año 2011)*. Manizales, Colombia, Corporación Autónoma Regional de Caldas (CORPOCALDAS). <http://www.slideshare.net/ConcejoManizales2015/presentacin-corpocaldas-informe-gestin-de-obras-concepto-sobre-tasa-ambiental>. (Slide set)
- [6] Pérez, M.P. 2007. *El impacto de las acciones de mitigación sobre los deslizamientos: el costo–beneficio de invertir en reducción como mejor opción*. Cali, Colombia, Universidad del Valle and Tulane University of Louisiana. (Master's thesis)

### Strengthening disaster risk governance from the bottom up

- [1] CONEVAL. 2012. *Report of poverty in Mexico: The country, its federal entities and its municipalities 2010*. Mexico, Mexico, National Council for the Evaluation of Social Development Policy (CONEVAL). [http://www.coneval.org.mx/Informes/Coordinacion/INFORMES\\_Y\\_PUBLICACIONES\\_PDF/REPORT\\_OF\\_POVERTY\\_IN\\_MEXICO\\_2010.pdf](http://www.coneval.org.mx/Informes/Coordinacion/INFORMES_Y_PUBLICACIONES_PDF/REPORT_OF_POVERTY_IN_MEXICO_2010.pdf).
  - [2] Chiapas Gobierno del Estado. 2010. *Índice de dispersión poblacional para Chiapas. Nota Metodológica*. Tuxtla Gutiérrez, Chiapas, Mexico, Dirección de Geografía, Estadística e Información, Subsecretaría de Planeación, Presupuesto y Egresos Secretaría de Hacienda. [http://www.ceieg.chiapas.gob.mx/home/wp-content/uploads/downloads/productosdgei/info\\_estadistica/PublicacionesCEIEG/AsentamientosHH/IDP\\_Chiapas\\_2010.pdf](http://www.ceieg.chiapas.gob.mx/home/wp-content/uploads/downloads/productosdgei/info_estadistica/PublicacionesCEIEG/AsentamientosHH/IDP_Chiapas_2010.pdf).
- Secretaría de Protección Civil, Gobierno del Estado de Chiapas. 2016. Planes municipales para la reducción de vulnerabilidades y riesgos – PNUD. *Descargas: Desarrollo*. <http://proteccioncivil.chiapas.gob.mx/planes-municipales>. (Web page providing access to municipal DRR plans in Spanish)
- UNDP Mexico. Publicaciones. *PMR – Programa de Apoyo a la Reducción de Riesgos de Desastres en México*. <http://pmmexico.org.mx/publicaciones.html>. (Web page providing access to various publications, guides, and tools for DRR and climate change adaptation in Spanish, including the *Ficha de análisis de riesgos* (FIAR) or risk analysis questionnaire)

### Analysing costs and benefits to set the right DRR priorities

- [1] Global Platform for Disaster Risk Reduction. 2013. Official statement of the Government of Georgia at the Fourth Session of the Global Platform for Disaster Risk Reduction, 19–23 May 2013, Geneva. *Official statements from the Fourth Session of the Global Platform for Disaster Risk Reduction*. <http://www.preventionweb.net/globalplatform/2013/programme/statements>.

- [2] CENN & ITC, eds. 2013. *Atlas of natural hazards & risks of Georgia*. Tbilisi, Georgia, Caucasus Environmental NGO Network & Faculty of Geo-Information Science and Earth Observation (ITC), University of Twente. <http://drm.cenn.org/index.php/en/background-information/paper-atlas>.
  - [3] IFRC. 2016. *How preparedness pays off: Evolution, costs, benefits and prospects of disaster risk management in Georgia*. Geneva, Switzerland, International Federation of Red Cross and Red Crescent Societies. <http://www.preventionweb.net/publications/view/48021>.
  - [4] UNISDR. 2009. *Central Asia and Caucasus Disaster Risk Management Initiative (CAC DRM): Risk assessment for Central Asia and Caucasus desk study review*, by S. Gupta. Washington, DC, USA, Geneva, Switzerland & Manila, The Philippines, The World Bank, International Strategy for Disaster Reduction & Central Asia Regional Economic Cooperation. [http://www.unisdr.org/files/11641\\_CentralAsiaCaucasusDRManagementInit.pdf](http://www.unisdr.org/files/11641_CentralAsiaCaucasusDRManagementInit.pdf).
  - [5] Institute of Democracy. 2016. Natural disaster victim families: State support and registration. Tbilisi, Georgia, Institute of Democracy. <http://iod.ge/files/Documents/ecomigration.pdf>. (In Georgian)
  - [6] CENN. 2013. *Ecomigration in Georgia: Background, gaps and recommendations*. Tbilisi, Georgia, Caucasus Environmental NGO Network. [http://w3.cenn.org/wssl/uploads/Eco\\_migration\\_Georgia\\_FINAL\\_23052014.pdf](http://w3.cenn.org/wssl/uploads/Eco_migration_Georgia_FINAL_23052014.pdf).
  - [7] IOM. 2007. *Discussion note: Migration and the environment. Ninety-fourth session*. MC/INF/288. Geneva, Switzerland, International Organization for Migration. [http://www.iom.int/jahia/webdav/shared/shared/mainsite/about\\_iom/en/council/94/MC\\_INF\\_288.pdf](http://www.iom.int/jahia/webdav/shared/shared/mainsite/about_iom/en/council/94/MC_INF_288.pdf).
  - [8] UNDP. 2014. *Disaster risk reduction capacity assessment report*. Tbilisi, Georgia, United Nations Development Programme in Georgia. [http://www.ge.undp.org/content/georgia/en/home/library/environment\\_energy/disaster-risk-reduction-capacity-assessment-report.html](http://www.ge.undp.org/content/georgia/en/home/library/environment_energy/disaster-risk-reduction-capacity-assessment-report.html).
- Zimmermann, M., Pozzi, A. & Stoessel, F. 2005. *Vademecum. Hazard maps and related instruments: The Swiss system and its application abroad. Capitalisation of experience*. Bern, Switzerland, Swiss Agency for Development and Cooperation (SDC). [http://www.planat.ch/fileadmin/PLANAT/planat\\_pdf/alle\\_2012/2001-2005/PLANAT\\_2005\\_-\\_Vademecum.pdf](http://www.planat.ch/fileadmin/PLANAT/planat_pdf/alle_2012/2001-2005/PLANAT_2005_-_Vademecum.pdf).

### Preventing water disasters: Different interests, common goals

- [1] WWF European Alpine Programme. 2014. *Save the Alpine rivers!* Vienna, Austria, WWF EALP Freshwater. [http://assets.panda.org/downloads/wwf\\_study\\_save\\_the\\_alpine\\_rivers\\_\\_c\\_\\_wwf\\_2014.pdf](http://assets.panda.org/downloads/wwf_study_save_the_alpine_rivers__c__wwf_2014.pdf).
- Alpine Convention. No date. Natural hazards platform. *Organization: Working groups platforms*. <http://www.alpconv.org/en/organization/groups/WGHazards/default.html>. (Web page)
- Alpine Convention. No date. Water management in the Alps platform. *Organization: Working groups platforms*. <http://www.alpconv.org/en/organization/groups/WGWater/default.html>. (Web page)
- Austrian Federal Ministry for Agriculture, Forestry, Environment and Water Management. 2015. *Nationaler Gewässerbewirtschaftungsplan 2015, Entwurf*. Vienna, Austria, Federal Ministry of Agriculture, Forestry, Environment and Water Management. [http://wisa.bmlfuw.gv.at/fachinformation/ngp/ngp-2015/text/textdokument\\_ngp2015.html](http://wisa.bmlfuw.gv.at/fachinformation/ngp/ngp-2015/text/textdokument_ngp2015.html). (Draft national river basin management plan 2015, in German)
- Unser Inn, [www.unser-inn.at](http://www.unser-inn.at). (Project website of the WWF initiative for multistakeholder management of the river Inn in the Austrian Federal State of Tyrol)

## Sendai priority 3: Increasing resilience

### Linking risk reduction and development

- [1] Alexander, DE. 2013. Resilience and disaster risk reduction: An etymological journey. *Nat. Hazards Earth Syst. Sci.*, 13(11): 2707–2716. <http://dx.doi.org/10.5194/nhess-13-2707-2013>.
  - [2] Zimmermann, M. & Keiler, M. 2015. International frameworks for disaster risk reduction: Useful guidance for sustainable mountain development? *Mt. Res. Dev.*, 35(2): 195–202. <http://dx.doi.org/10.1659/MRD-JOURNAL-D-15-00006.1>
  - [3] Molden, D., Sharma, E. & Acharya, G. 2016. Lessons from Nepal's Gorkha earthquake 2015. *Resources: Nepal earthquake 2015*. Kathmandu, Nepal, International Centre for Integrated Mountain Development. <http://www.icimod.org/?q=24104>. (Web page)
  - [4] Le Masson, V. 2015. Considering vulnerability in disaster risk reduction plans: From policy to practice in Ladakh, India. *Mt. Res. Dev.*, 35(2): 104–114. <http://dx.doi.org/10.1659/MRD-JOURNAL-D-14-00086.1>.
  - [5] FOCUS. 2008. *A guide to improving disaster resilience of mountain communities*. Sugar Land, TX, USA, Focus Humanitarian Assistance. <http://www.akdn.org/file/62281/download?token=zvhTogrz>.
  - [6] Hewitt, K. & Mehta, M. 2012. Rethinking risk and disasters in mountain areas. *J. Alp. Res. | Rev. géogr. alpine*, 100(1). <http://dx.doi.org/10.4000/rga.1653>.
- Gaillard, J.C. & Kelman, I. 2012. Mountain, marginality and disaster: Foreword. *J. Alp. Res. | Rev. géogr. alpine*, 100(1). <http://rga.revues.org/1649>.
- IPCC. 2012. *Managing the risks of extreme events and disasters to advance climate change adaptation: A special report of Working Groups I and II of the Intergovernmental Panel on Climate Change*, by C.B. Field, V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor & P.M. Midgley, eds. Cambridge, UK & New York, NY, USA, Cambridge University Press. [https://www.ipcc.ch/pdf/special-reports/srex/SREX\\_Full\\_Report.pdf](https://www.ipcc.ch/pdf/special-reports/srex/SREX_Full_Report.pdf).

### Women-centric approach to enhance resilience

- [1] ICIMOD. 2016. Resilient mountain village. *Mountain topics: Agriculture*. Kathmandu, Nepal, International Centre for Integrated Mountain Development. <http://www.icimod.org/?q=23586>. (Web page)
- [2] ICIMOD. 2016. Naubise farmer finds relief in climate smart practices. *MRI: The mountain blogs*. Bern, Switzerland, Mountain Research Initiative. <http://www.blogs-mri.org/naubise-farmer-finds-relief-climate-smart-practices/>. (ICIMOD contribution to MRI blog)

### Microinsurance to reduce impacts of climatic hazards

- [1] Wyser Vizcarra, N. 2013. *PROFIN promoting agricultural microinsurance in Bolivia: Enormous potential for rural poverty alleviation*. Case study No. 12, update, May 2013. Bern, Switzerland, Swiss Agency for Development and Cooperation (SDC). <https://www.shareweb.ch/site/EI/Documents/FSD/Projects/fsd%20case%20studies%20-%202012update.pdf>.

Cooperación Suiza en Bolivia. 2015. *Proyecto Microseguros rurales*. La Paz, Bolivia, Cooperación Suiza en Bolivia, Swiss Agency for Development and Cooperation (SDC). [https://www.fdfa.admin.ch/content/dam/countries/countries-content/bolivia/es/Cartilla\\_Microseguros.pdf](https://www.fdfa.admin.ch/content/dam/countries/countries-content/bolivia/es/Cartilla_Microseguros.pdf).

Fundación PROFIN, [www.fundacion-profin.org](http://www.fundacion-profin.org). (Organization's website)

### Preventing the "White Death": More than an avalanche dam

- [1] Fuchs, S., Keiler, M. & Zischg, A. 2015. A spatiotemporal multi-hazard exposure assessment based on property data. *Nat. Hazards Earth Syst. Sci.*, 15(9): 2127–2142. <http://dx.doi.org/10.5194/nhess-15-2127-2015>.
- [2] Keiler, M. 2004. Development of the damage potential resulting from avalanche risk in the period 1950–2000, case study Galtür. *Nat. Hazards Earth Syst. Sci.*, 4(2): 249–256. <http://dx.doi.org/10.5194/nhess-4-249-2004>.
- [3] Fuchs, S., Röthlisberger, V., Thaler, T., Zischg, A. & Keiler, M. 2017. Natural hazard management from a co-evolutionary perspective: The cycle of exposure and policy response in the European Alps. *Ann. Am. Assoc. Geogr.*, 107(2): 382–392. <http://dx.doi.org/10.1080/24694452.2016.1235494>.
- [4] Keiler, M., Sailer, R., Jörg, P., Weber, C., Fuchs, S., Zischg, A. & Sauermoser, S. 2006. Avalanche risk assessment – a multi-temporal approach, results from Galtür, Austria. *Nat. Hazards Earth Syst. Sci.*, 6(4): 637–651. <http://dx.doi.org/10.5194/nhess-6-637-2006>.
- [5] Holub, M. & Fuchs, S. 2009. Mitigating mountain hazards in Austria – legislation, risk transfer, and awareness building. *Nat. Hazards Earth Syst. Sci.*, 9(2): 523–537. <http://dx.doi.org/10.5194/nhess-9-523-2009>.
- [6] Hattenberger, D. 2006. Naturgefahren und Öffentliches Recht. In S. Fuchs, L. Khakzadeh & K. Weber, eds. *Recht im Naturgefahrenmanagement*, pp. 67–91. Innsbruck, Austria, Studienverlag.

## Sendai priority 4: Enhancing preparedness

### Strengthening local capacities for effective response

- [1] Holub, M. & Fuchs, S. 2009. Mitigating mountain hazards in Austria – legislation, risk transfer, and awareness building. *Nat. Hazards Earth Syst. Sci.*, 9(2): 523–537. <http://dx.doi.org/10.5194/nhess-9-523-2009>.
- [2] Owens, P.N. & Slaymaker, O. 2004. An introduction to mountain geomorphology. In P.N. Owens & O. Slaymaker, eds. *Mountain Geomorphology*, pp. 3–29. London, UK, Edward Arnold.
- [3] Zimmermann, M. & Keiler, M. 2015. International frameworks for disaster risk reduction: Useful guidance for sustainable mountain development? *Mt. Res. Dev.*, 35(2): 195–202. <http://dx.doi.org/10.1659/MRD-JOURNAL-D-15-00006.1>.
- [4] Holub, M., Suda, J. & Fuchs, S. 2012. Mountain hazards: Reducing vulnerability by adapted building design. *Environ. Earth Sci.*, 66(7): 1853–1870. <http://dx.doi.org/10.1007/s12665-011-1410-4>.
- [5] Dekens, J. 2007. *Local knowledge for disaster preparedness: A literature review*. Kathmandu, Nepal, International Centre for Integrated Mountain Development (ICIMOD). <http://lib.icimod.org/record/22470>.
- [6] Jandl, R., Borsdorf, A., Van Miegroet, H., Lackner, R. & Psenner, R. 2009. *Global change and sustainable development in mountain regions*. Innsbruck, Austria, Innsbruck University Press.
- [7] UNISDR. 2015. *Sendai framework for disaster risk reduction 2015–2030*. Geneva, Switzerland, United Nations Office for Disaster Risk Reduction. [http://www.preventionweb.net/files/43291\\_sendai-frameworkfordren.pdf](http://www.preventionweb.net/files/43291_sendai-frameworkfordren.pdf).

### Enhancing preparedness for glacial lake outburst floods

- [1] Mool, P.K., Wangda, D., Bajracharya, S.R., Joshi, S.P., Kunzang, K. & Gurung, D.R. 2001. *Inventory of glaciers, glacial lakes, and glacial lake outburst flood monitoring and early warning systems in the Hindu Kush-Himalayan region: Bhutan*. Kathmandu, Nepal, International Centre for Integrated Mountain Development (ICIMOD). <http://lib.icimod.org/record/21962>.

UNDP. 2013. *Glacial lake outburst flood (GLOF): Reducing risks and ensuring preparedness. The report on the international conference, 5–7 December 2013, Hotel Olathang, Paro, Bhutan*. Thimphu, Bhutan, United Nations Development Programme in Bhutan. <http://www.undp.org/content/dam/undp/documents/projects/BTN/Proceeding%20of%20International%20GLOF%20Conference%20Dec%202013%20Paro.pdf>.

UNDP. No date. Reducing Climate Change-induced Risks from Glacial Lake Outburst Floods in Bhutan. <http://adaptation-undp.org/projects/ldcf-glof-bhutan>. (Project pages on UNDP's Climate Change Adaptation Portal)

### "Why this storm ... this flood ... this hospital?"

- [1] Pharoah, R., Holloway, A., Fortune, G., Chapman, A., Schaber, E. & Zweig, P. 2016. *OFF the RADAR: Synthesis report. High impact weather events in the Western Cape, South Africa, 2003–2014*. For the Provincial Disaster Management Centre, Western Cape, by Research Alliance for Disaster and Risk Reduction (RADAR), Department of Geography and Environmental Studies, Stellenbosch University. <http://www.riskreductionafrica.org/wp-content/uploads/2016/05/New-Synthesis-Report-14-June-2016.pdf>.

- [2] Engelbrecht, C.J., Landman, W.A., Engelbrecht, F.A. & Malherbe, J. 2015. A synoptic decomposition of rainfall over the Cape south coast of South Africa. *Clim. Dyn.*, 44(9): 2589–2607. <http://dx.doi.org/10.1007/s00382-014-2230-5>.
- [3] Engelbrecht, C.J. 2015. *Meteorological analysis of four severe weather events in the Western Cape*. Pretoria, South Africa, Agricultural Research Council, Institute for Soil, Climate and Water.
- [4] Schaber, E. 2015. *The impact of land use and climate change on flood risk in the Lourens River catchment, South Africa*. Innsbruck, Austria, University of Innsbruck. (Master's thesis)
- [5] Singleton, A.T. & Reason, C.J.C. 2007. Variability in the characteristics of cut-off low pressure systems over subtropical southern Africa. *Int. J. Climatol.*, 27: 295–310. <http://dx.doi.org/10.1002/joc.1399>.
- [6] Sills, D.M. 2009. On the MSC forecasters forums and the future role of the human forecaster. *Bull. Am. Meteorol. Soc.*, 90 (5): 619–627. <http://dx.doi.org/10.1175/2008BAMS2657.1>.
- Favre, A., Hewitson, B., Lennard, C., Cerezo-Mota, R. & Tadross, M. 2013. Cut-off lows in the South Africa region and their contribution to precipitation. *Clim. Dyn.*, 41(9): 2331–2351. <http://dx.doi.org/10.1007/s00382-012-1579-6>.
- Favre, A., Hewitson, B., Tadross, M., Lennard, C. & Cerezo-Mota, R. 2012. Relationships between cut-off lows and the semiannual and southern oscillations, *Clim. Dyn.*, 38(7): 1473–1487. <http://dx.doi.org/10.1007/s00382-011-1030-4>.

#### Fostering gender-inclusive emergency preparedness

- Aga Khan Agency for Habitat, [www.akdn.org/our-agencies/aga-khan-agency-habitat](http://www.akdn.org/our-agencies/aga-khan-agency-habitat). (Organization's website)
- Blanchard, K. 2015. Gender and the Sendai Framework. *Crisis Response J.*, 10(4): 52–53. [https://www.academia.edu/12911506/Gender\\_and\\_the\\_Sendai\\_Framework](https://www.academia.edu/12911506/Gender_and_the_Sendai_Framework).
- Duryog Nivaran – South Asia Network for Disaster Mitigation. 2014. *Towards post-2015 agenda for DRR (HFA2): Women as a force in resilience building, gender equality in DRR. Report of the consultations in Asia Pacific*. HFA2 Key Area4 Paper – Women and Gender Equality in DRR. <http://www.preventionweb.net/publications/view/36778>.
- Government of the Republic of Tajikistan Committee of Emergency Situations and Civil Defence & UNDP Tajikistan. 2010. *National disaster risk management strategy for 2010–2015, Republic of Tajikistan*. <http://www.preventionweb.net/english/professional/policies/v.php?id=27582>.
- The World Bank. 2010. *Tajikistan: Economic and distributional impact of climate change*. Washington, DC, USA, Poverty Reduction and Economic Management Unit, Europe and Central Asia Region, The World Bank. <http://documents.worldbank.org/curated/en/850031468119374663/Main-report>.

#### Earthquake-proof reconstruction

- EcoHimal, [www.ecohimal.org](http://www.ecohimal.org). (Organization's website)
- Rasul, G., Sharma, B., Mishra, B., Neupane, N., Dorji, T., Khadka, M. & Joshi, S. 2015. *Strategic framework for resilient livelihoods in earthquake-affected areas of Nepal*. ICIMOD Working Paper 2015/6. Kathmandu, Nepal, International Centre for Integrated Mountain Development (ICIMOD). <http://lib.icimod.org/record/30799>.

## Enabling safer livelihoods in and beyond mountains

#### Messages for policy-makers

- [1] UNISDR. 2015. *Sendai framework for disaster risk reduction 2015–2030*. Geneva, Switzerland, United Nations Office for Disaster Risk Reduction. [http://www.preventionweb.net/files/43291\\_sendai\\_frameworkfordrren.pdf](http://www.preventionweb.net/files/43291_sendai_frameworkfordrren.pdf).
- [2] UN. 2015. *Transforming our world: The 2030 agenda for sustainable development*. A/RES/70/1. New York, NY, USA, United Nations. <https://sustainabledevelopment.un.org/post2015/transformingourworld/publication>.
- [3] United Nations General Assembly. 2017. *Sustainable mountain development*. A/RES/71/234. New York, NY, USA, United Nations. [http://www.un.org/en/ga/search/view\\_doc.asp?symbol=A/RES/71/234](http://www.un.org/en/ga/search/view_doc.asp?symbol=A/RES/71/234).






Making the Sendai Framework for Disaster Risk Reduction 2015–2030 work for sustainable development in mountains means giving special attention to the specific challenges mountain people face. Many mountain people are vulnerable and exposed to multiple natural hazards: Safe living space is limited and often close to hazard zones. The frequency and magnitude of disasters is increasing, with contributing factors including population growth, urbanization, economic development, ecosystem degradation and climate change. There is growing competition for safe land, often to the detriment of economically weaker people, who are pushed to the fringes of safe zones. Moreover, hazards occurring in mountains not only threaten the lives and livelihoods of people in remote rural settlements and in the growing urban centres in mountains – they also affect people in the lowlands.

This publication presents 15 case studies from mountain regions around the world, illustrating the efforts and experiences of public and private actors to implement the Sendai Framework’s four priorities for action. Messages for policy-makers emphasize the need for mountain-specific disaster risk reduction policies – ideally, integrated with development activities and climate change adaptation measures – to make livelihoods in mountains and beyond safer.

ISBN (print): 978-3-906813-35-6  
ISBN (e-print): 978-3-906813-36-3

Austrian  
Development Cooperation

 Schweizerische Eidgenossenschaft  
Confédération suisse  
Confederazione Svizzera  
Confederaziun svizra

Swiss Agency for Development  
and Cooperation SDC



UNIVERSITÄT  
BERN  
CDE  
CENTRE FOR DEVELOPMENT  
AND ENVIRONMENT



University of Natural Resources  
and Life Sciences, Vienna



UNIVERSITÄT  
INNSBRUCK

ICIMOD

