Thank you for agreeing to be an expert reviewer of one or more of the Hindu Kush Himalayan Monitoring and Assessment Programme (HIMAP) Comprehensive Assessment of the Hindu Kush Himalaya report chapters. The external review period is now open for the second order drafts of the chapters. This external review phase will run from 16 June to 28 July 2017, with 28 July 2017 being the cut-off date for submitting reviews. The function of expert reviewers is to comment on the accuracy and completeness of the content and the overall scientific, technical and socio-economic balance of the chapter drafts. Every reviewer will be acknowledged in the chapter they reviewed.

Comments will only be considered if they are submitted before the end of the external review phase, using the official Excel review template for the chapter that you are reviewing. Please use a separate Excel review file for each chapter you are reviewing. Your completed review needs to be uploaded to the Open Review Forum page on the HIMAP website (www.hi-map.org) before 28 July 2017. Also see this website to download the chapters and review forms and for more information.

We would like to remind you that by undertaking this review you commit to respect the terms of this external review phase – specifically to not quote, cite, copy or disseminate (including in blogs or to the media) the draft HIMAP chapters; to only provide comments using the provided templates; to comment only in English and to comment only on substance (not grammar and spelling).

The International Centre for Integrated Mountain Development (ICIMOD) is coordinating the HIMAP Comprehensive Assessment of the Hindu Kush Himalaya (see www.hi-map.org), with the engagement of over 300 researchers, practitioners, experts, and decision makers from the region and around the world. The publication of the assessment report is planned towards the end of 2017. A comprehensive assessment that goes beyond climate change, the Assessment Report, consisting of 15 chapters, contains a wide-ranging, innovative evaluation of the current state of knowledge of the region and of various drivers of change and their impacts, and a set of policy messages.

Review is an essential part of the HIMAP process to ensure the accuracy and completeness of the scientific, technical and socio-economic content and the overall balance of the HIMAP chapters. The review process of the HIMAP Assessment Chapters consists of external peer review by experts and government representatives, and open peer review, of the 2nd order drafts of the chapters. All written review comments will be provided to the chapter teams anonymously and the Review Editor of each chapter will ensure that all comments are taken into account by the author teams and adequately addressed. A record of all review comments and how they were addressed will be published online on completion of the HIMAP assessment.

Three major principles underpin the HIMAP review process. Firstly, the best possible scientific and technical advice should be included so that HIMAP Assessment Report represent the latest scientific, technical and socio-economic findings and is as comprehensive as possible. Secondly, a wide circulation process assuring representation of independent experts not involved in the preparation of the assessment report will aim to involve as many expert reviewers as possible in the HIMAP process. Thirdly, the review process will be neutral, open and transparent. Thank you for your review.
CHAPTER 11: DISASTER RISK REDUCTION AND INCREASING RESILIENCE

Coordinating Lead Authors:
Ramesh Ananda Vaidya, International Centre for Integrated Mountain Development (ICIMOD)
Mandira Singh Shrestha, International Centre for Integrated Mountain Development (ICIMOD)
Nusrat Nasab, Aga Khan Agency for Habitat

Lead Authors
Deo Raj Gurung, International Centre for Integrated Mountain Development (ICIMOD)
Nagami Kozo, Japan International Cooperation Agency (JICA)
Neera Shrestha Pradhan, International Centre for Integrated Mountain Development (ICIMOD)
Robert James Wasson, National University of Singapore

Contributing Authors
Arun Bhakta Shrestha, International Centre for Integrated Mountain Development (ICIMOD)
Chanda Goodrich Gurung, International Centre for Integrated Mountain Development (ICIMOD)
Ajay Bajracharya, International Centre for Integrated Mountain Development (ICIMOD)
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CHAPTER OVERVIEW

KEY FINDINGS

1. Mountain communities in the HKH live in a multi-hazard environment. The region is especially prone to floods, flash floods, and landslides, but also to droughts and earthquakes.

2. Disaster-related indicators for the HKH are on the increase. Rising trends appear in the number of disasters reported, the numbers of people killed and affected, and the size of economic losses.

3. When disasters hit the HKH, they kill more women than men. This difference can be ascribed to women’s lack of information, power, money, and training, along with other gender-based norms and barriers (as well as high rates of male outmigration).

4. Past assessments of natural hazard risk in the HKH suffer from methodological weaknesses. One problem is an overemphasis on particular sites and areas (the micro scale). Another is the lack of standard vulnerability measurements.

5. Five considerations are central for efforts to build disaster resilience in the HKH:
   - The multi-hazard environment.
   - The upstream and downstream linkages of hazard events.
   - The effects of climate change and variability.
   - The challenge of connectivity and physical access to mountain areas.
   - The role of governance.

POLICY MESSAGES

1. Institutions and governments in the HKH urgently need to formulate and adopt a standardized, multi-hazard risk assessment approach. Such an approach should address primary, secondary, and cascading hazards.

2. Policies and programs should seek to enhance women’s and men’s resilience at the local level. Such efforts should promote an enabling environment through education, capacity building, and incentivized risk management.

3. The countries of the HKH need to cooperate more extensively and more effectively. They can do so by sharing data, information, and knowledge, and by fostering transboundary disaster risk reduction (DRR) practices.

The Hindu Kush Himalaya (HKH) – covering more than four million square kilometers from Afghanistan to Myanmar -- is one of the world’s most ecologically diverse mountain biomes, with extreme variations in vegetation. It is also one of the most hazard-prone. Because of its weak geology,
high seismicity, steep terrain, and intense and highly variable precipitation, the HKH is especially vulnerable to floods, landslides, and earthquakes [well established].

Currently, natural hazards in the HKH are increasing in magnitude and occurrence -- a trend driven partly by climate change (Shaw and Nibanupudi 2015). Environmental degradation generally poses a major threat to lives and livelihoods. However, a community’s vulnerability to natural hazards also includes the exposure of people and property to disasters and their impact. Such exposure can reflect various factors.

While some of the factors in exposure and vulnerability are physical and environmental, other factors are socioeconomic. Poverty leaves many people in the region with few resources when trying to rebuild their homes and livelihoods. The countries of the HKH - with the sole exception of China - rank below the global average on the Human Development Index (HDI). Income inequality is also high throughout the region, except in China and Bangladesh. These facts imply high vulnerability to natural hazards [well established].

Gender is another socioeconomic factor affecting vulnerability. While both men and women in the HKH have valuable knowledge, skills, experience, and coping capacities, these strengths tend to differ by gender. And unlike men’s typical capacities and knowledge, those of women are often ignored in policies and formal arrangements related to mitigation and recovery. As we stress in the chapter, policy makers and planners must ensure that women actively participate in capacity building and gain access to the information that would prepare them better for disasters. Education levels also affect vulnerability. Indicators related to both gender equality and education are even more dramatically low for the HKH, compared with world averages, than are income and income equality [well established].

When seeking ways to increase resilience to hazards in the HKH, policy makers need to consider five key issues: the multi-hazard environment, the close links between upstream and downstream hazards, the effects of climate change and variability, the challenge of connectivity and physical access, and the role of governance. The *multi-hazard environment* is common to many countries of the HKH [well established]. In Nepal, for example, the local word for floods is *badi-pahiro*, “floods and landslides” - probably because of how flooding mountain streams can erode by undercutting their banks, leading to landslides; such landslides can also form natural dams that are later breached, causing subsequent flash floods. Similarly, earthquakes can trigger both landslides and flash floods. Efforts to build resilience thus need to consider not just the primary event, but also secondary hazards involving cascading threats and disasters (Shrestha et al. 2016).

Also important are the *upstream and downstream linkages of hazard events*. Exposure to hazards can extend, though with a time lag, to an area much larger than the site of the primary event, often across international borders. Even within the same country, physical infrastructure that is supposed to increase resilience, such as early warning systems for flash floods, may not be as widely available as necessary.

Institutional arrangements to manage linkages between upstream and downstream hazard events can be difficult, especially if the communities at each end lack mechanisms for reciprocal cooperation (Vaidya, 2015). Further, the affected areas may lie across international boundaries. For example, the outburst of a landslide-dammed lake in the Tibetan Autonomous Region of China could seriously damage a Nepalese hydropower plant. Similar events in Nepal could endanger India’s densely populated Bihar State. Communication channels between local authorities of the two nations are often
poorly developed -- and central government efforts to establish communication may succeed too late
to save infrastructure or human lives [established but incomplete].

Among the effects of climate change and variability is the growing number and size of glacial lakes:
Himalayan glaciers have retreated rapidly in recent decades, causing many such lakes to form and
expand [well established]. Climate change is expected to lead to further increases [established but
incomplete]. The instability of the moraine materials holding back these lakes poses a risk of glacial
lake outburst floods. In addition, shifting monsoon patterns may result in episodes of intense
precipitation, leading to further increases in floods, landslides, and erosion [established but
incomplete].

The challenge of connectivity and physical access can involve road and air travel, but also phone
communication, in sparsely-settled and often remote mountain areas. Finally, this very remoteness
raises the role of governance as a key issue. More than in better connected areas, local governments and
communities need the capacity to make decisions about hazards such as flash floods that commonly
affect isolated and remote locations (Shrestha et al., 2008). In addition, national plans and institutional
options for strengthening adaptive capacity may not fully reflect local realities and could be more
thoroughly informed by local adaptation concerns (Molden et al., 2015) [inconclusive].

To address these five key issues for upstream and downstream communities in the HKH, we present a
new disaster risk reduction (DRR) framework that can help in assessing hazard risks and discussing
adaptation and resilience measures. While developed specifically for the region, it draws on two
Risk Reduction 2015-2030. It has four elements:

- **Information**: sharing hazard information between upstream and downstream communities,
  ensuring communication about cascading hazards.

- **Infrastructure**: adapting to climatic and seismic risks, investing to enhance connectivity.

- **Institutions**: addressing gender and governance dimensions and developing mechanisms to
  connect national institutions, policies, and actions with local ones.

- **Insurance**: insuring, or transferring risk, to build resilience to residual disaster risks (those that
  may not be eliminated).

We also present a matrix showing how these four DRR elements can interact with four components of
resilience-building programs. These components are, first, command-and-control mechanisms such as
zoning regulations, land use guidelines, and building codes; second, monetary incentives such as
subsidies on insurance premiums; third, persuasive information such as risk maps; and fourth, “nudges”
such as early warning systems.

Alongside the new DRR framework, standard multi-hazard risk assessment protocols are needed to
study the HKH as a multi-hazard environment. Cascading hazards especially require a multi-hazard
methodology that integrates complex “hazard interactions and interaction networks” (Gill &
Malamud, 2016). Successful management critically depends on such assessments -- but standard tools
for the HKH have not yet been developed. The process of creating these standard protocols must be as
participatory as possible, comprising diverse stakeholder perspectives.

Because natural hazards know no borders, disaster risk reduction in the HKH would benefit greatly
from stronger regional cooperation [established but incomplete]. Events such as the 2005 Kashmir
earthquake and the 2010 Pakistan floods have prompted calls for increased multinational efforts. A regional approach, with efforts in timely data sharing and modelling, should improve flood management and help mitigate adverse impacts in transboundary basins.

### Disaster Risk Reduction (DRR), the HKH, and the Sustainable Development Goals (SDGs)

Building disaster resilience in the mountains requires decision making that is informed by the best available studies of disaster risk reduction (DRR) and climate change adaptation. Because of mountain communities’ high vulnerability to extreme weather events and natural disasters, such as floods, landslides, earthquakes, and avalanches, DRR assumes a high profile on the 2030 sustainable development agenda. Especially relevant to the HKH are Sustainable Development Goals (SDGs) 1, 9, 11, 13, and 15.

To complement the relevant formal SDGs, we propose the following vision for mountain DRR: *By 2030, build resilience and reduce deaths from natural disasters in mountain regions substantially through informed decision making and enhanced preparedness.* Supporting this vision are four targets:

1. Reduce economic loss, human deaths, and the number of people affected due to disasters and extreme climate events, especially for women and children.
2. Make human settlements and habitats safe, inclusive, resilient, and sustainable through laws, education, capacity building, better zoning and building regulations, and a multi-hazard risk reduction approach.
3. Assure protection from extreme events such as floods and droughts.
4. Provide access to DRR and mitigation measures, including finance and technology, with the knowledge and capacity building needed to use them.
11.1 THE HINDU KUSH HIMALAYA: AN UNCERTAIN, MULTI-HAZARD ENVIRONMENT

Disaster risk depends on how likely different kinds and intensities of natural hazards are to occur, the elements exposed, and their vulnerability (World Bank, 2005). Mountain development and disaster risk are inherently linked, as many mountain settlements are located on unstable mountain slopes and river terraces that are prone to erosion by floods and on alluvial fans that are susceptible to debris flows and water floods. The Hindu Kush Himalaya (HKH) is one of the most fragile mountain regions in the world. Because of its unique geology, steep terrain, intense seasonal precipitation, and high seismicity, the settlements in the region are highly vulnerable to floods (especially flash floods), landslides, droughts, and earthquakes. It is not, then, an understatement to suggest that the HKH is a multi-hazard environment.

11.1.1. Multi-hazard environment

11.1.1.1. Distribution of hazards

There is an increasing occurrence of geophysical and hydrometeorological events resulting in part in the growing loss of lives and increasing damage to livelihood support systems. The HKH accounts for 21% (4,115 of 18,956) of the major disaster events between 1980 and 2015, as recorded in the Em-DAT global database, and 36% of major disaster events in Asia alone. Floods and landslides are the most frequently-occurring natural hazards in the region, particularly during monsoon season (Shrestha, 2008; Gaire et al., 2015). Floods and landslides account for nearly half of the recorded events and deaths and more than two-thirds of the damage in the countries across the HKH (Figure 1).

![Figure 1](https://example.com/fig1.png)

*Figure 1:* Disaster damage by persons killed and persons affected, by percentage and their proportionate dollar impact, on HKH countries between 1980 and 2015 (Data source: Em-DAT).

Between 1980 and 2015, 739 disaster events were recorded in China, 438 in India, and 229 in Bangladesh (Figure 2). Apart from floods, which are prominent across all the countries, landslides figure prominently in inland countries (Afghanistan, Nepal, and Pakistan) and storms in coastal countries (China, India, and Myanmar). Wildfires are also on the rise across the region.
Floods and flash floods: Floods are the most common hazard in the HKH and account for 40% of people killed (Shrestha et al. 2015) and 51% of the damage (Figure 1). In recent years, increasingly erratic and unpredictable monsoon rainfall patterns and increased climate variability have led to severe and frequent flood disasters in the region. This has adversely impacted lives and livelihoods, agriculture productivity, and hydropower production, among other things. For example, the 2010 floods in Pakistan killed more than 2,000 people, with an estimated loss of US$10 billion (FFC, 2010). In India, the 2013 flood in Uttarakhand killed more than 5,000 (Awasthi et al., 2014; Guha-Sapir et al., 2014; Champati et al., 2016), and possibly as many as 30,000 (Ziegler et al. 2014). Bangladesh is one of the most vulnerable countries in the region to floods, as it is situated on the delta of the three major river systems of the HKH: the Ganges, Brahmaputra, and Meghna (Islam et al., 2010). In Pakistan, flooding is the most frequently occurring hazard and affects thousands of people, causing damage in the millions of dollars annually (Tariq & Giesen, 2011). Table 1 provides a list of the large flood events reported during the period 1980 to 2015. The spatial extent and impact of flood disasters between 2010 and 2014 is presented in Figure 3.

To date the HKH has witnessed over 35 glacial lake outburst floods, or GLOFs (Richardson & Reynolds, 2000), and accelerated glacial thinning and additional retreat in response to rising global temperatures are expected to increase GLOF events in the future (Ives et al., 2010). The most recent GLOFs occurred at Lemthang Tsho in western Bhutan in June 2015 (Gurung et al., 2017) and in multiple locations at Chitral, Pakistan in July 2016. Another GLOF upstream of Uttarakhand in 2013 (Allen et al., 2015; Champati Ray et al., 2016) damaged high value infrastructure like hydropower dams (Schwanghart, 2016) and impacted the lives of more than 100,000 people.

Global flood projections based on the Multiple Coupled Model Intercomparison Project, Version 5 – Global Climate Model (CMIP5 GCM) simulations, coupled with global hydrology and land surface models, showed flood hazards increasing over approximately half of the globe, but with great variability at the catchment scale (Dankers et al., 2014). The projected increases in temperature and intense precipitation will induce regional-scale changes in flood frequency and intensity (IPCC 2012), resulting in changes in extreme weather patterns (Elalem & Pal, 2015). Climate change, the increase in the intensity of rainfall, and alteration of the hydrological cycle have increased the likelihood of landslides and flooding in HKH countries such as Bhutan and Nepal (Khanal et al., 2007).

An additional component of climate change is the role of the Arctic Oscillation and its interaction with the monsoon (Joseph et al., 2014). As the Arctic grows warmer, outbursts of cold and dry air are likely to increase, producing more frequent and intense rainfall and triggering increased flooding in the HKH.
Table 1: Severe floods during 1980–2015 in the HKH

<table>
<thead>
<tr>
<th>Country</th>
<th>Year</th>
<th>Month</th>
<th>Killed</th>
<th>Total affected</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>2013</td>
<td>June</td>
<td>6,453</td>
<td>3,419,473</td>
</tr>
<tr>
<td>Pakistan</td>
<td>2010</td>
<td>July</td>
<td>2,113</td>
<td>20,363,496</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>2007</td>
<td>September</td>
<td>1,230</td>
<td>13,851,440</td>
</tr>
<tr>
<td>India</td>
<td>1998</td>
<td>July</td>
<td>2,131</td>
<td>29,652,200</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>1998</td>
<td>September</td>
<td>1,050</td>
<td>15,000,050</td>
</tr>
<tr>
<td>India</td>
<td>1997</td>
<td>September</td>
<td>2,357</td>
<td>30,259,020</td>
</tr>
<tr>
<td>Nepal</td>
<td>1993</td>
<td>July</td>
<td>1,048</td>
<td>553,268</td>
</tr>
<tr>
<td>Pakistan</td>
<td>1992</td>
<td>September</td>
<td>1,446</td>
<td>12,839,868</td>
</tr>
<tr>
<td>Afghanistan</td>
<td>1991</td>
<td>May</td>
<td>1,193</td>
<td>139,400</td>
</tr>
</tbody>
</table>

Figure 3: Spatial extent and impact of flood disasters in the HKH from 2010 to 2014. Source: OFDA/CRED Emergency Disaster Database (Em-DAT).

Landslides: The HKH is characterized by steep topography: more than 60% of its land area has a slope of 15° or more (Figure 4). With fragile geology, a seismically active mountain system, and intense precipitation, the region is a global hot spot for landslides. Hydroclimatic and seismic sensitivity in the area increase this condition (Figures 5a and 5b). Anthropogenic influences like unsustainable development and excessive resource extraction – particularly deforestation and road building – have adversely influenced slope stability and aggravated the landslide possibilities.
According to historical landslide records in the period 1980 to 2015 (Em-DAT), the HKH constitutes 52% of the landslide events and 61% of deaths from landslide in Asia. Although global disaster databases grossly underestimate landslide fatalities (as they are normally recorded based on primary triggers and not the hazard) (Nadim et al., 2006), landslides still register as one of the most catastrophic disasters in the region (Upreti & Dhital, 1996; Sarwar, 2008; MoSWRR, 2009; SAARC, 2010; Khan & Khan, 2015; Lotay, 2015) (Figure 5). Projections give even more cause for concern: In a simple analysis of global population density data and a digital elevation model to estimate the number of people living between a 10° and 50° slope in the HKH, approximately 5.2 million people are deemed at risk for exposure to landslides (Figure 6).

![Figure 4: Area Characterization of the HKH](image)

![Figure 5: Landslides a) induced by precipitation b) induced by earthquake](image)
Earthquakes: The HKH is one of “the world’s youngest mountain belts” (GFDRR, 2012) and is tectonically active. The major cause of earthquakes in the Himalaya is the subduction of the Indian plate underneath the Eurasian plate, which causes contraction and stress concentration. Seismicity is considered high in this region based on the frequency and intensity of past earthquakes (Rai et al., 2004). Plate motion models and GPS measurements indicate that the India-Eurasia convergence continues today at a rate of about 40-50 mm per year (Demets et al., 1994), while the rate of contraction across the Himalaya is estimated to be only 17.52 ± 2 mm per year (Bilham et al., 1997). The difference in these rates is absorbed by a combination of thrusting, crustal extension, and strike-slip motion within the Eurasian plate (Armijo et al., 1989; Avouac & Tapponnier, 1993). Figure 7 provides an earthquake hazard map of South Asia and Table 2 provides a list of large earthquakes that have occurred in the HKH from 1993 to the present.

### Table 2: List of recent large earthquakes in the HKH

<table>
<thead>
<tr>
<th>Year</th>
<th>Month</th>
<th>Country</th>
<th>Name</th>
<th>Death1 (thousand)</th>
<th>Affected1 (thousand)</th>
<th>Economic loss (thousand US$)1</th>
<th>GDP (current million US$)2, 3</th>
<th>Loss/GDP (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>Sep.</td>
<td>India</td>
<td>1993 Latur</td>
<td>9,748</td>
<td>30</td>
<td>280,000</td>
<td>278,384</td>
<td>0.10</td>
</tr>
<tr>
<td>1998</td>
<td>May</td>
<td>Afghanistan</td>
<td>1998 Afghanistan</td>
<td>4,700</td>
<td>955</td>
<td>10</td>
<td>2,912</td>
<td>0.34</td>
</tr>
<tr>
<td>2008</td>
<td>May</td>
<td>China</td>
<td>2008 Sichuan</td>
<td>87,476</td>
<td>45,976</td>
<td>85,000,000</td>
<td>4,564,509</td>
<td>1.86</td>
</tr>
<tr>
<td>2010</td>
<td>Apr.</td>
<td>China</td>
<td>2010 Yushu</td>
<td>2,968</td>
<td>112,000</td>
<td>500</td>
<td>6,005,388</td>
<td>0.0083</td>
</tr>
<tr>
<td>2015</td>
<td>Apr.</td>
<td>Nepal</td>
<td>2015 Nepal</td>
<td>8,831</td>
<td>5,6</td>
<td>5,174,000</td>
<td>20,881</td>
<td>24.78</td>
</tr>
</tbody>
</table>

1: Em-DAT; 2: UN National Accounts Main Aggregates Database (Other than Nepal 2015); 3: World Bank, World Development Indicators (Nepal 2015)
Droughts: The arid and semi-arid regions of western and northwestern HKH (i.e., the Tibetan Plateau, Afghanistan, northern Pakistan, northwest India, and northwest Nepal) are located in drought-prone areas (Ahmad et al., 2004; Wang et al., 2013). The humid and semihumid regions also face severe water shortages during the dry months of the year. The occurrence of drought in the Em-DAT database from 1980 to 2015 accounts for only 4% of all disasters reported globally, yet it accounts for 25% of all people affected by climate-related disasters (CRED & UNISDR, 2016).

Extreme temperatures: Climatological hazards, including extreme temperatures (heat wave, cold wave, and extreme winter conditions) interacting with exposed and vulnerable human and natural systems, can lead to disasters (IPCC, 2012). Extreme heat is a prevalent public health concern throughout the temperate regions of the world. Extreme heat events have been experienced recently in the HKH (see Box 1), and it is likely that the length, frequency, and/or intensity of warm spells, including heat waves, will continue to increase. The factors that contribute to physiological and social vulnerability to heat-related illness and death are age, gender, body mass index, and pre-existing health conditions. A common public health approach, early warning systems, and hazard education can play a significant role in reducing exposure and mortality due to extreme temperatures.

11.1.2. Trends of disasters in the HKH

According to the Em-DAT database, there is an increasing trend in the number of disaster events reported, people killed and affected, and economic loss in the HKH (Figure 8). Between 2000 and 2010, 749 events were reported and 399,609 people killed in the HKH, resulting in a total economic loss of US$ 261 million. This represents a 143% increase from 1990 to 2000. China and India rank as the countries most affected by disasters. This corresponds with the report on the rising frequency of natural disasters in Asia and the Pacific (ADB, 2013b).
**BOX 1: Heat Wave in Southern Pakistan**

A severe heat wave with temperatures as high as 49°C (120 °F) struck southern Pakistan in June 2015. It caused the deaths of about 2,000 people from dehydration and heat stroke, mostly in Sindh province and its capital city, Karachi. The event followed a separate heat wave in India in May 2015 that killed 2,500 people. The South Indian states of Andhra Pradesh and neighboring Telangana, where more than 1,735 and 585 people died, respectively, were the areas most affected by the heat wave.

![Figure 8: Decadal impact of disasters in the HKH](image)

According to the mortality ranking conducted by the ADB, spanning 44 Asian countries, 20 are rated as mortality hotspots, including seven countries from the HKH (ADB, 2013b). These data are presented in Table 3.

**Table 3: High mortality risks from multiple hazards in the HKH**

<table>
<thead>
<tr>
<th>Mortality ranking</th>
<th>Ranking Countries</th>
<th>Percent of population in areas at risk</th>
<th>Estimated number of people at risk (millions)</th>
<th>Percent of total area at risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bangladesh</td>
<td>97.7</td>
<td>139.6</td>
<td>97.1</td>
</tr>
<tr>
<td>2</td>
<td>Nepal</td>
<td>97.4</td>
<td>25.9</td>
<td>80.2</td>
</tr>
<tr>
<td>5</td>
<td>Bhutan</td>
<td>60.8</td>
<td>0.4</td>
<td>31.2</td>
</tr>
<tr>
<td>7</td>
<td>Pakistan</td>
<td>49.6</td>
<td>87.84</td>
<td>22.8</td>
</tr>
<tr>
<td>14</td>
<td>Afghanistan</td>
<td>46.0</td>
<td>12.2</td>
<td>7.2</td>
</tr>
<tr>
<td>16</td>
<td>Myanmar</td>
<td>16.8</td>
<td>10.1</td>
<td>4.5</td>
</tr>
</tbody>
</table>

A review of hazard assessments in the region shows that Nepal and India prepared landslide hazard maps at 1:10000 scale in the 1980s (SAARC 2010). Gaire et al., (2015) highlight the need for a standard, uniform source of information for appropriate hazard-susceptibility analysis and the establishment of Early Warning Systems (EWS), a gap also identified in South Asia by the SAARC Disaster Management Centre (SDMC, 2011). The SDMC (2011) proposes development of a common procedure with standardized terminology, classification scheme, and mapping methods.

There is an increasing trend of extreme rain events over India (Goswami et al., 2006). Historical records of extreme floods by the Alaknanda River in Uttarakhand, India reveal that there may be an increase in flood events (see Box 2). GLOFs in the HKH also show increasing occurrences (Box 3).

**BOX 2: A history of extreme floods in the Alaknanda River, Uttarakhand, India**

Extreme floods occurred in 1894, 1970, and 2013. The most recent flood is fresh in local memory, while the older generation recalls the 1970 flood as one of the forces that kept the Chipko Andolan alive. No one recalls the 1894 deluge. Also, the 2013 flood is thought by some to have been unique, and a similar event unlikely to recur. But the history of extreme floods over the past 2000 years, reconstructed from historical accounts and sediments deposited from floodwaters near Srinagar, tells a different story.

As can be seen from the graph, from roughly 100 to 1700 CE, the frequency of floods has been relatively constant at approximately one every 200 years. But in the late 1700s there was a cluster of five floods on average every 10 years. The most recent three floods in the Alaknanda have occurred on average every 40 years. Thus, for the past 120 years there is no evidence for an increasing hazard. Most of these floods were likely a consequence of the confluence of warm and moist monsoon air from the south and cold dry air from the Arctic. This confluence is likely to become more common as the Arctic warms, and thus flood events will also increase.

**Source:** Wasson et al., 2013; Ziegler et al., 2013

Vulnerability, which is defined as susceptibility to physical harm or damage, is represented by the number of deaths, and reflects an increasing trend of vulnerability to floods and landslides. The World
Bank (2005) has mapped the HKH, illustrating the high mortality from landslides in the region (Figure 9).

Figure 9: Global map of landslide mortality (World Bank, 2005).

Large earthquakes are low-probability but high-impact (Figure 10). However, despite the rare occurrence of earthquakes, there has been a gradual temporal increase in the number of fatalities and level of damage from earthquakes, most of which can be attributed to an increasing concentration of economic development and urbanized habitation in the HKH. For example, when we compare the fatalities from the 2005 Kashmir and 2008 Sichuan earthquakes, the loss of life was similar (~70,000), but the Sichuan disaster (closer to urban areas) resulted in economic loss 16 times greater than the Kashmir earthquake.

Figure 10: Impact of earthquakes on the number of people killed and total damage in the HKH (Source: Em-DAT)
Glacial Lake Outburst Floods (GLOFs) can cause considerable damage to life and property. Reviewing 174 years of data from the Karakoram region, Hewitt and Liu (2010) note that GLOF events have become more frequent in the Upper Indus catchment (illustration below). When compared with tree-ring-based precipitation (Singh et al. 2006) and temperature records (Yadav and Singh 2002) in the high Western Himalaya, we can conclude that during period A (1826-1893) temperatures were low and precipitation was decreasing, but during period B (1893-1934) temperatures were even lower and precipitation still decreasing. However, during period C (1934-2000) we find temperatures rising and precipitation increasing. The highest frequency of GLOFs occurred when temperatures were at their lowest, particularly in the first part of period B. The climatic controls on the glaciers and these floods are not clear, but there is no evidence of a recent increase of GLOFs that may be attributed to global warming.

Source: Hewitt and Liu, 2010

11.1.3. Linking primary and secondary hazards – the mountain perspective

Natural processes, including mountain geohazards in the Himalayan watershed, are often interlinked, as a result of which a primary event triggers a subsequent secondary event. The interlinkage in the case of natural hazards is well illustrated by the 2015 Gorkha Earthquake of Nepal (Kargel et al., 2015), Tsatichu landslide in Bhutan (Dunning et al., 2006, Shrestha & Chhophel, 2010), glacial lake outburst flood in Nepal and Bhutan (Higaki & Sato, 2012), and flash floods (Gupta et al. 2016). When we discuss hazards in the HKH, we think of primary and secondary hazards that are interrelated. Primary hazards may be geophysical or hydrometeorological (e.g., landslide) and trigger a number of secondary hazards, such as landslide dams and subsequent outburst floods. For example, the 2015 Nepal earthquake resulted in more than 4,000 landslides (Kargel et al., 2015). We provide some other examples of primary and secondary hazards in Table 4.
Table 4: Primary and secondary hazards in the mountains of the HKH

<table>
<thead>
<tr>
<th>Type of hazard Primary</th>
<th>Secondary</th>
<th>Occurrence</th>
</tr>
</thead>
<tbody>
<tr>
<td>Earthquake</td>
<td>Landslides</td>
<td>2005 Kashmir earthquake in Pakistan and India</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2008 Wenchuan earthquake in China</td>
</tr>
<tr>
<td></td>
<td></td>
<td>2015 Gorkha earthquake in Nepal</td>
</tr>
<tr>
<td>Landslide</td>
<td>Landslide dam and subsequent outburst flood</td>
<td>2014 Nepal: Jure landslide that dammed the Sunkoshi river</td>
</tr>
<tr>
<td></td>
<td>Landslide dam and subsequent outburst flood</td>
<td>2010 Pakistan: Hunnza Attabad landslide</td>
</tr>
<tr>
<td></td>
<td>Landslide dam and subsequent outburst flood</td>
<td>2008 China: Landslide-dammed lake at Tangjiashan, Sichuan province</td>
</tr>
<tr>
<td>Flood</td>
<td>Erosion and deposition</td>
<td>2008 Koshi floods in Nepal, India</td>
</tr>
<tr>
<td></td>
<td>(aggradation and degradation), sand casting (deposition)</td>
<td></td>
</tr>
</tbody>
</table>

11.2 VULNERABILITIES: PHYSICAL, SOCIAL, ECONOMIC, AND ENVIRONMENTAL DIMENSIONS

Disaster risks are a function of interplay among three key elements: natural hazards, exposure, and vulnerability. The term vulnerability is a state of susceptibility to harm and assumes different connotations depending on the context (Ciurean et al., 2013). A plurality of views and meanings of the term “vulnerability” is explicit in the way the natural system and social systems frame the term and construct measurement frameworks differently. Similarly, climate change, environmental change, and disaster risk reduction all possess different visions of vulnerability. This section will focus on vulnerability in the context of disaster risk management, which is framed as the potential for loss caused by natural hazards, and is a function of exposure, susceptibility, and coping capacity. Birkmann et al., (2013) describe three core thematic dimensions of vulnerability, which we also adopt for our examination of the topic:

Social dimension: propensity for human well-being to be damaged by disruption to individuals (mental and physical health) and the collective social systems (health, education services) and their characteristics (e.g., gender, marginalization of social groups).

Economic dimension: propensity for loss of economic value from damage to physical assets and/or disruption of productive capacity.

Physical dimension: potential for damage to physical assets, including built-up areas, infrastructure, and open spaces.

According to UNISDR, vulnerability is “determined by physical, social, economic, and environmental factors or processes, which increase the susceptibility of an individual, community [assets or systems] to the impact[s] of hazards” (UN, 2016). The World Bank and IPCC include governance as the fifth factor influencing vulnerability, and suggest it is particularly important in regions like South Asia, where governance is generally weak. The definition implies that vulnerability is a condition that depends on multiple factors. The vulnerability of HKH countries to disaster occurrence is characterized...
by complex interactions between natural and socioeconomic conditions (Elalem & Pa, 2015). Mountain systems are inherently challenged by what Jodha (1992) calls “mountain specificities”, which aggravate vulnerability to disaster. Mountain specificities include, among others, constraining features such as accessibility, marginality, and fragility.

Table 5: Percentage of area and population exposed to hazards by HKH country.

<table>
<thead>
<tr>
<th>Country Name</th>
<th>Percent of Total Area Exposed</th>
<th>Percent of Population Exposed</th>
<th>Maximum Number of Hazards*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>11.1</td>
<td>29.5</td>
<td>3</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>35.6</td>
<td>32.9</td>
<td>4</td>
</tr>
<tr>
<td>Bhutan</td>
<td>20.1</td>
<td>29.2</td>
<td>4</td>
</tr>
<tr>
<td>China</td>
<td>8.4</td>
<td>15.7</td>
<td>3</td>
</tr>
<tr>
<td>India</td>
<td>10.5</td>
<td>10.9</td>
<td>4</td>
</tr>
<tr>
<td>Myanmar</td>
<td>10.7</td>
<td>10.4</td>
<td>4</td>
</tr>
<tr>
<td>Nepal</td>
<td>60.5</td>
<td>51.6</td>
<td>3</td>
</tr>
<tr>
<td>Pakistan</td>
<td>5.6</td>
<td>18.2</td>
<td>2</td>
</tr>
</tbody>
</table>


11.2.1 Physical factors

Physical vulnerability refers to vulnerability that stems from limitations posed by physical characteristics of the exposed elements; for example, population density, remoteness, limited access to critical amenities, legal challenges, proximity to hazard zones, and design and quality of infrastructure. Communities with lower levels of exposure that have good access to emergency response services and high-quality infrastructure are least vulnerable. Table 5 presents by percentage the amount of area and number of people exposed to hazards by country in the HKH.

Regarding infrastructure, the overall quality of infrastructure services in Bangladesh, India, Nepal, and Pakistan is much lower than the global average (WEF, 2014). This is true for roads (except for China), airports (except for India), and electricity services (except for China), as well. For more information, please refer to Table 6. This variance in quality infrastructure among HKH countries is partly due to an inadequate level of investment in infrastructure (World Bank, 2013). From 1973-2009, Bangladesh, India, and Pakistan spent, on average, only six percent of their Gross Domestic Product on infrastructure, and Nepal only five percent. The World Bank has projected that all these countries will need to invest a higher share of GDP in their respective infrastructures during 2011-2020.

Table 6: Quality of infrastructure services

<table>
<thead>
<tr>
<th>Country</th>
<th>Overall Infrastructure</th>
<th>Roads</th>
<th>Air Transport</th>
<th>Electricity Supply</th>
</tr>
</thead>
<tbody>
<tr>
<td>World</td>
<td>4.23</td>
<td>4.02</td>
<td>4.36</td>
<td>4.50</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>2.82</td>
<td>2.88</td>
<td>3.02</td>
<td>2.55</td>
</tr>
<tr>
<td>Bhutan</td>
<td>4.65</td>
<td>4.31</td>
<td>3.51</td>
<td>5.85</td>
</tr>
<tr>
<td>China</td>
<td>4.56</td>
<td>4.61</td>
<td>4.72</td>
<td>5.22</td>
</tr>
<tr>
<td>India</td>
<td>3.75</td>
<td>3.79</td>
<td>4.27</td>
<td>3.43</td>
</tr>
<tr>
<td>Nepal</td>
<td>2.93</td>
<td>2.90</td>
<td>2.92</td>
<td>1.83</td>
</tr>
<tr>
<td>Pakistan</td>
<td>3.32</td>
<td>3.81</td>
<td>3.92</td>
<td>2.07</td>
</tr>
</tbody>
</table>

11.2.2 Social factors

Social vulnerability is human vulnerability to characteristics inherent in social interactions, institutions, and systems of cultural values which determine the capacity of groups and individuals to deal with disasters and hazards, and based on their positions and situations within physical and social worlds (Dow, 1992). Over the years, the term “social vulnerability” has become broader in meaning and increasingly interdisciplinary to incorporate the idea that vulnerability is not just an inherent characteristic of certain groups, but rather produced, underlaid, and driven by a wide variety of conditions. Therefore, vulnerability is not just defined in respect to exposure to hazards, but also by numerous socioeconomic factors. Some common factors determining social vulnerability include social and economic inequality, marginalization, social exclusion, and discrimination by gender, social status, disability, and age. Affluent communities with equity in all spheres of social practice are generally less vulnerable compared to poor communities, where inequality is prevalent. Efforts to reduce vulnerability must therefore not be confined only to hazard exposure, but should also include the social systems within which vulnerability is produced (Blaikie et al., 1994).

The UN’s Human Development Index (HDI) is one of the most widely-used indicators for measuring quality of life, and it provides an interesting starting point for evaluating HKH countries. Generally, HKH countries (except China) show lower HDI values compared to the world average, which implies that these populations also have higher than average social vulnerability. Looking more closely at the HDI figures, we note that education and gender inequality are particularly pronounced in the HKH. On the other hand, the HKH ranks low (as a unit) in income inequality, except for China and Bangladesh (Table 7).

### Table 7: Human development index and inequalities

<table>
<thead>
<tr>
<th>Country</th>
<th>Human Development Index (HDI)</th>
<th>Inequality in education (%)</th>
<th>Inequality in income (%)</th>
<th>Income inequality Quintile ratio</th>
<th>Palma ratio</th>
<th>Gini coefficient 2005–2013</th>
<th>Gender Development Index Value</th>
<th>Gender Inequality Index Value</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>China</td>
<td>0.727</td>
<td>29.5</td>
<td>10.1</td>
<td>2.1</td>
<td>37.0</td>
<td>0.943</td>
<td>0.191</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>India</td>
<td>0.609</td>
<td>42.1</td>
<td>16.1</td>
<td>5.0</td>
<td>33.6</td>
<td>0.795</td>
<td>0.563</td>
<td>130</td>
<td></td>
</tr>
<tr>
<td>Bhutan</td>
<td>0.605</td>
<td>44.8</td>
<td>19.6</td>
<td>6.8</td>
<td>18.7</td>
<td>0.897</td>
<td>0.457</td>
<td>97</td>
<td></td>
</tr>
<tr>
<td>Bangladesh</td>
<td>0.570</td>
<td>38.6</td>
<td>28.3</td>
<td>4.7</td>
<td>13.3</td>
<td>0.917</td>
<td>0.503</td>
<td>111</td>
<td></td>
</tr>
<tr>
<td>Nepal</td>
<td>0.548</td>
<td>41.4</td>
<td>15.1</td>
<td>5.0</td>
<td>13.2</td>
<td>0.908</td>
<td>0.489</td>
<td>108</td>
<td></td>
</tr>
<tr>
<td>Pakistan</td>
<td>0.538</td>
<td>44.4</td>
<td>11.6</td>
<td>4.1</td>
<td>11.1</td>
<td>0.725</td>
<td>0.536</td>
<td>121</td>
<td></td>
</tr>
<tr>
<td>Myanmar</td>
<td>0.536</td>
<td>19.4</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>85</td>
<td></td>
</tr>
<tr>
<td>Afghanistan</td>
<td>0.465</td>
<td>44.8</td>
<td>10.8</td>
<td>4.0</td>
<td>1.0</td>
<td>0.600</td>
<td>0.693</td>
<td>152</td>
<td></td>
</tr>
<tr>
<td>Developing countries</td>
<td>0.660</td>
<td>32.3</td>
<td>24.3</td>
<td>--</td>
<td>--</td>
<td>0.899</td>
<td>0.478</td>
<td>19</td>
<td></td>
</tr>
<tr>
<td>World</td>
<td>0.711</td>
<td>26.8</td>
<td>24.0</td>
<td>--</td>
<td>--</td>
<td>0.924</td>
<td>0.449</td>
<td>--</td>
<td></td>
</tr>
</tbody>
</table>


11.2.3 Economic factors

The premise that disaster affects rich and poor differently underpins the idea that economically stronger communities have options to invest in resilient infrastructure, and are economically empowered to invest in better access to emergency services. Therefore, one’s level of vulnerability is highly dependent upon the economic status of the individual, the community, and the nation. While disasters cause higher economic damage and greater loss to infrastructure in developed nations, they generally take a larger number of human lives in developing countries (Pusch, 2004). Because economic
vulnerability is particularly important in building resilience to disaster and reducing exposure to
disaster, it is especially important for the HKH, where five of the eight countries in the region are
classified as Least Developed Countries (Afghanistan, Bangladesh, Bhutan, Myanmar, and Nepal).

Table 8 presents a summary of Gross Domestic Products (GDP) by country. GDP is a commonly used
indicator to gauge the health of a country’s economy. Apart from China and India, other HKH countries
rank low in GDP, which also suggests high economic vulnerability.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Country</th>
<th>Ranking</th>
<th>USD (million)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Afghanistan</td>
<td>108</td>
<td>19,351.29</td>
</tr>
<tr>
<td>2</td>
<td>Bangladesh</td>
<td>45</td>
<td>195,078.67</td>
</tr>
<tr>
<td>3</td>
<td>Bhutan</td>
<td>168</td>
<td>2,057.95</td>
</tr>
<tr>
<td>4</td>
<td>China</td>
<td>2</td>
<td>11,007,720.59</td>
</tr>
<tr>
<td>5</td>
<td>India</td>
<td>7</td>
<td>2,095,398.35</td>
</tr>
<tr>
<td>6</td>
<td>Myanmar</td>
<td>72</td>
<td>62,600.91</td>
</tr>
<tr>
<td>7</td>
<td>Nepal</td>
<td>104</td>
<td>21,194.89</td>
</tr>
<tr>
<td>8</td>
<td>Pakistan</td>
<td>41</td>
<td>271,049.89</td>
</tr>
</tbody>
</table>

Source: World Bank, 2014

### 11.2.4 Environmental factors

The state of environmental conditions plays a role in determining a community’s vulnerability to
disaster. Badly managed environments create unsafe situations and thereby increase vulnerability to
disaster. Some of the determinants of environmental vulnerability are poor environmental
management, overconsumption of natural resources, decline of risk-regulating ecosystem services,
and climate change. Depletion of natural resources (for example, wetlands) exposes people and
infrastructures to natural hazards like floods and storm surges.

The HKH is both a climate change hotspot and a densely populated region, a factor contributing to the
depletion and degradation of natural resources, and a pathway to increased vulnerability.

### 11.2.5 Gender dimensions

Records of natural disasters in the Himalayan region over the last few decades show that women are at
greater risk of dying than men (Mehta, 2007). Studies indicate that more women than men die when
disasters strike, a result of women’s lack of information, mobility, and decision-making power and the
inequitable access to resources and training, as well as gender-based sociocultural norms and barriers,
conventional gender responsibilities, and high rates of male outmigration (Mehta, 2007; Ariabandhu,
2009; Nellemann et al., 2011). For example, during the 1991 cyclone in Bangladesh, the mortality rate
for women was three times higher than for men (UNEP 1997; Twigg, 2009). Gender inequities can be
evident in a lack of, or inadequate, early warning information targeting women and evacuation
procedures and arrangements. Knowledge of early warnings and the decision to evacuate may be the
exclusive domain of men. In some cases, women may be ill-informed about natural hazards and not
allowed to make the decision to evacuate (Stark et al., 2013). A UNEP report (UNEP, 1997) concluded
that the early warning signals had not reached many women downstream.
Vulnerability is particularly high when poverty intersects with discrimination, whether because of gender, caste, ethnicity, or other reasons. This is especially true for women and low caste people (Adger & Kelly, 1999; Brooks & Adger, 2005; Aguilar et al., 2015). During the 2015 Nepal earthquake, more women than men died in all the affected districts except Kathmandu (Golam et al., 2015). Fewer opportunities exist for education, political involvement, and access to information, markets, and a myriad of other resources (Madhavi, 2003). Considering vulnerability factors such as social roles and access to resources and information, women are more vulnerable to climate change and disasters than men. Women also know less than men about their communities’ disaster prevention and mitigation projects. Furthermore, natural disasters and climate change often exacerbate existing inequalities and discrimination in such a way that women and girls become more vulnerable and are at higher risk of gender-based violence, sexual harassment, exploitation, abuse, trafficking, and rape during displacement caused by major disasters such as flood, drought, or earthquake.

Men and women possess valuable, but different, knowledge, skills, experience, and coping capacities. However, the strengths and capabilities of women are often ignored in policy decisions and in formal arrangements related to mitigation and recovery. Policy makers and planners generally give little attention to the social barriers and constraints that hinder women’s participation in capacity building and their access to information that could help achieve better preparedness. Gender differences are manifested in the disproportionately poorer health and nutritional status, lower levels of access to formal literacy and education, higher levels of economic poverty, higher morbidity/mortality rates, and high workloads of women compared to men, as well as extremely low rates of property ownership, decision making, and representation in governance institutions (Leduc, 2011). Adopting a gender-sensitive early warning system approach with appropriate policies in place will help in reducing the disaster mortality of women and contribute to reducing the adverse impact of flood disasters (Shrestha et al. 2014). To have disaster-resilient communities, the participation of both men and women at various levels is essential. Inequalities that exist in society are often strengthened during disaster, and this must be kept in mind when collecting data and analyzing and formulating disaster resilience plans and activities (Rahman et al., 2015). A gender-sensitive approach that not only recognises the vulnerabilities of women, but also works towards enhancing their resilience and strengthening their ability through awareness raising and capacity building initiatives, is needed to respond effectively to disasters.

### 11.2.6 Risk assessment

Risk is a likelihood of harmful consequences of natural hazards (UNDP, 2000) arising from the interaction of the probability that different kinds and intensities of hazards will occur, the elements exposed to these hazards, and the vulnerability of the elements exposed to specific hazards (World Bank, 2005). Risk information forms the cornerstone of any risk reduction agenda; thus, awareness of existing and anticipated risk to guide DRR interventions, strategies, and policies is imperative. Based on the calculated risks, the cost effectiveness of protection measures can be evaluated. Risk assessment involves the identification, quantification, and characterization of threats to human health and the environment. But risk analysis is as much a political enterprise as a scientific one, and public perception of risk also plays a role in risk analysis, bringing the issues of values, process, power, and trust into the overall picture (Slovic, 1999).
Because the HKH is characterized by natural hazard hot spots and a low HDI (except China and India), it is considered a high disaster risk region. According to the indicators for hydrometeorological hazards and disaster risk developed in the Asian Water Development Outlook (AWDO) 2013, India is most prone to hydrometeorological hazards, followed by China, Bangladesh, Pakistan, and Nepal (indicators are not available for Afghanistan, Bhutan, and Myanmar) (ADB, 2013a).

The AWDO report considers vulnerability as a function of exposure, basic vulnerability, soft coping capacity, and hard coping capacity. Bangladesh faces the highest level of exposure to hazards, followed by Pakistan, Nepal, India, and China. Basic vulnerability, measured by proxies such as poverty levels, among others, is also high in Bangladesh, Pakistan, and Nepal compared to China and India. Soft coping capacity, measured by proxies such as literacy rate, among others, is lowest in Nepal and highest in China, with Bangladesh, Pakistan, and India falling in between these two countries. Finally, hard coping capacity, measured by proxies such as infrastructure facilities, is the lowest in Nepal, with other countries showing indicators close to each other (Table 9).

Table 9: Hazard, Vulnerability, and Risk Indicators

<table>
<thead>
<tr>
<th>Country</th>
<th>Bangladesh</th>
<th>China</th>
<th>India</th>
<th>Nepal</th>
<th>Pakistan</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hazard</td>
<td>6.96</td>
<td>7.68</td>
<td>7.22</td>
<td>3.19</td>
<td>6.23</td>
</tr>
<tr>
<td>Basic vulnerability</td>
<td>9.88</td>
<td>5.32</td>
<td>8.60</td>
<td>7.12</td>
<td>8.29</td>
</tr>
<tr>
<td>Soft coping capacity</td>
<td>4.23</td>
<td>11.18</td>
<td>7.19</td>
<td>2.66</td>
<td>4.71</td>
</tr>
<tr>
<td>Hard coping capacity</td>
<td>10.74</td>
<td>10.52</td>
<td>11.28</td>
<td>5.29</td>
<td>9.9</td>
</tr>
<tr>
<td>Risk</td>
<td>30.95</td>
<td>16.19</td>
<td>23.80</td>
<td>17.92</td>
<td>25.51</td>
</tr>
</tbody>
</table>

Note: Hydro-meteorological hazards include floods and windstorms, droughts, and storm surges and coastal floods. Source: (ADB, 2013a)

Many global risk assessment exercises mark HKH countries as highly vulnerable (Garschagen et al., 2016) (Table 10).

Table 10: Risk Index in the HKH countries

<table>
<thead>
<tr>
<th>Country</th>
<th>World Risk Index</th>
<th>Exposure</th>
<th>Vulnerability</th>
<th>Susceptibility</th>
<th>Lack of coping capacities</th>
<th>Lack of adaptive capacities</th>
<th>Rank</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afghanistan</td>
<td>9.50%</td>
<td>15.17%</td>
<td>72.12%</td>
<td>56.05%</td>
<td>92.85%</td>
<td>67.48%</td>
<td>41</td>
</tr>
<tr>
<td>Bangladesh</td>
<td>19.17%</td>
<td>31.70%</td>
<td>60.48%</td>
<td>38.23%</td>
<td>86.56%</td>
<td>56.85%</td>
<td>5</td>
</tr>
<tr>
<td>Bhutan</td>
<td>7.51%</td>
<td>14.81%</td>
<td>50.70%</td>
<td>29.43%</td>
<td>73.77%</td>
<td>48.90%</td>
<td>60</td>
</tr>
<tr>
<td>China</td>
<td>6.39%</td>
<td>14.43%</td>
<td>44.29%</td>
<td>22.81%</td>
<td>69.86%</td>
<td>40.18%</td>
<td>85</td>
</tr>
<tr>
<td>India</td>
<td>6.64%</td>
<td>11.94%</td>
<td>55.60%</td>
<td>35.79%</td>
<td>80.22%</td>
<td>50.78%</td>
<td>77</td>
</tr>
<tr>
<td>Myanmar</td>
<td>8.90%</td>
<td>14.87%</td>
<td>59.86%</td>
<td>35.63%</td>
<td>87.00%</td>
<td>56.93%</td>
<td>42</td>
</tr>
<tr>
<td>Nepal</td>
<td>5.12%</td>
<td>9.16%</td>
<td>55.91%</td>
<td>38.05%</td>
<td>81.05%</td>
<td>48.64%</td>
<td>108</td>
</tr>
<tr>
<td>Pakistan</td>
<td>6.96%</td>
<td>11.36%</td>
<td>61.26%</td>
<td>35.04%</td>
<td>86.26%</td>
<td>62.48%</td>
<td>72</td>
</tr>
</tbody>
</table>

Source: Garschagen et al., 2016

While the region already faces a high natural hazard risk, the impacts of climate change will further aggravate the situation, as manifested in the loss and fragmentation of habitats, a reduction in forest biodiversity, the degradation of wetland and riverine island ecosystems, a decline in forage and fodder resources, a reduction in agrobiodiversity, an increase in forest fires, soil fertility degradation, changes...
in land use patterns, and an increased variability in agricultural productivity (Tse-ring et al., 2010).

Like other mountain regions, the Hindu Kush Himalaya have experienced above-average warming (see Chapter 4; Nogues-Bravo et al., 2007), which has adversely impacted freshwater primarily snow, glacier, and permafrost (Yao et al. 2012). A dwindling water availability scenario projected using climate change impact modelling (Immerzeel et al., 2010) could undermine the socioeconomic fabric of the downstream societies.

The HKH has experienced rapid environmental changes and it is widely believed that the region will be one of the planet’s hot spots for future climate change impacts (Maplecroft, 2011). Mountain communities and their livelihoods are sensitive to such changes, which will have a variety of impacts on human well-being. Primary sector livelihoods such as agricultural livelihoods have become increasingly uncertain and risky and, because of inadequate resources, poor households have especially limited adaptation options and are simply coping (Gentle & Maraseni, 2012). Mountain areas are challenging living spaces, and mountain communities have a long history of adapting to extreme conditions. Nevertheless, traditional adaptation mechanisms are often insufficient to cope with recent socioeconomic and environmental changes (Jodha, 1997), which have considerably increased the challenges for mountain people in securing their livelihoods (O’Brien & Leichenko, 2000).

In developing countries, economic development in mountain regions already lags behind that in the lowlands, foothills, and urban areas (Tanner, 2003; Barrera-Mosquera et al., 2010). Climate change is expected to exacerbate the existing challenges faced by mountain people and their environments, intensify some existing hazards, and result in the emergence of new hazards (O’Brien & Leichenko, 2000; Sonesson & Messerli, 2002; Macchi et al., 2011). These processes will intensify the exposure component of vulnerability. The sensitivity component will include environmental aspects embedded in the biophysical features of a region and social elements that are closely linked to the nature and range of available livelihood options (Jodha, 1997), as well as access to resources (Adger & Kelly, 1999; Brooks & Adger, 2005; Aguilar et al., 2015).

Risk assessment is the first step to augment risk-informed decision making and development. While many excellent risk assessments exist risk assessment in practice remains few. Other challenges in translating risk knowledge to practice are inadequate granularity of information and what has been termed by Carr et al., (2015) as “spatial scale challenges”. The Consultative Workshop on Landslide Inventory, Risk Assessment, and Mitigation in Nepal (Gurung et al., 2017) identified “spatial scale challenges” and “inconsistency in methodology” as two of the main setbacks to implementing risk assessment results. Strategic decision making at the national and sub-national levels has different informational needs compared to local level decision making, which is more operational in nature. There is an obvious gap in national and sub-national risk assessment, as much of it is done at a micro scale for specific sites/areas. Other challenges in the HKH in terms of assessment is that it is skewed towards hazards more than vulnerability and risk. Risk assessment as a process is still far from being mainstreamed into government systems, and is mostly done through project support. This has resulted in risk assessment being conducted in pockets and based on different methods favored by various project proponents.

In view of the above discussion, there is a need to standardize assessment methods and develop uniform risk assessment protocols (Gaire et al., 2015; ICIMOD, 2016; SDMC, 2011). The SAARC Comprehensive Disaster Management Framework adopted in 2005 identified “developing standards
and methodology for risk assessment....” as one of the pathways necessary to develop and implement risk reduction strategies.

11.3 A FRAMEWORK FOR POLICIES TO REDUCE RISK AND ENHANCE RESILIENCE

This section proposes a disaster risk reduction (DRR) framework to reduce risk and enhance resilience in the HKH. In this section, we address key issues for mountain and downstream communities. The framework we propose is based on the principles of the 1994 Yokohama Strategy and Plan of Action, the 2005 Hyogo Framework of Action, UNDP’s 2007 Human Development Report, and the 2015 Sendai Framework for Disaster Risk Reduction.

11.3.1 A framework for reducing risk and increasing resilience to disasters

Our DRR framework for the HKH has four principal elements:

- **Information**: sharing hazard information between upstream and downstream communities, ensuring communication about cascading hazards.

- **Infrastructure**: adapting to climatic and seismic risks, investing to enhance connectivity among communities.

- **Institutions**: addressing gender and governance dimensions and developing mechanisms to connect national institutions, policies, and actions with local ones.

- **Insurance**: insuring, or sharing risk, to build resilience to residual disaster risks (those that may not be eliminated).

**Information**: Since the HKH is a hotspot for both hydrometeorological and geophysical hazards, developing a strong knowledge base on extreme weather events and seismic activities in the region is vital to understanding the increasing resilience. In addition, hazard maps for communities and real-time information systems can substantially reduce vulnerability to potential hazards through early warning systems and prudent land use planning, especially in situations where financial protection measures, such as insurance, are not in place. The value a society places on such information may depend on their perception of risk -- and their perception may, in turn, depend on the information they have available to sense the likelihood of the hazards.

Often, the government shows a willingness to invest in information systems soon after the hazard event occurs. For example, after a massive earthquake devastated two of its districts in 1993, Maharashtra became the first state in India to implement a comprehensive plan, complete with a state-of-the-art satellite-linked computer network connecting various civic bodies, collectorates, and blocks in the state (Vatsa, 2002). It would be much better, however, if such initiatives could be proactive rather than reactive.

Data and information are a prerequisite for informed decision making for disaster risk reduction. A broad range of environmental and social data and information may be shared to promote transboundary cooperation for better river basin planning and management and to address climate change (Chenoweth & Feitelson, 2001; Grossman, 2006; Gerlak et al., 2010). Sharing data and information builds trust and confidence amongst the countries and provides a common understanding of the issues which may result in agreement, joint implementation, and improved transboundary
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cooperation (Shrestha et al., 2015; Blumstein et al., 2016). In the HKH, there has been some progress with the HYCOS system under the World Meteorological Organization’s WHYCOS framework in which countries share real-time hydrometeorological data for flood risk reduction (Shrestha et al., 2015) and work toward an end-to-end EWS. Working in partnership with several regional and international partners, ICIMOD offers a regional platform for utilizing the latest advances in space technology and GIS applications to address disaster challenges and to support risk identification and early warning systems.

It is important to note that after disasters occur, funds do become available from various sources, both internal and external, but the same quantum of money can be more efficiently and effectively used, in part, by helping the communities in the HKH with hazard maps, real-time information systems, and communication channels to the last mile, before it happens -- so that they can be better prepared and thus save lives and livelihoods. Global agendas, such as the 2015 Sendai Framework, may also help to attract funds for generating information on risk. This is a significant change in priority from the 2005 Hyogo Framework, where risk assessment was identified as the second priority (Box 4).

Infrastructure: Investments in infrastructure may also be necessary to create hazard-resilient critical infrastructure such as hospitals for healthcare services and school buildings for use as community shelters after hazardous events. Similar investments in road networks for access to settlements and communications systems for information flow may also be necessary for connectivity immediately after disasters. Furthermore, critical infrastructure such as water supply systems and electric power plants should be made climate-resilient, and standards for rebuilding structures after earthquakes should be improved.

It is important to note that there was an implicit shift toward a balance of structural and non-structural measures after the announcement of the Hyogo Framework. But the emphasis on the importance of balanced investments in the structural measures has reappeared with the promotion of “Build Back Better” as Priority 4 of the Sendai Framework, and for investment in disaster-resilient critical facilities as Priority 3 on disaster risk reduction. The same priority also highlights investments in ecosystem-based natural resource management approaches.

Institutions: Resources need to be invested in capacity building through training programs for formal and informal institutions at the local level. Appropriate policies and mechanisms also need to be developed for supportive interfaces between these institutions at both the national and local levels. Institutional arrangements supported by communications technologies for end-to-end communications up to the last mile must be developed. For example, the ability to send alerts for flood hazards or deliver relief measures after earthquakes is crucial.

The Hyogo Framework’s first priority was the establishment of institutions for disaster risk reduction: “Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.” In view of the weaknesses of the institutional basis for converting national policy into local action (Oxley, 2013), the Sendai Framework, in its Priority 2 on strengthening disaster risk governance, has emphasized the need “to carry out an assessment of the technical, financial, and administrative disaster risk management capacity to deal with the identified risks -- at the local and national levels.”

In addition, the Sendai Framework also explicitly mentions the need to develop institutions “to promote transboundary cooperation to enable policy and planning for the implementation of
ecosystem-based approaches,” which has high relevance to the HKH. Transboundary cooperation can be enhanced at the national and local levels between two or more countries. The Sendai Framework clearly highlights, in Priority 3, the need to promote mechanisms for disaster risk transfer, risk sharing and retention, and financial protection to reduce the financial impact of disasters. In the Hyogo Framework, Priority 4 discusses the need to develop financial risk-sharing mechanisms (See Box 4).

**BOX 4: Priorities of the Global Agenda: The Hyogo and the Sendai Frameworks**

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Priority 1</td>
<td>Ensure that disaster risk reduction is a national and a local priority with a strong institutional basis for implementation.</td>
<td>Understanding disaster risk</td>
</tr>
<tr>
<td>Priority 2</td>
<td>Identify, assess, and monitor disaster risks and enhance early warning.</td>
<td>Strengthening disaster risk governance to manage disaster risk</td>
</tr>
<tr>
<td>Priority 3</td>
<td>Use knowledge, innovation, and education to build a culture of safety and resilience at all levels.</td>
<td>Investing in disaster risk reduction for resilience</td>
</tr>
<tr>
<td>Priority 4</td>
<td>Reduce underlying risk factors</td>
<td>Enhancing disaster preparedness for effective response and to “Build Back Better” in recovery, rehabilitation, and reconstruction</td>
</tr>
</tbody>
</table>

**Source:** United Nations, 2015; UNISDR, 2005

**Insurance:** Mechanisms need to be developed for raising precautionary funds or for sharing risks before disaster strikes in order to provide relief, rehabilitation, and reconstruction efforts. The question is how much residual risk the government can manage itself -- and how much residual risk it would need to share or transfer. The government would need to maintain a pool of reserve funds to address small disasters. It would also need to subsidize insurance premiums, if necessary, for promoting private insurance products, such as index-based weather insurance for drought. Furthermore, beyond a certain level of risk, the government may have to share the indemnities with the private insurer, or the insurer will need to find a reinsurance company for risk-pooling through international markets. Further on, when the risk involves a major catastrophe, the government may have to transfer risk to capital markets through financial instruments such as catastrophe bonds. In such bonds, the issuer is liable to pay interest and principal if the event does not occur during the maturity period, and is not liable to pay back the principal if the event does occur.

It is also critical that special measures and mechanisms of such insurance be designed for women, the poor, and marginalised groups. Until such mechanisms are developed, informal institutions like social networks and social capital, where extended families and communities help each other, may be the only forms of insurance available to the communities within a reasonable amount of time after the
event occurs. Furthermore, even after developing reasonable private insurance products, people may need to be "nudged" to buy them because of the time inconsistency problem. For example, for drought protection, a farmer would need to decide now to purchase insurance and pay the premiums, but the payout, if any, would take place in the future, which tends to discourage farmers from enrolling in insurance programs (Banerjee & Duflo, 2011).

### 11.3.2. Relating the DRR elements to program components

In practice, decision makers and governments ultimately will determine if and how the separate elements of DRR (information, infrastructure, institutions, and insurance) will be applied to help increase the strength and modalities of resilience to hazards. And that motivation, in turn, depends upon perceptions of risk -- by individuals, by communities, by experts, and by society at large (Slovic, 1987).

To account for these motivations and perceptions, resilience-building programs should consider four strategies for changing human behavior: 1) Restrictions on choices through command-and-control mechanisms (e.g., zoning regulations; land use guidelines and building codes); 2) monetary incentives (e.g., subsidies on insurance premiums); 3) persuasion by providing information (e.g., risk maps); and 4) "nudging" (e.g., early warning systems). Often, a combination of these methods may be appropriate, and they will, of course, depend on the type of hazard event under consideration for resilience building. See Table 11 for a fuller description of these DRR strategies.

#### Table 11: DRR elements and behavioral change strategies

<table>
<thead>
<tr>
<th>Command-and-control methods</th>
<th>Information</th>
<th>Infrastructure</th>
<th>Institutions</th>
<th>Insurance</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>zoning and building code enforcements</td>
<td>infrastructure development projects</td>
<td>Institutionalization of formal and informal institutes</td>
<td>Subsidizing insurance premium the farmer has to pay for index-based weather insurance for crops</td>
</tr>
<tr>
<td>Incentives</td>
<td></td>
<td>- technical design standards</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- building codes</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- land use plan/zoning</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>- Rural Housing Reconstruction Program (RHRP): financial support for seismic-resistant housing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Persuasion</td>
<td>Reviving drying springs</td>
<td>- multi-sectoral DRR budgets</td>
<td>Support from formal and informal institutes CBFЕWS Reviving drying springs</td>
<td>Engaging NGOs as social mobilizers to raise awareness of market insurance for crops</td>
</tr>
<tr>
<td></td>
<td>Providing hazard maps</td>
<td>- technical guidelines and dissemination training by engineers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Nudging</td>
<td>Community-based flood early warning systems (CBFEWS)</td>
<td>- promoting retrofitting with nudges to consider traditional and cultural preferences</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
11.3.3 Information flows are crucial for early warning systems

Flood early warning systems are one of the most effective non-structural ways to minimize the loss of life and property (Shrestha et al., 2008). Early warnings are transmitted from upstream to downstream communities to minimize the impacts of disasters. Accurate rainfall estimations and sharing of data and information are critical for reliable and timely flood forecasting and warnings. In many regions, operational flood forecasting has traditionally relied on a dense network of rain gauges or ground-based rainfall measuring radars that report in real time. Rapid advances in communication technology are making access to information faster, more reliable, and cheaper. At the same time, hydrological and meteorological monitoring technologies continue to improve significantly. These technological advances can be exploited to promote regional cooperation for flood risk reduction in the HKH by providing an end-to-end flood information system. The system functions as a decision support tool for decision makers to alert vulnerable communities in a timely and accurate manner.

In the HKH, a regional flood information system has been developed (Shrestha et al., 2015) that allows the visualization and extrapolation of real-time data from the stations to any geographical location by providing information on the river water levels and the amount of rainfall. Using this real-time data, a flood outlook has been developed for the Ganges Brahmaputra basin. In August 2014, this flood outlook was used by Nepal’s Department of Hydrology and Meteorology to issue a flood warning for the rivers of Nepal. It did so by means of a flood bulletin which was widely disseminated through its website (Shrestha & Pradhan, 2015). At the local level, a low-cost technology using wireless and solar-powered transmitters and receiver stations and mobile phone text messaging was developed to disseminate flood information to vulnerable communities downstream.

BOX 5: Reaching the most vulnerable: Community-based flood early warning system (CBFEWS) in India

In 2013, five CBFEWS were installed in the Jiadhal and Singora rivers in Assam, India. These involved local communities; a local NGO, Aaranyak; and the District Disaster Management Authorities, serving 45 flood-vulnerable communities downstream. With an investment of $1,000 per instrument, CBFEWS in Dihiri was able to save assets worth $3,300 in one flood event in 2013. The project, scaled up in Nepal and Afghanistan after receiving UNFCCC’s Momentum for Change 2014 Lighthouse Activity Award, is supported by ICIMOD’s core fund, the Himalayan Climate Change Adaptation Programme, and the Koshi Basin Initiative.

11.3.4 Building critical infrastructure resilient to disasters

Critical infrastructure is highly vulnerable to, and a major casualty of, natural disasters. Repairing or replacing infrastructure assets after a disaster is often difficult and costly, which can exacerbate the suffering of affected communities. The need to address climate risks in infrastructure projects is becoming increasingly urgent for economic development in emerging markets (Moller & Swann, 2016). The World Bank Group and other international financial institutions are well-placed to address the intersection of climate risks and infrastructure. They are screening such investments for climate risks, providing analytical tools to measure those risks, and designing measures to respond to those risks, including innovative insurance approaches. Sudmeier (2013) developed an operational framework to measure resilience and vulnerability, which could be used as a tool for guidance, providing direct interventions to reduce the risk of landslides and floods in the vulnerable mountainous regions of
Nepal. Sudmeier (2013) made an effort to quantify the resilience and vulnerability to disasters in the mid-hill regions of Nepal by defining resilience indicators based on literature review, field observations, and a participatory approach with the stakeholders.

The HKH region is also physically vulnerable to earthquakes. Two major recent earthquakes in the region exemplify the imminent need for enhancing physical resilience. On 8 October 2005, Pakistan’s northern areas were struck by a 7.6 Mw earthquake. The impact of the “2005 Kashmir earthquake” was devastating. More than 73,000 people were killed, 150,000 people were injured, and more than 200,000 houses were destroyed, rendering 3.5 million people homeless. In response, the Government of Pakistan collaborated with international partners to launch the Rural Housing Reconstruction Program (RHRP) at a cost of over US$1.5 billion (GFDRR, 2013). RHRP relied on an owner-driven mechanism providing multi-tranche financial support to beneficiary households, based on inspection and certificate at various stages of construction to ensure compliance with seismic-resistant standards (GFDRR, 2013).

On 25 April 2015, Nepal was struck by a 7.8 Mw earthquake affecting more than 8 million people. A comparison of the two earthquakes is summarized in Table 12.

<table>
<thead>
<tr>
<th>Table 12: Comparison of the Pakistan and Nepal earthquakes</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>2005 Pakistan earthquake</strong></td>
</tr>
<tr>
<td><strong>Total Damage and Loss</strong></td>
</tr>
<tr>
<td><strong>Total Damage and Loss</strong></td>
</tr>
<tr>
<td><strong>Housing Damage and Loss</strong></td>
</tr>
<tr>
<td><strong>Deaths</strong></td>
</tr>
<tr>
<td><strong>Injured</strong></td>
</tr>
<tr>
<td><strong>Houses Destroyed</strong></td>
</tr>
<tr>
<td><strong>Houses Damaged</strong></td>
</tr>
<tr>
<td><strong>Total Recovery Needs</strong></td>
</tr>
<tr>
<td><strong>Housing Recovery Needs</strong></td>
</tr>
</tbody>
</table>

Source: 1 ADB & World Bank, 2005; 2 NPC, 2015

Reflecting on a comparison of the actions taken in the wake of the 2005 Pakistan and 2015 Nepal earthquakes, “Building resilience to earthquakes” would indicate that the following aspects be taken into account:

- Developing seismic-resistant structural designs should be the first important step to develop resilience, but this step needs reflection on common vulnerabilities in local practices, identifying the damage patterns and construction materials from damage assessments.

- In communicating those technical requirements with communities, evidence-based persuasion and nudging are the keys to inducing them to apply the technical requirements and designs on the ground.
A transparent mechanism for cash disbursement and technical inspection is another key factor to develop resilience. Dedicated authority to implement and enforce such standards should be a consistent and reliable agent for change in the community’s behaviour.

Likewise, Bhutan succeeded in lowering the lake level by 86 cm by digging and realigning the existing outlet channels to safely drain water from the lake. The goal was to artificially lower the water level at Thorthormi Lake by five metres in three years (see Box 6).

**BOX 6: The Cost of Climate Change: The Story of Thorthormi Glacial Lake In Bhutan**

For Bhutan, scenarios from an outflow from Thorthormi Tsho include crop destruction and livestock losses over more than half of the fertile and economically critical Punakha and Wangdi valleys, loss of a vital bridge and roads, and damage to hydropower facilities under construction. Punakha Dzong, a 14th century royal palace and religious centre, would be among 16 historic monuments at risk, along with numerous other buildings, including vocational centres and a noted weekend market.

The Royal Government of Bhutan (RGB), monitoring the growth of the glacier with Japanese assistance, has sought assistance to reduce the dangers posed by Lake Thorthormi by artificially draining its waters. A large effort by the government, communities, and WWF, supported by the Global Environment Facility (GEF), the United Nations Development Programme (UNDP), and the Austrian Coordination Bureau, succeeded in lowering the lake level by 86 cm by digging and realigning the existing outlet channels to safely drain water from the lake. The intention was to artificially lower the water level at Thorthormi Lake by five metres in three years.


### 11.3.5. Role of institutions are critical in resilience building measures

Building resilience to climate change and its effectiveness depends on how institutions (formal and informal) at the local and national level structure and internalize incentives for individual and collective actions. In this regard, the role of the institution is important if it is to support vulnerable social groups at the local level (Agrawal, 2010). Considering the role of institutions as a specific component for enhancing capacity and the means for delivering external resources to facilitate resilience and adaptation (Agrawal, 2010; Christoplos et al., 2010; Dovers & Hezri, 2010), Pradhan et al. (2012) presented learnings from four case studies in the HKH, which analyze the role of policy and institutions in local adaptation planning to enhance community resilience.

The building of effective resilience is determined by the interface between the civic (civil society), public (state/government), and private (market/service organizations) institutions in their formal and informal roles that operate at different scales. Agrawal (2010) emphasized that the public sector is more likely to facilitate adaptation strategies related to communal pooling, diversification, and storage owing to their command over authoritative action and their ability to channel technical and financial inputs to rural areas. Private sector organizations, because of their access to financial resources, are more likely to have greater expertise in promoting market exchange and diversification. Non-profit service organizations may also be able to advance communal pooling. Civic sector institutions can
strengthen different responses because of their greater flexibility in redefining goals and adopting new procedures. Depending on the extent to which there is a match or mismatch between the aims and comparative advantages of different institutions, the interface between institutions can be supportive or unsupportive.

A supportive interface is obviously desirable, but rarely found, where formal public institutions are supporting formal and informal institutions at all stages of adaptation planning. An example from China shows that after extreme drought, the Ministry of Water Resources, National Reform and Development Commission, and the Ministry of Civil Affairs jointly issued a “Suggestion on strengthening the establishment of water users associations” (Policy Decision 10) in 2005, which recommended the establishment of water user associations to manage rural water infrastructure. The Baoshan Municipality Water Bureau established 520 water user associations from 2006 to February 2009, covering 142,449 households in 506 villages across 65 townships, and managing a total of 13,281 ha of irrigated land. All the counties in Baoshan issued their own implementation guidelines to establish the water user associations, with their own constitutions and regulations governing the operation of the associations. According to the government’s report, a supportive interface was achieved between the policy implementation and water user associations, who owned and managed their water infrastructure, promoted water-saving practices, and reduced conflicts in the collection of fees in order to deal with drought.

However, some water user associations experienced an unsupportive interface due to lack of funds for their operation, inefficient leadership, and lack of legal clarity regarding their status. The empirical evidence showed that the ability of the communities to maintain a supportive interface largely depended on the relationship between village leaders and local officials. This is an informal mechanism for obtaining supportive interface from the public sector, which is a barrier to some communities that are not well positioned to procure the support they require from the local government.

Another example from Baoshan emphasized that after the severe drought of March 2009, the Longyang District Government sent a “Notification on Strengthening Work against the current Drought” to all government units mentioned in the Plan. The district agriculture bureau submitted the needs assessment and recovery report prepared in consultation with the communities in 18 townships. Based on the report, the provincial committee disbursed funds to those townships, which had requested relief such as water pumping machines. The supportive interface between the provincial government and the communities was liaised by the district agriculture bureau to implement the government plan, which resulted in enhanced adaptive capacity and resilience of the communities to address drought.

These examples suggest that resilience building cannot occur in a social vacuum: It needs to be supported by institutions and policies. Planning for resilience building should give greater attention to the development of effective institutional arrangements, which requires supportive interfaces between institutions for building adaptive capacity and enhancing the resilience of communities (Pradhan et al., 2012).

11.3.6. Nudging could help motivate people for self-insurance

In industrialized countries, market insurance is the primary means of risk management. In the HKH, governments and the private sector are currently trying to promote market insurance for various uses, such as crop insurance. In the present context, while market insurance is yet to be adopted widely in
the region, self-insurance products could be adopted for increasing resilience to natural disasters. Self-
insurance in this context is defined as having adequate personal resources to cope with the
consequences of a disaster. It has been reported that it is easier to motivate people to save when the
purpose for which they are saving is clearly visible to them (Soman & Cheema, 2011). This implies that
it would be easier to motivate individuals to purchase self-insurance if they live in areas prone to floods
and landslides that occur more frequently (Tversky & Kahneman, 1974) -- annually in some areas -- in
the region, compared to those living in areas prone to earthquakes and droughts, which occur less
frequently. It has also been reported that financial products and institutional mechanisms for saving
need to be simple and practical, including those for small savings by the marginalized and the poor
(Dupas & Robinson, 2013).

We will discuss two field experiments conducted to motivate individuals to save -- although not
directly for natural hazards. There are lessons that can be learnt from these general experiments to
build up savings for natural hazards. These experiments are noteworthy because they demonstrate how
nudging by developing the appropriate choice architecture could help motivate people to save for self-
insurance.

Soman and Cheema (2011) in India demonstrated the importance of clear objectives for which
individuals are saving -- “earmarking” money in the sense of reserving or setting it aside for a
particular purpose. The researchers tested to see if infrastructure construction worker households,
whose “earmarked” money envelope is labeled with their children’s pictures, would save more than
participants whose earmarked envelope was not labeled with pictures. They found that the 14-week
household savings of 146 daily-wage laborers where the earmarked money envelope was labeled with
children’s pictures differed from the ones where it was not; the experiment was conducted for two
different situations, where the target savings were set at high (Rs. 80) and low (Rs. 40). In both cases,
the savings with an earmarked money envelope with children’s pictures were higher.

Dupas and Robinson (2013) in Kenya demonstrated the importance of the storage mechanism, the
earmarking process, and the social commitment in the process of saving for preventive health and
health emergencies. Individuals participating in 113 local savings circles, where the participants met
periodically and contributed equal amounts to a pot that would be taken by one of them, called
Rotating Savings and Credit Associations (ROSCA), were encouraged to save for health and divided
into five groups: two for preventive health with nudging, one for health emergencies only with
nudging, one for both with nudging, and one without nudging or a saving device. For preventive health,
they found that the average impact of earmarking was Ksh. 57.54 and that of social commitment
273.46. For health emergencies, they estimated the percentage of participants who could not afford
medical treatment for an illness in the past three months --but could afford it now -- after participating
in the earmarking process. The average impact of the earmarking process was 8% when not monitored
and 12% when monitored.

These experiments suggest that a simple savings device, such as an envelope or a storage box, may
help to nudge people to save. The savings could be increased by mentally clarifying in their cognitive
systems the purpose for which they are saving or be further increased by placing normative pressure
on the savers through social commitment. In the DRR literature, Kunreuther and Michel-Kerjan (2008)
argue that "recent disasters have provided empirical evidence that a large number of people do nothing
in advance of a disaster because they use budgeting heuristics, misperceive the risk, underestimate the

future and/or are myopic, fail to learn from past experience, and are influenced by social norms and interdependencies” (p. 60). The experiments discussed here have addressed two of these issues:

(1) Earmarking, monitored and unmonitored, to take care of budgeting heuristics by clarifying in their cognitive systems the purpose they are saving for; and (2) normative pressures on the savers through social commitment to take care of social norms and interdependencies. These experiments do not have to do with natural hazards, but there are important lessons to be learned, because they have strong significance for the effectiveness of self-insurance through savings for vulnerable populations.

11.3.7. Resilience building programs: four examples

When we consider increasing resilience to hazards by reducing the vulnerability of communities by pursuing various measures, we should ask three questions, in this order:

- Whose resilience would we like to enhance? Individuals? Communities? Cities? Or larger units?
- What can be done to increase resilience? Pursuing one or more of the four DRR elements: Information, infrastructure, institutions, and insurance.
- How can individuals, communities, or city governments be motivated to adopt the measures that fall into one of these four DRR elements?

Having discussed best practices for resilience building in detail, let us discuss four examples using the 4x4 matrix in Table 11 of the four DRR elements (information, infrastructure, institutions, and insurance) and four behavioral strategies (command-and-control, economic incentives, persuasion through information, and nudging).

1. Index-based weather insurance: Index-based weather insurance can improve drought resilience. Actions on five major fronts have been identified for such insurance:

   a. Invest in hydromet networks;
   b. Engage NGOs as social mobilizers to raise awareness;
   c. Invest in science to understand better the correlation of the index with actual crop yields;
   d. Invest in risk assessment; and
   e. Develop reinsurance markets.

In this case, the answer to the first two questions mentioned in the preceding paragraph involves talking about increasing the resilience of the farmers using the insurance approach. On the third question, engaging NGOs as social mobilizers to raise awareness would be the persuasion strategy; subsidizing the insurance premium the farmer pays would be the incentives strategy; and offering help with maps to the location where insurance can be purchased would be a nudging strategy. Improving the uptake of crop insurance by farmers is often a real challenge and the combination of a number of these strategies may need to be employed.

2. Reviving drying springs: Research suggests five different approaches for reviving dying springs:

   a. Identify recharge areas accurately;
   b. Prepare hydrogeological layout maps of the spring aquifer and recharge area;
c. Build simple artificial recharge structures (e.g., trenches);

d. Incentivize rainwater harvesting in farmers’ fields; and

e. Build local institutional arrangements to regulate demand.

In the case of resilience, we are trying to bolster the capacity of farmers through information, infrastructure, and institutions. On the third question, building local institutional arrangements to regulate demand would be the command-and-control mechanism; grants or subsidized loans for building simple recharge structures such as trenches and ponds would be an incentive method; making the maps available would be persuasion by information; and incentivizing rainwater harvesting in farmers’ fields would also be an incentive method, but it may require some nudging as well.

3. Building resilience to flash floods: Third, let us consider an example of building resilience to flash floods. A number of actions have been identified: hazard mapping, zoning policies, modern hydromet stations, information and communication technologies, local community involvement, and the national-local supportive interface. In this case, we are trying to build the resilience of the community through information, infrastructure, and institutions. On the third question, zoning policies would be the command-and-control mechanism; these policies would include road alignment and hydropower station location policies as well. Providing hazard maps would be persuasion. Community-based flood early warning systems would be a nudge.

4. Building resilience to earthquakes: A number of actions identified for the evidence-based analysis of water-related disasters may be useful for identifying geophysical hazards as well, especially in the context of earthquakes that lead to landslides, dammed rivers, and flash floods subsequent to the breaching of those dams. The actions suggested for evidence-based disaster risk assessment are:

a. Conduct risk assessment to identify the nature and magnitude of risk;

b. Assess the effectiveness of preventive investment, land use planning, and emergency actions;

c. Collect and archive hazard and damage data to develop indicators that make risk assessment evidence-based; and

d. Apply the latest science and technology to promote practical risk assessment.

Developing and enforcing land use guidelines with the aim of limiting exposure to geohazards and paying more attention to areas where major infrastructure development projects such as roads and hydropower are proposed (Shrestha et al., 2016) would be a command-and-control mechanism. Similarly, developing applicable project design standards/building codes and communicating them to the households and builders to enhance local government management for construction quality control in rural and urban areas (Molden et al., 2016; Shrestha et al., 2016) would be a combination of persuasion and command-and-control mechanisms. Both measures -- zoning and building code enforcements -- would also require nudges to motivate households and builders to follow the land use guidelines and building codes.

For pursuing these measures, evidence-based analysis could help to build a strong knowledge base. First, land use guidelines based on potential hazard maps could be updated with evidence-based hazard
maps. Second, building codes based on potential hazards could be updated with the evidence of the
damage to the buildings during the earthquake. Evidence-based analysis may also help as a nudge for
households occupying existing buildings, because they can see for themselves what could happen if
the building codes are not followed.

In a typical case, especially because of the low-probability, high-impact nature of earthquakes, there
may be a tendency for such households to procrastinate and postpone retrofitting measures for a
number of reasons. First, there may be some ambiguity about what constitutes optimal mitigation,
because households cannot see what damage would have occurred if the retrofitting measures are not
taken or the building codes not respected. Second, households may have budget constraints for
investing in protective measures. In addition, they may see it as affordable or unaffordable, based on
how they frame it -- an improvement similar to installing a leaky roof -- which might ultimately lead
a house to collapse, or similar to a leaky faucet -- which might lead to high water bills. Third, they may
also shy away from mitigation efforts because there is uncertainty as to when the next earthquake is
likely to occur. It has been found that when making choices for the distant future, we may see the
benefits clearly and decide on those, but when the time comes to pay for the benefits, we tend to focus
on costs rather than benefits -- leading to procrastination. Therefore, nudges may be necessary to
motivate households to invest in retrofitting measures and to respect building codes sincerely
(Kunreuther & Michel-Kerjan, 2008).

11.4 CONCLUSION

Mountain communities are threatened by numerous risks from natural hazards and a changing risk
pattern. DRR is particularly important in mountain areas for many reasons, including its multi-hazard
environment, land use pressure, and the effects of climate change. Floods and landslides are the most
frequently occurring natural hazards, particularly during monsoon season in the middle hill terrains
and flooding in the plains of the HKH. There is an increasing trend in the number of events reported,
people killed, and economic loss in the HKH due to natural disasters. Records of natural disasters and
related studies indicate that more women than men die when disasters strike. This is the result of
women’s lack of information, mobility, decision-making power, and access to resources and training,
as well as gender-based sociocultural norms and barriers, conventional gender responsibilities, and
high rates of male outmigration.

Assessing risk without considering the effects of climate change is no longer an option in the
mountainous areas, which are particularly sensitive to climate change. Risk-informed planning will
help to create safer land use practices and hazard-proof infrastructure and housing. In addition, cross-
border cooperation to share information and best practices is necessary for early warning systems and
other precautionary measures. Access is important in effective response. Due to their remoteness,
inaccessibility, and lack of emergency communication, the mountain communities are more
vulnerable. Thus, sustainable mountain development requires a systematic and integrated risk
management approach to avoid or reduce future losses.

Disaster risk is expressed as a probability of loss of life, injury, or destroyed or damaged assets which
could occur to a system, society, or a community in a specific period of time. Such probability can be
estimated from assessing hazards, exposure, and vulnerability. While hazards and exposure can be
estimated empirically and quantitatively using historical events, vulnerability assessment has multiple
disciplinary theories. Although it is not easy to assess the physical vulnerability in HKH quantitatively based on data, estimation is possible through the national data, such as infrastructure service quality data from the World Economic Forum as proxies. Socioeconomic vulnerability assessment should take into account multiple dimensions, such as income inequality, gender inequality, governance, and national progress for DRR in light of HFA.

Enhancing community resilience to hazards by reducing vulnerability and pursuing resilience-building measures needs a clear understanding of disaster risks, which can help policy makers to prioritize strategies that increase their population’s resilience to these events. A framework for assessing risks due to hazard events and measures to increase resilience of the communities in the HKH is necessary. The framework proposed draws upon the principles of the 1994 Yokohama Strategy and Plan of Action, the 2005 Hyogo Framework of Action, the 2015 Sendai Framework for Disaster Risk Reduction, and UNDP’s 2007 Human Development Report. It envisions a 4X4 matrix emphasizing four elements of disaster risk reduction: information, infrastructure, institutions, and insurance, against four elements for successful planning and execution: command-and-control mechanisms (e.g., zoning regulations; land use guidelines and building codes); monetary incentives (e.g., subsidies on insurance premiums); persuasion by providing information (e.g., risk maps); and nudging (e.g., early warning systems). The framework also helps to address three key questions to pursue resilience-building measures: Whose resilience would we like to enhance? What can be done to increase resilience? How can the individuals, communities, or city governments be motivated to adopt the measures that fall into one of these four categories? Ultimately, the individual or the group of beneficiaries whose resilience we are trying to enhance must select one or more of these methods of increasing resilience. Often, a combination of these methods may be appropriate; it will, of course, depend on the type of hazard event under consideration for resilience building.
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