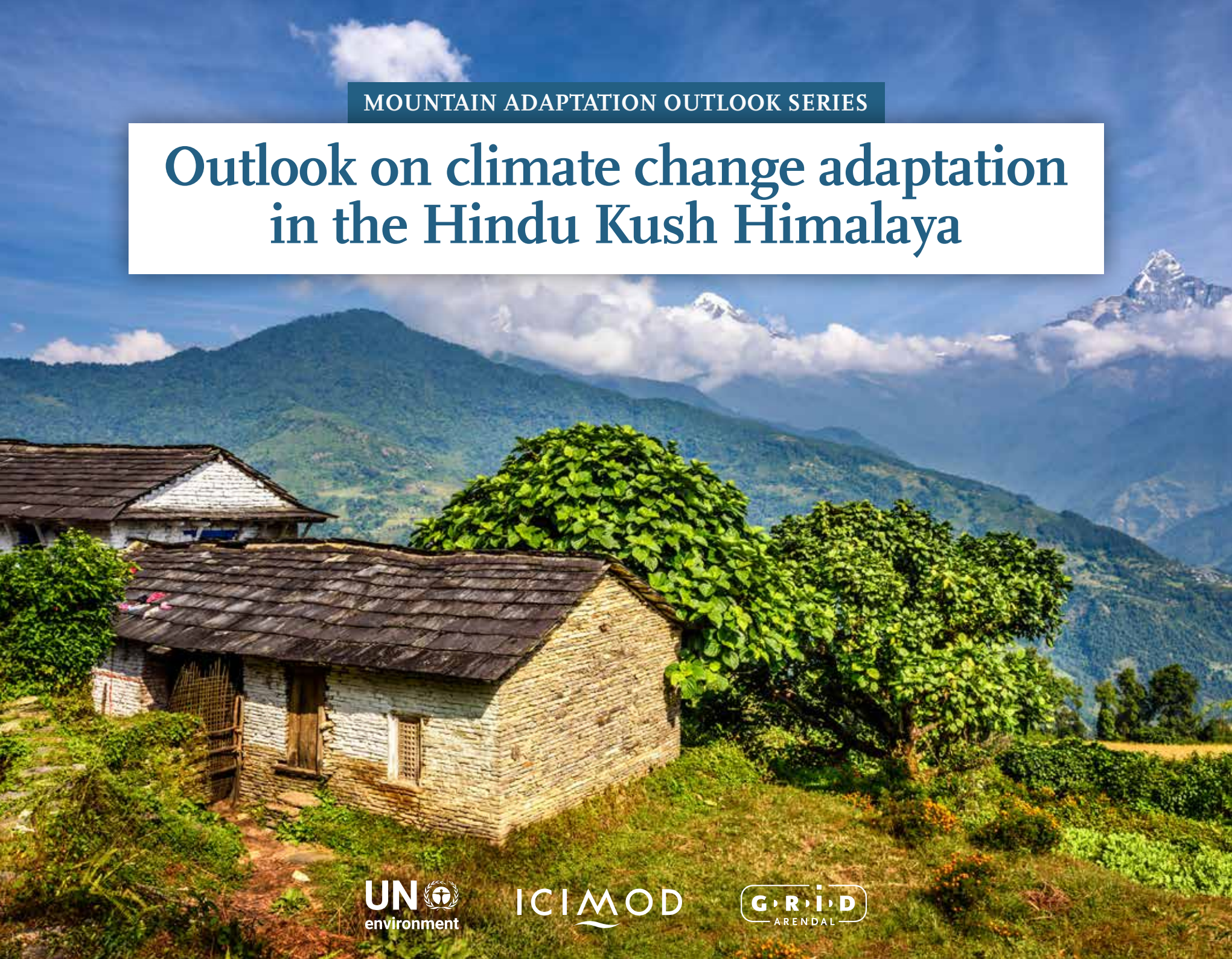
MOUNTAIN ADAPTATION OUTLOOK SERIES

Outlook on climate change adaptation in the Hindu Kush Himalaya



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DISCLAIMER
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Front cover photo:
Farm near Pokhara, Nepal

MOUNTAIN ADAPTATION OUTLOOK SERIES

Outlook on climate change adaptation in the Hindu Kush Himalaya

Aerial view of Swat Valley, Pakistan

Foreword

Mountain ecosystems enrich the lives of over half of the world's population as a source of water, energy, agriculture and other essential goods and services. Unfortunately, while the impact of climate change is accentuated at high altitude, such regions are often on the edge of decision-making, partly due to their isolation, inaccessibility and relative poverty.

That is why the United Nations Environment Programme and partners have developed a series of outlook reports about the need for urgent action to protect mountain ecosystems and to mitigate human risk from extreme events. The series includes the Western Balkans, Southern Caucasus, Central Asia, Tropical Andes, Eastern Africa, and the Carpathian Mountains.

Now, the seventh report in the series focusses on the Hindu Kush Himalaya, one of the world's most important mountain regions because of its sheer size, available water resources, and large human populations both within the mountains and downstream. This report was developed in close collaboration with the International Centre for Integrated Mountain Development (ICIMOD) and GRID-Arendal.

Each report in the series assesses the effectiveness of existing adaptation policy measures and the extent to which they apply to mountain landscapes, going on to identify critical gaps that must be addressed to meet current and future risks from climate change. As a result of a broad assessment process involving national governments and regional and international experts, the reports offer concrete recommendations for adaptation. This includes sharing regional good practices with the potential for wider replication to improve cost efficiency and adaptation capacity.

Stretching over 3500 kilometres and across eight countries (Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar and Pakistan) – the Hindu Kush Himalaya are arguably the world's most important 'water tower', being the source of ten of Asia's largest rivers as well as the largest volume of ice and snow outside of the Arctic and Antarctica. This mountainous region is home to 240 million people, and an additional 1.9 billion people depend on the services it provides. Climate change impacts are already being felt, manifested through rising temperatures and changing precipitation. The pace of change, especially at higher altitudes, is faster than the global average and the region could experience average warming of between 4–5°C by 2100. While future precipitation trends are less clear, increases in precipitation extremes are likely in the future, bringing with it increased risks of flooding and other climate-related hazards. The Himalayan countries are already amongst the most disaster-prone on Earth, evidenced by the serious flooding which hit the region in 2017 which affected millions of people.

While the world must reduce greenhouse gases to limit warming to safe levels, the reality for the Hindu Kush Himalaya is that adaptation actions across all sectors is essential now and in the coming decades. Many of the current and future challenges are of a transboundary nature, calling for increasing cooperation between the countries in the region.

We hope that this report will serve as a practical companion for local, regional and national policy makers seeking to protect fragile mountain ecosystems and the people who depend on them.

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Executive summary

The Hindu Kush Himalaya (HKH) is on the frontline of climate change. Over the past decades, there has been a strong and clear warming trend across the region. Higher altitude areas have warmed faster than lowland areas, and also faster than the global average. Most HKH glaciers are retreating and losing mass, and will continue to do so into the future. In the future, temperatures will increase by 1–2°C on average by 2050, even reaching 4–5°C in some mountainous and high-altitude areas under a high-emissions scenario. Even in a 1.5°C world, the average increase in the HKH is projected to be 1.8 ± 0.4°C. Asia as a whole is likely to see more precipitation, and the same is true for the Hindu Kush Himalaya. The monsoon season is likely to start earlier and end later, and rainfall will become more erratic within the monsoon season. While the number of extreme rainfall events are likely to decrease, the amount (i.e. intensity) of rain during such events may increase.

Both fast and slow onset climate hazards create risks for the mountain and for downstream populations and for all sectors. These are not far-off risks, but very real present-day concerns. The HKH region and its downstream areas are very familiar with extreme events, many of which cause natural disasters with very significant impacts on lives and livelihoods. The four largest floods over the period 2000–2013 in the region killed a combined total of more than 10,000 people and displaced over 50 million. Large amounts of rainfall over a short period of time will further increase the risk of floods and landslides; while the continued melting of glaciers is expected to increase the size and number of glacial lakes, translating into greater risk of glacial lake outburst floods (GLOFs).

The majority of the population is still rural, and strongly dependent on agriculture. Most is rain-fed and therefore vulnerable to changes in rainfall timing as well as frequency. This vulnerability is exacerbated by low diversification of livelihoods. Because of the socially constructed gender roles, climate change is also impacting men and women differently. With high outmigration of men in many rural areas, a significant burden is borne by the rural women who are left behind.

In the absence of adequate adaptation measures, it is expected that food production in the HKH will generally be negatively affected through delayed or early onsets of monsoon and change in its duration, higher rainfall variability, as well as increased extreme events including floods and droughts. But the impacts will likely vary across the region, both in terms of positive and negative outcomes, and to what degree these will be felt. The people that will be most affected by climate change are the poorest, those from a low caste, women, children and the elderly, as they are the most vulnerable and have the least ability to cope. Further risks exist for forest and other ecosystems, which are essential in providing ecosystem services for mountain and downstream populations.

There are also large, growing and dense human populations living in cities across the HKH. Many lack basic infrastructure and are located in areas exposed to climate-related hazards, the most significant being floods, landslides and droughts. All sorts of infrastructure, including hydropower, will be at increasing risk from climate change. While improvements in disaster risk reduction are being made, these measures often struggle to keep pace with rapid population growth, which have led to the uncontrolled expansion of many urban areas, including the development of informal settlements and slums in hazard-prone areas.

In order to prevent or minimize the damage, governments need to anticipate the effects of climate change, and take appropriate action. Adaptation takes place at all levels, including autonomous adaptation at the local level, through to the international level. The HKH countries are all involved in international cooperation on climate change and in the respective countries' Nationally Determined Contributions (NDCs), adaptation for relevant sectors are overall well addressed, apart from tourism and human health. Regional cooperation should be a priority in the region as many climate change impacts are transboundary in nature, but collaboration and support for the generation and sharing of scientific data is still limited. Cooperation between upstream and downstream communities, also across borders, is also an issue demanding more attention.

National climate change adaptation policies are in place or under development throughout the HKH, and National Adaptation Plans (NAPs) are under preparation by most of the countries, whereas the Least Developed Countries (LDCs) have established National Adaptation Programmes of Action (NAPAs). The findings from the sectoral policy analysis made visible that there are great differences to what extent the eight countries in the HKH address mountain related climate hazards and climate change adaptation for different sectors. Below is a summary of key policy responses, gaps and recommendations.

Identified gaps and recommendations

Sectoral policies

Water: Policies in the water sector are relatively advanced in terms of climate change adaptation and recognise the need to adapt to hazards such as floods, flash floods and droughts. Certain countries also specifically address certain hazards, such as GLOFs in Nepal, China, Bhutan and India; reduced snow cover in India and China; and avalanches in Nepal. However, more focus should be placed on both local and regional preventive measures when dealing with relevant hazards. Enhancing transboundary cooperation amongst countries could be a way forward. With the projected climate uncertainty and uneven spatial and temporal water availability, innovative water storage and management solutions are needed for the times of plenty, and times of scarcity.

Food and Agriculture: None of the existing food and agricultural policies explicitly offer comprehensive measures to address climate change adaptation, however certain countries do address specific hazards (e.g. Bangladesh and Pakistan have strategies addressing floods, and together with Afghanistan they address droughts, and Afghanistan also address ecosystems degradation). Current agricultural policies rarely consider the socially uneven impact of climate change specifically on women, children and the elderly. More attention must be paid to having more resilient agriculture in terms of the water availability for irrigation purposes. The quality of food with a strong focus on nutrition needs to be looked into. Furthermore, the connection between risks of climate change, farmers' practices, and policies need to be strengthened. Good practices on the ground (done autonomously) need to be further supported by appropriate research, policies, and extension services.

Forests and biodiversity: Forest and biodiversity conservation policy documents in the HKH are mainly focussed on sustainable forest management, conforming to a number of global programs and conventions such as REDD+ and the Convention on Biological Diversity (CBD), and regional cooperation for the management of protected areas. The policies, however, do not adequately address mountain relevant hazards or adaptation measures. In particular, forest fires are a rapidly emerging concern for the region, and legislation and management policies need to be strengthened to provide targeted solutions such as fire alerts. Furthermore, policies need to better consider the current and projected vegetation and species range shift due to the warming temperatures, which has the potential to adversely impact local livelihoods, ecosystem services, and human-wildlife conflicts.

Paddy cultivation in Myitkyina, Myanmar

Sundhara, Kathmandu, Nepal

Energy: Countries' policies generally aim to increase the efficiency of production and consumption, and promote a transition to low/zero-carbon energy sources (mitigation), but are less focused on adaptation. Given the current and potential future importance of hydropower in the region, policies which seek to promote hydropower development need to consider the changing hydrological regimes, extreme climate and other events such as earthquakes and need to work better across borders to share critical information regarding the above. Energy policies furthermore need to address the existing barriers for uptake through decentralized clean energy options, for example, micro-hydro, solar, wind, biomass through small businesses.

Infrastructure: The majority of the HKH countries have developed policies to regulate and guide the development of infrastructure and urban areas. However, apart from basic statements on climate-induced impacts, the policy documents offer little information about adaptation measures or goals. Policies need to ensure that any infrastructure development includes consideration of the projected risks from climate hazards, for example through the integration of vulnerability assessments and timely sharing of updated information on potential risk zones.

Human Health: The linkage between human health and climate change, and the potential impacts of mountain-relevant hazards are not considered as an adaptation priority by the HKH countries, despite the projected increase in the burden of climate-related health impacts. There is a need for targeted research and better understanding of the direct and indirect links between climate change and human health to make informed policy decisions. This includes for policies addressing the impacts of slow and sudden onset of climate and extreme events on human health. Furthermore, there is a need for

better post-disaster recovery measures to prevent the spread of diseases and reduce the vulnerabilities to trafficking and violence, especially of/towards women and children.

Tourism: The majority of the HKH countries have tourism policies and strategies in place. These policies acknowledge the negative impact of influx of tourists on mountain environments and the need for sustainable management, and some countries have begun to recognize that the impact of climate change can be a limiting factor for the sector. However, there is a gap in anticipating the potential adverse impacts of climate hazards on this sector. Furthermore, the sector needs to be better prepared for the increasing number of tourists visiting the mountains due to frequent heat waves in low lands. The policies furthermore need to have a mechanism in place to take care of tourists in times of extreme events.


Paro Taktsang, Bhutan

Cross-cutting issues

Gender: Gender discrimination is a critical issue for the HKH region, nonetheless, gender mainstreaming in policy documents is weak in the majority of countries. Gender-relevant vulnerabilities are not adequately addressed, and there is no specific strategy to address the differential impacts of climate change on women (who are disproportionally at the forefront of climate change, also due to the additional challenge of male outmigration). The participation of women in key decision-making and policy process is limited. These are key obstacles to facilitating women's safety and productivity, and for identifying them as distinct stakeholders in adaptation planning.

Indigenous communities: The specific focus on indigenous communities in climate change adaptation is almost absent in the HKH countries. Research literature, worryingly, suggest an existing social discrimination against these communities, especially in terms of access to land. Also troublingly, various HKH countries do not recognize indigenous people as indigenous, leading to difficulties in applying the UN Declaration on the Rights of Indigenous People (UNDRIP).

Transboundary cooperation

Strengthening scientific data sharing and collaboration: To get a better understanding of projected climate change impacts, the HKH countries would benefit from regional collaboration on the generation and sharing of scientific data. Climate data constraints could be addressed by developing region- and topography-specific climate models based on comprehensive local data, and by scaling up regional information to general circulation models to improve their accuracy and relevance to mountain regions.

Upstream – downstream: As many communities in the HKH depend upon the rivers in the region, there is a great potential to minimize damage from water related disaster by strengthening regional cooperation, including between upstream and downstream communities. In order to improve adaptation coordination and beneficial knowledge-sharing across communities and regions, the use of information and communications technology (ICT) solutions, including SMS-based technology, for real-time communication of early disaster warnings and more regular seasonal climate information such as updates on ongoing changes in water flow and droughts could be introduced across the HKH countries.

Background

The Hindu Kush Himalaya (HKH) is one of the most vulnerable regions in the world to the impacts of climate change. Wide-ranging threats are already impacting ecosystems and millions of people living in the region and downstream, and are also being felt across all sectors of society.

In the face of new challenges brought about by climate change and its economic, social and environmental impacts, it is crucial that HKH countries (Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan) increase their knowledge of climate change and its ongoing and projected impacts. In order to adapt to such impacts, HKH countries must also determine whether they have appropriate policies in place for ecosystems, peoples and sectors. As neighbouring countries face many common challenges, HKH countries must identify ways to adapt not only at the local and national levels, but at the international level, encouraging cooperation to strengthen their efforts and raise global awareness of shared goals in the important mountain region. While mitigating climate change remains essential if the world is to limit dangerous warming, adaptation to its effects is also needed, since many impacts are already being felt and will continue to intensify, even if the world manages to limit warming to 1.5°C or lower.

This Outlook has been developed to address some of these critical information needs. The document synthesizes and analyses climate change adaptation policies and responses in the mountainous regions of the HKH, and examines whether these address key climate change risks.

This document has been prepared by the International Centre for Integrated Mountain Development (ICIMOD), GRID-Arendal and the United Nations Environment Programme (UN Environment), involving a number of national and international experts. It is part of a global series on adaptation to climate change in mountain regions, produced in cooperation with UN Environment. The series includes outlooks for the Tropical Andes, Central Asian, South Caucasus, Carpathian, Western Balkan and East African mountain ranges.

This Outlook was created through an assessment process that followed four main steps. Chapter 1 introduces the HKH region, setting out the context and in particular, highlighting the links between its environmental and socioeconomic conditions, its vulnerability to climate change, and adaptation efforts. Chapter 2 identifies the main climate hazards, vulnerabilities of different sectors and key risks that are considered priorities to be addressed through adaptation policies. Chapter 3 outlines existing policies and strategies for climate change adaptation, while chapter 4 analyses the extent to which these measures can respond to the key risks identified (gap analysis).

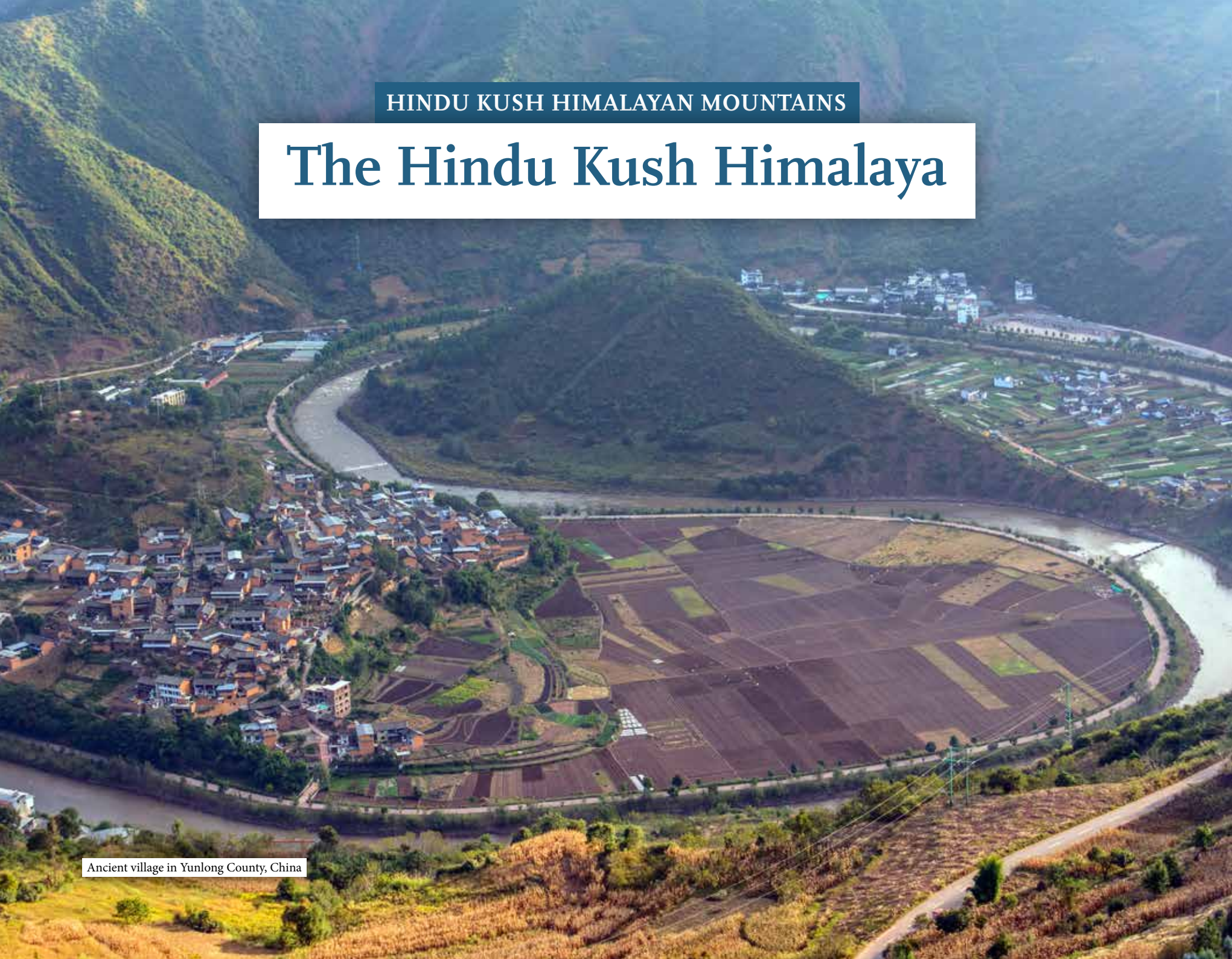
To determine key risks of climate change, the authors and contributors have followed the definitions set out in the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) (Oppenheimer et al., 2014).

Glossary

Important definitions of terms used in this report (IPCC, 2014):

Adaptation: The process of adjustment to actual or expected climate and its effects. In human systems, adaptation seeks to moderate or avoid harm or exploit beneficial opportunities. In some natural systems, human intervention may facilitate adjustment to expected climate and its effects.
Adaptive Capacity: The ability of systems, institutions, humans and other organisms to adjust to potential damage, to take advantage of opportunities, or to respond to consequences.
Exposure: The presence of people, livelihoods, species or ecosystems, environmental functions, services, and resources, infrastructure, or economic, social, or cultural assets in places and settings that could be adversely affected.
Hazard: Climate-related physical events or trends or their physical impacts.
Impacts: Effects on natural and human systems, also referred to as consequences or outcomes.
Risk: The potential for consequences where something of value is at stake and where the outcome is uncertain, recognizing the diversity of values.
Vulnerability: The propensity or predisposition to be adversely affected. Vulnerability encompasses a variety of concepts and elements including sensitivity or susceptibility to harm and lack of capacity to cope and adapt.

The Hindu Kush Himalaya



Ancient village in Yunlong County, China

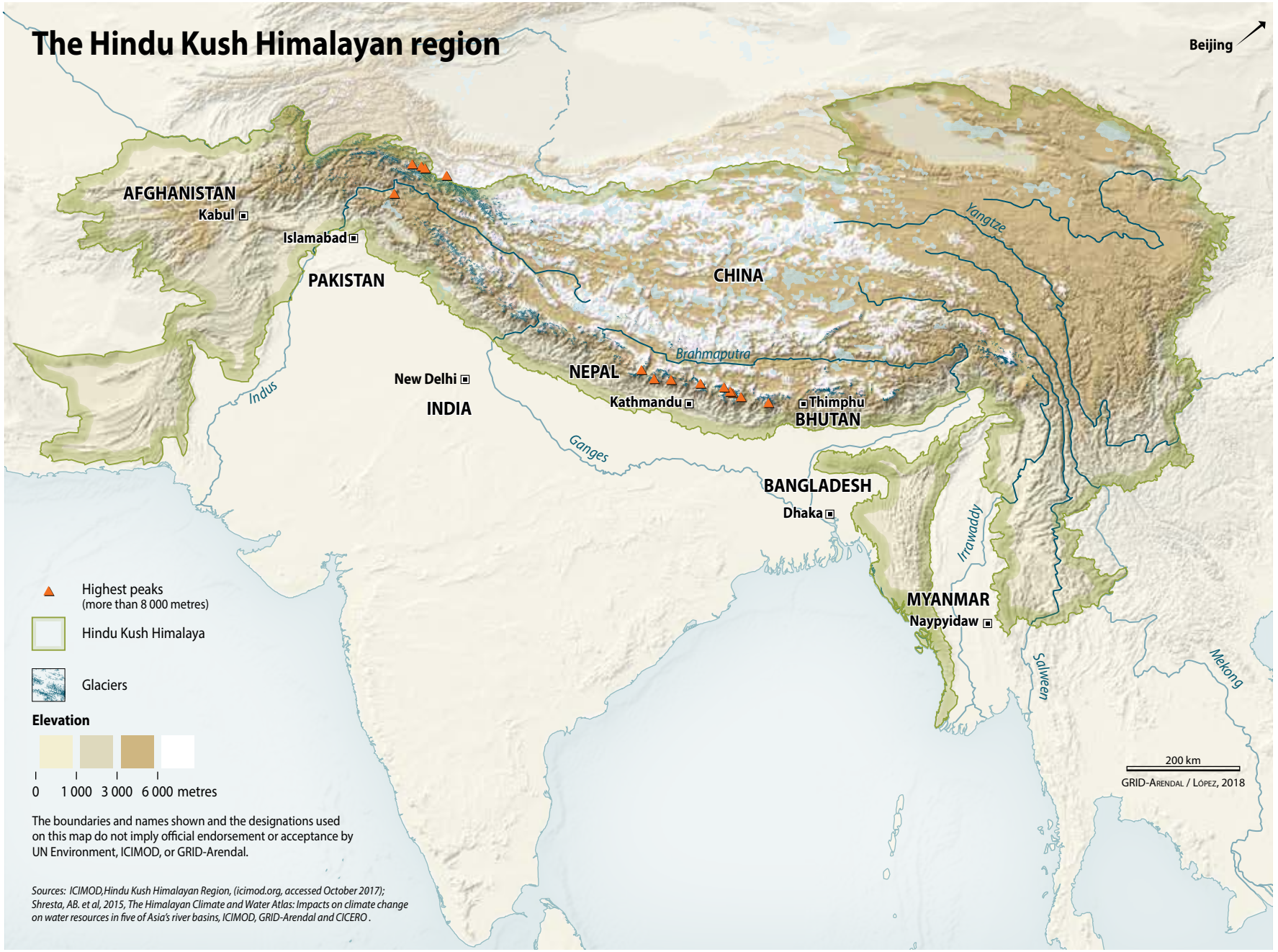
Introduction to the region

The Hindu Kush Himalaya (HKH) stretch 3,500 km across eight countries – Afghanistan, Bangladesh, Bhutan, China, India, Nepal, Myanmar and Pakistan. The rugged terrain creates different climates across the HKH region. In broader terms, the eastern Himalayas receive the majority of rainfall during the monsoon season, between June and July. Some areas – influenced by the Indian and East Asian monsoon systems – receive more than 80 per cent of annual precipitation between May and October during the pre-monsoon and monsoon seasons (Bookhagen & Burbank, 2010). In the Hindu Kush and Karakoram, located in the western HKH region, summers are drier and precipitation is more equally distributed throughout the year due to the influence of westerly and southwesterly winds (Palazzi et al., 2013; Lutz et al., 2014). Precipitation generally decreases from the east to the west. In the Himalayas, precipitation levels are higher in the south than in the north (Bookhagen & Burbank, 2010), whereas the opposite is seen in the Hindu Kush and Karakoram, where high mountains are wetter than the plains (Palazzi et al., 2013).

Karakoram range, Pakistan

Ten of Asia's largest rivers originate in these mountains: the Amu Darya, Brahmaputra (Yarlung Tsanpo), Ganges, Indus, Irrawaddy, Mekong (Lancang), Salween (Nu), Tarim (Dayan), Yangtze (Jinsha) and Yellow River (Huang He). These rivers are fed by the third largest ice and snow cover in the world after the North and South Poles, which is therefore often referred to as the "Third Pole". All countries in the region, except for Bangladesh, have glaciers, which total more than 54,000 and cover an area of approximately 60,000 km^2. The Indus, Brahmaputra and Ganges basins have the largest glacial areas, respectively. Combined, 73 per cent of glacial areas in the HKH region are within these three basins (Bajracharya and Shrestha, 2011). Contributions of glacial meltwater to river basin run-off tends to decrease from west to east, and are most important in the Upper Indus basin, where glacial meltwater comprises 41 per cent of total run-off (Lutz and Immerzeel, 2013). The average annual snow cover in the HKH region is more than 10 times larger than its glaciated area and covers roughly 760,000 km^2 or 18 per cent of its total land area (Gurung et al., 2011).

Due to the wide range of altitudes and climates over short distances, more than 60 different ecoregions are found within the HKH (Chettri et al., 2008). Below the peaks are areas that support a range of biomes, from tropical rainforests to arid steppes (Singh et al., 2011). In terms of land cover, about 14 per cent of the HKH is forest, 26 per cent agricultural land (including areas with a mixture of natural vegetation), 54 per cent rangelands and shrublands, 1 per cent water bodies, and 5 per cent permanent


The Hindu Kush Himalayan region
Beijing
AFGHANISTAN
Kabul
Islamabad
PAKISTAN
CHINA
Yangtze
Brahmaputra
NEPAL
New Delhi
INDIA
Kathmandu
Thimphu
BHUTAN
Indus
Ganges
BANGLADESH
Dhaka
Irrawaddy
MYANMAR
Naypyidaw
Salween
Mekong
Highest peaks
(more than 8 000 metres)
Hindu Kush Himalaya
Glaciers
Elevation
0 1 000 3 000 6 000 metres
200 km
GRID-Arendal / Lopez, 2018
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by UN Environment, ICIMOD, or GRID-Arendal.
Sources: ICIMOD,Hindu Kush Himalayan Region, (icimod.org, accessed October 2017); Shresta, AB. et al, 2015, The Himalayan Climate and Water Atlas: Impacts on climate change on water resources in five of Asia's river basins, ICIMOD, GRID-Arendal and CICERO .

snow cover (Singh et al., 2011). Within the HKH there are four biodiversity hotspots – Himalaya, Indo-Burma, the mountains of southwest China, and the mountains of Central Asia – covering roughly 32 per cent of the region. These hotspots are recognized as globally important due to their unique biological richness, which is currently threatened by a range of anthropogenic stressors (Chettri et al., 2008).

Rich with unique cultural, ethnic and religious diversity, the HKH is home to one sixth of all human languages (Turin, 2005). It also presents radical contrasts in the level of urbanization, from cities with millions of inhabitants, such as Kabul in Afghanistan and Kunming in China, to remote high mountain villages that are only accessible after days of trekking, including almost everything in between.

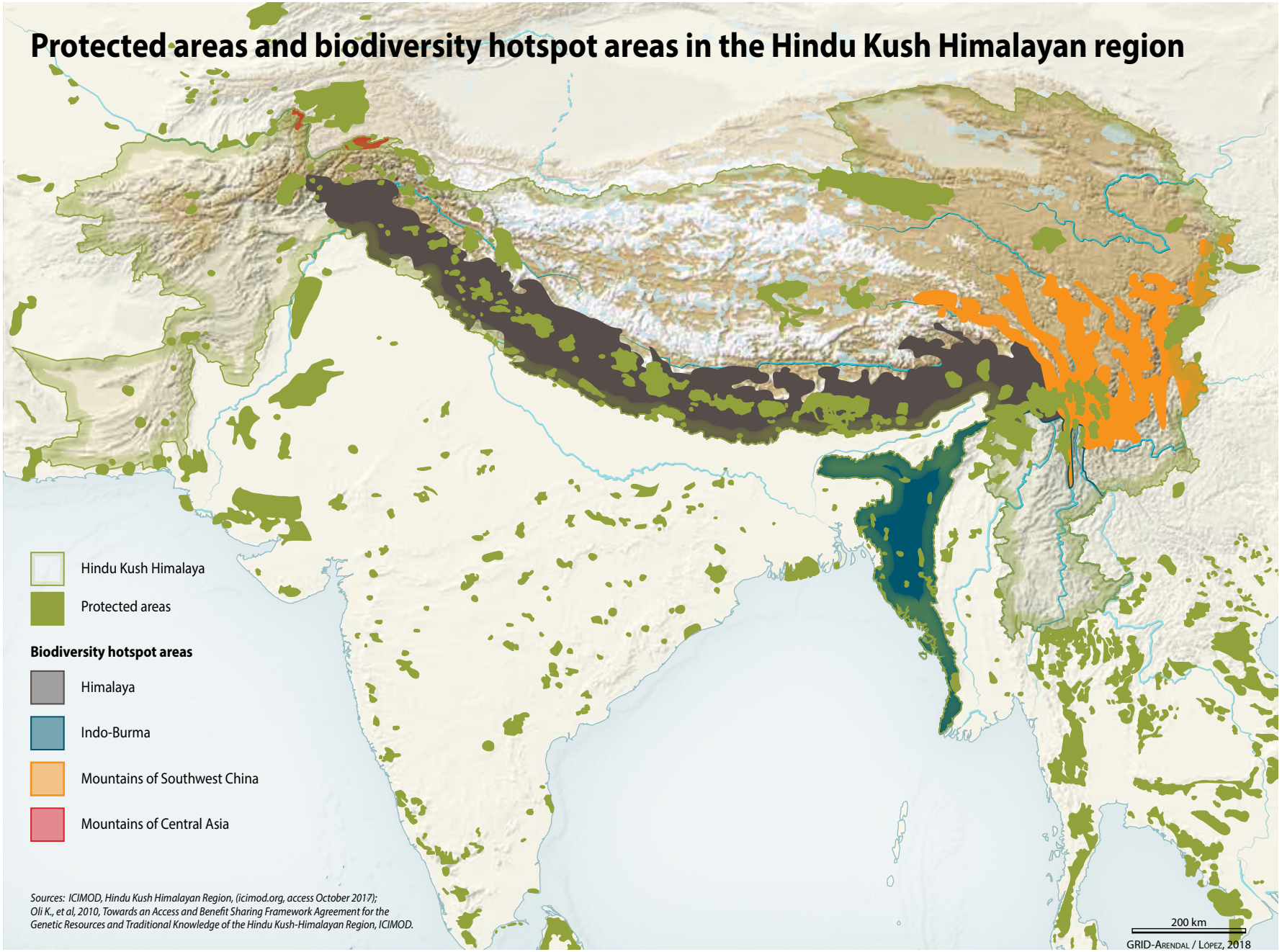
Ama Dablam mountain peak overlooking Dudh Kosi, Nepal

The water tower of the world

Water is one of the HKH region's most valuable resources. Ten of Asia's largest river systems originate in the HKH and are the main sources of freshwater in South Asia, providing drinking water for over 240 million people in the region and another 1.9 billion people living downstream (ICIMOD, 2018).

These mountains offer far more than drinking water – they are the basis of communities' livelihoods, where subsistence farming is the main way of life, which is essential to the HKH and key to Asia's food security.[1] The agriculture sector throughout the region and downstream depends on water for irrigation and ecosystem services that these rivers provide (Shrestha et al., 2015). For example, Pakistan's food security relies heavily on the Indus River, which provides water for up to 80 per cent of the country's crops (Government of Pakistan, 2010). Similarly, 60 per cent of India's irrigated area is located within the Ganges river system (NGRBA, 2011). The region's rivers are also essential for industry and hydropower (Shrestha et al., 2015; Rasul, 2014), and provide important waterways, such as in Vietnam, for example, where over 70 per cent of cargo tonnage and 27 per cent of passengers travel on the Mekong River annually (Mekong River Commission, 2018). In Central Asia, the Amu Darya River, which runs through the HKH (from the Pamir Mountains in Tajikistan), is one of Central Asia's most important rivers. The Amu Darya and Syr Darya river basins jointly provide 90 per cent of the regions' water and are home to 80 per cent of the region's population. Most of the water in the region is used for irrigation (Russell, 2018).

Protected areas and biodiversity hotspot areas in the Hindu Kush Himalayan region

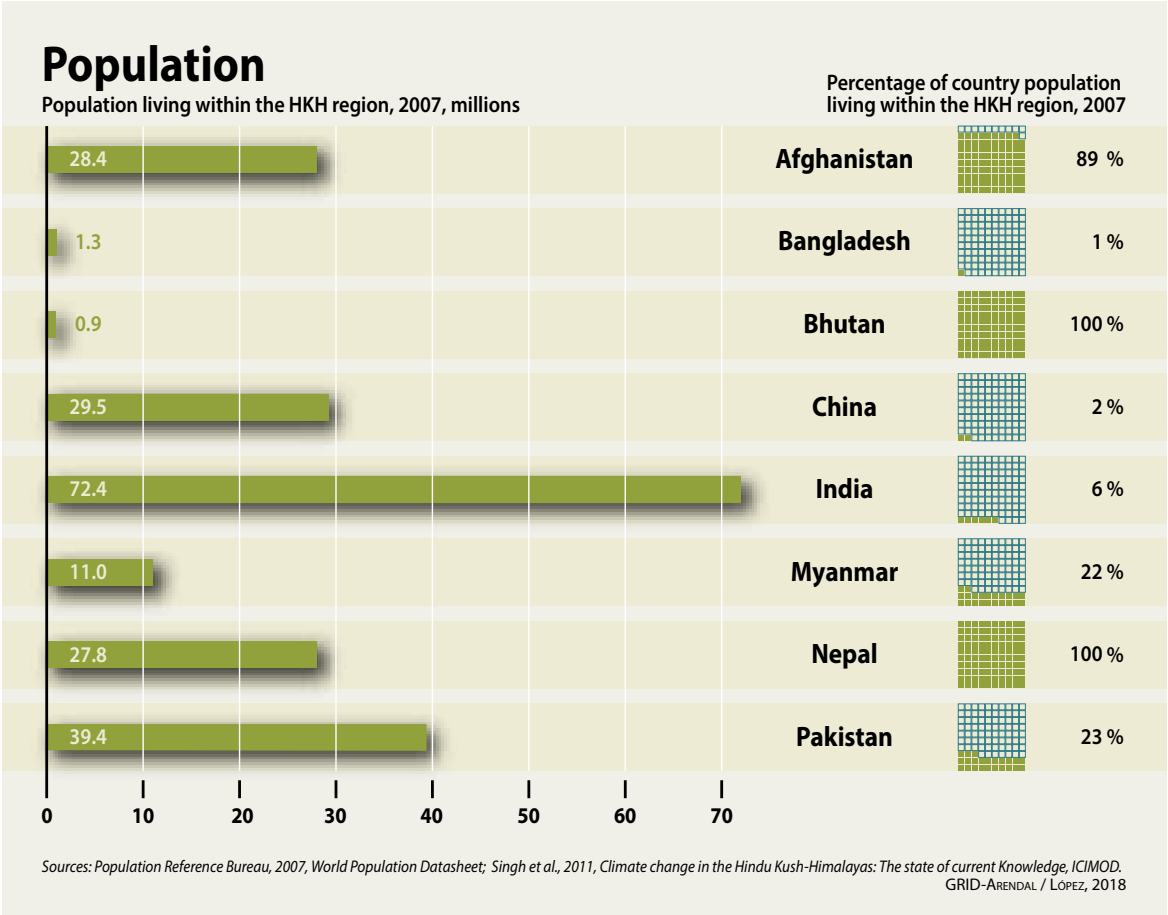


Sources: ICIMOD, Hindu Kush Himalayan Region, (icimod.org, access October 2017); Oli K., et al, 2010, Towards an Access and Benefit Sharing Framework Agreement for the Genetic Resources and Traditional Knowledge of the Hindu Kush-Himalayan Region, ICIMOD.

Underlying causes of vulnerability to climate change

In the HKH region, socioeconomic, cultural and political factors, among many others, are shaping people's vulnerability to the effects of climate change. The IPCC (2014) defines vulnerability as the propensity or predisposition to be adversely affected, which in other words, refers to people's sensitivity to adverse impacts and their capacity to cope with these.

For communities living in the HKH, access to resources and poverty are key factors contributing to their vulnerability to climate change. Poor people[2] have less funds for adaptation measures, moving them towards dangerous tipping points, such as hunger and loss of livelihoods. While some countries in the HKH are experiencing rapid economic growth, others are struggling with issues of governance and conflict which have exacerbated poverty, such as in Afghanistan, Pakistan and Myanmar. In general, poverty is most prevalent and more persistent in remote mountainous areas (Hunzai et al., 2011). One estimate suggests that although an average of 26 per cent of the population of HKH countries live below the national poverty line, the figure is 31 per cent within the borders of the HKH region (excluding China and Myanmar) (Hunzai et al., 2011). The higher poverty rates are partly the result of lower access to basic facilities, poor physical access to markets and urban centres, small and decreasing landholdings and more dependents within a household. Limited access to centres of commerce and power restricts not only economic opportunities, but also political influence (Hunzai et al., 2011). Remoteness from markets and services and inaccessibility therefore exacerbates poverty in the mountains (Jodha, 2005; Gerlitz et al., 2014) and also increases vulnerability to and costs of adapting to climate change. For example, transport costs can be prohibitive for improving and adapting infrastructure in remote mountain villages.



Sources: Population Reference Bureau, 2007, World Population Datasheet; Singh et al., 2011, Climate change in the Hindu Kush-Himalayas: The state of current Knowledge, ICIMOD.
GRID-Arendal / López, 2018

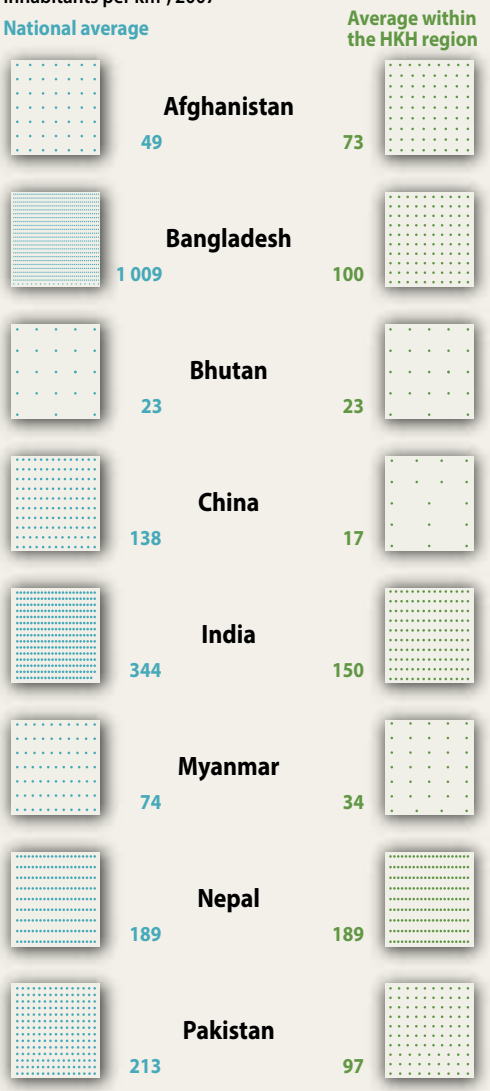
Although mountainous areas tend to be poorer than lowland areas, there are some exceptions. For example, in India, within the Indian Himalayan region[3] the average proportion of the population living below the poverty line is lower than the national average (Hunzai et al., 2011).

Widespread poverty in the HKH directly impacts people, both in terms of producing and acquiring food, and is a major factor contributing to food insecurity (Kurvits et al., 2014). For the majority of HKH mountain communities, subsistence farming is

Tibet Autonomous Region, China

Population density

Inhabitants per km², 2007



Sources: Population Reference Bureau, 2007, World Population Datasheet; The World Bank, 2018, World Development Indicators; Ealem S. and Pal I., 2015, Mapping the vulnerability hotspots over Hidu-Kush Himalaya region to flooding disasters, Weather and Climate Extremes, Vol. 8, pp. 46-58.

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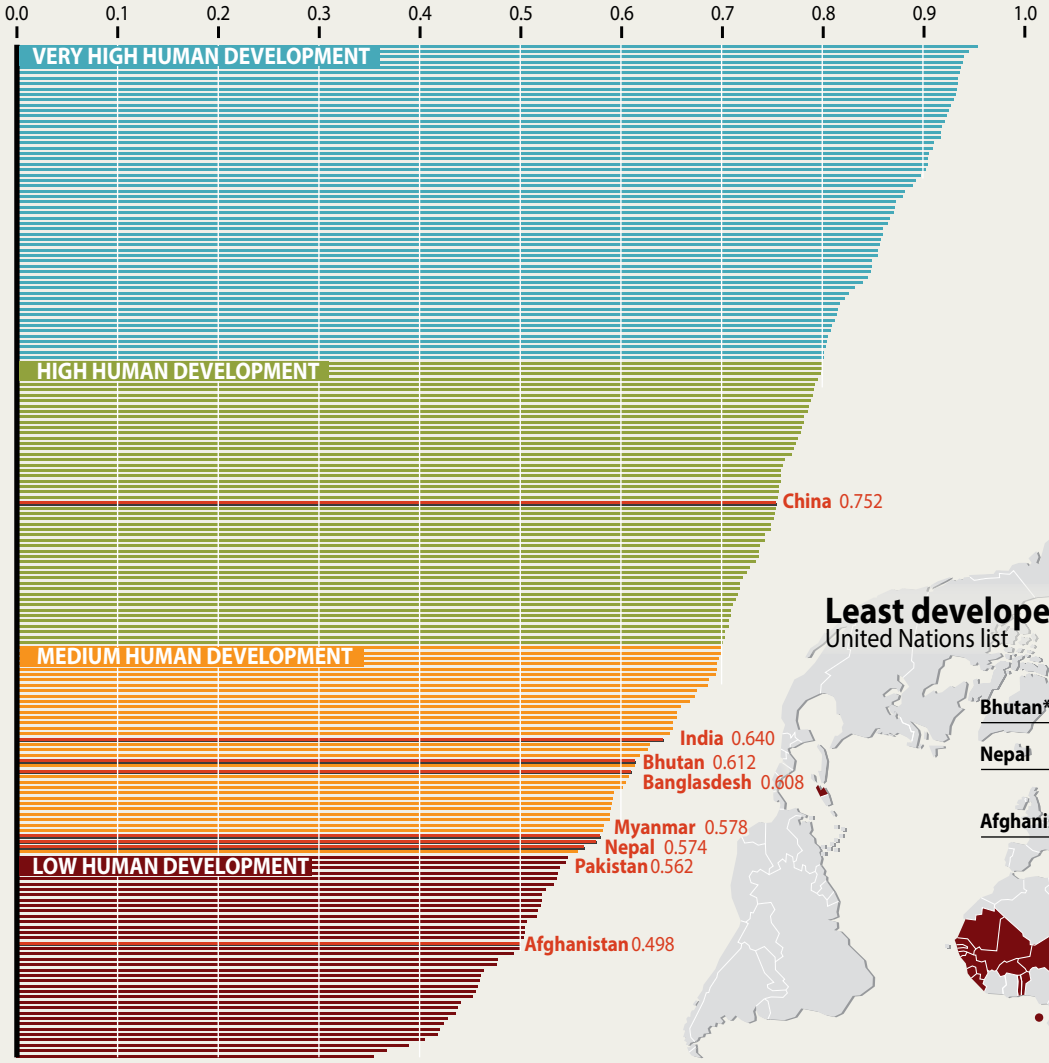
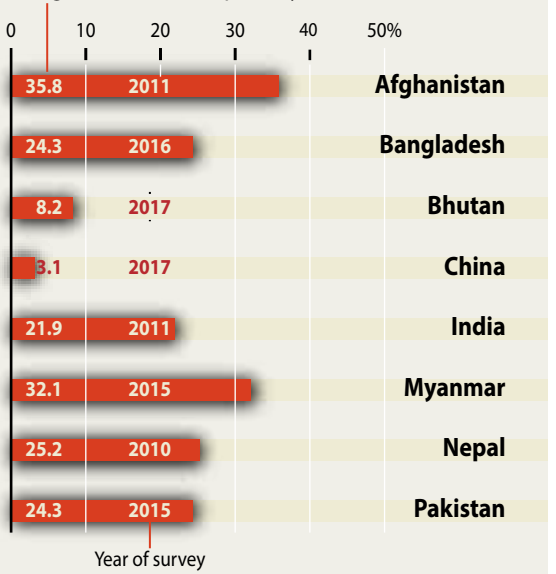
Socioeconomic indicators

Human Development Index



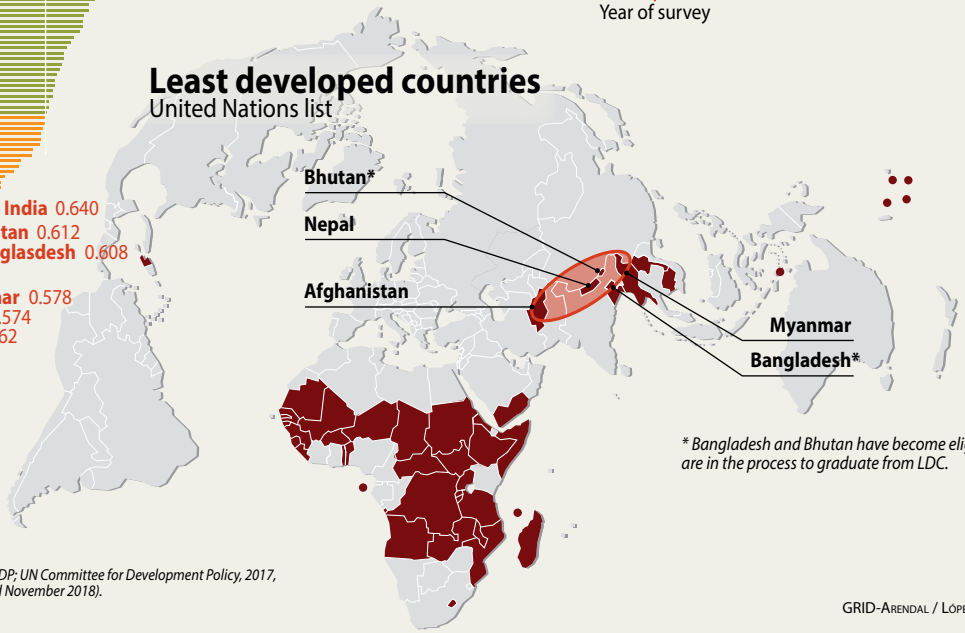
Poverty rate

Percentage of population
living below national poverty line



Least developed countries

United Nations list



** Bangladesh and Bhutan have become eligible and are in the process to graduate from LDC.*

Sources: UN Development Programme, 2018, Human Development Indices and Indicators 2018 Statistical Update, UNDP; UN Committee for Development Policy, 2017, List of Least Developed Countries (un.org, accessed April 2018); World Bank, Data Bank, (data.worldbank.org, accessed November 2018).

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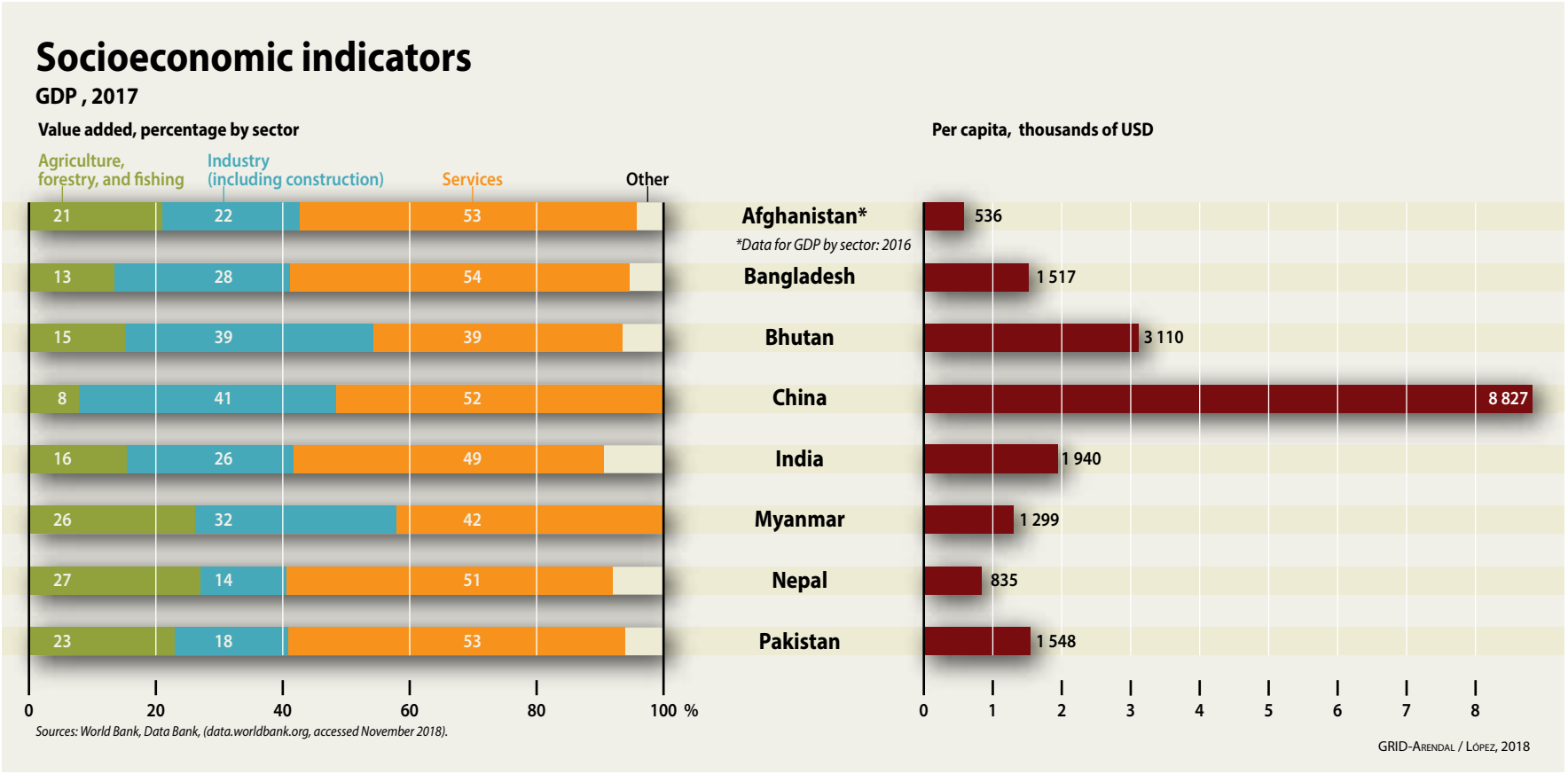
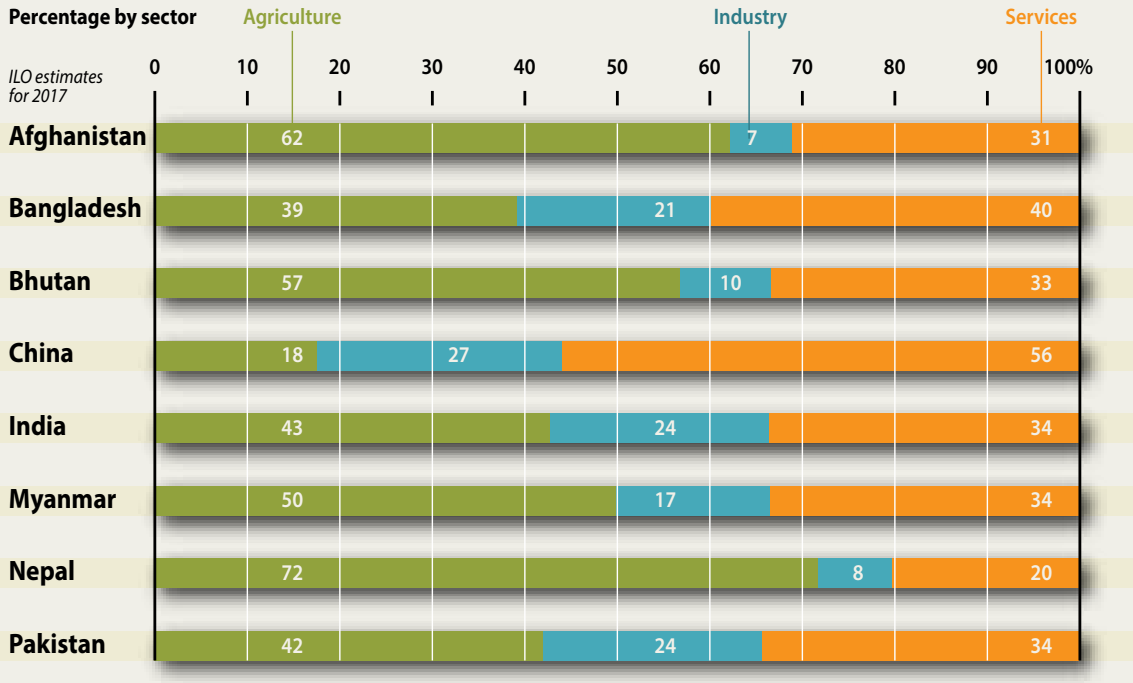


the main source of food and livelihood income (Rasul and Hussain, 2015). Typically, households have a small plot of land between 0.23 hectares and 0.83 hectares, where they grow a small variety of staple crops (Kurvits et al., 2014). Landholdings in mountainous areas are generally smaller than in the plains and more fragmented, making cultivation more time-consuming and labour intensive (Hunzai et al., 2011). Issues such as population growth and land degradation have caused average landholdings to decrease in some areas, including Nepal (Deshar, 2013), where the average size of landholdings reduced by almost 19 per cent from 2001 to 2011 (CBS, 2014). There are also differences between the average size of landholdings belonging to female-headed and male-headed households, with females tending to have smaller plots (CBS, 2014). Tough conditions across the HKH means that the agricultural productivity of mountain communities is generally low (Kurvits et al., 2014).

While substantial gains have been made in reducing undernourishment, with the number of people undernourished in the eight HKH countries decreasing from 598 million (1990–1992) to 414 million (2014–2016), the region is still the most food insecure in the world in absolute numbers. Just over half (52 per cent) of the world's undernourished live in the eight HKH countries. Mountain communities are especially vulnerable to food and nutrition insecurity due to harsh climates, rough and slope terrains, poor soils, short growing seasons and low temperatures. According to a study carried out by the Food and Agricultural Organization of the United Nations (FAO) in 2015, the proportion of food insecure people in developing countries worldwide was approximately 13 per cent, while for mountain populations it was

Employment



Source: International Labour Organization, (ilo.org, accessed November, 2018)

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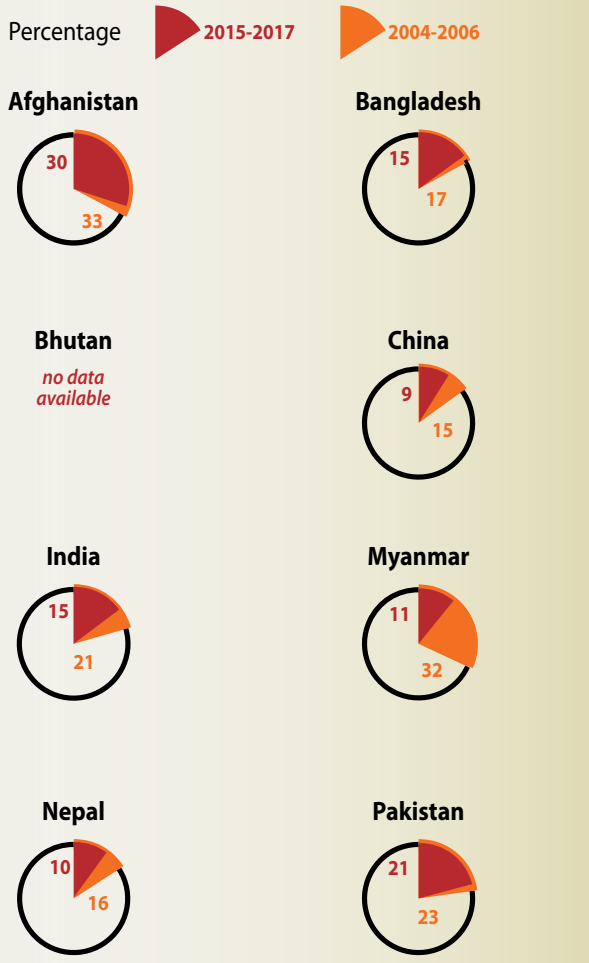
Food and nutrition insecurity

Prevalence of undernourishment



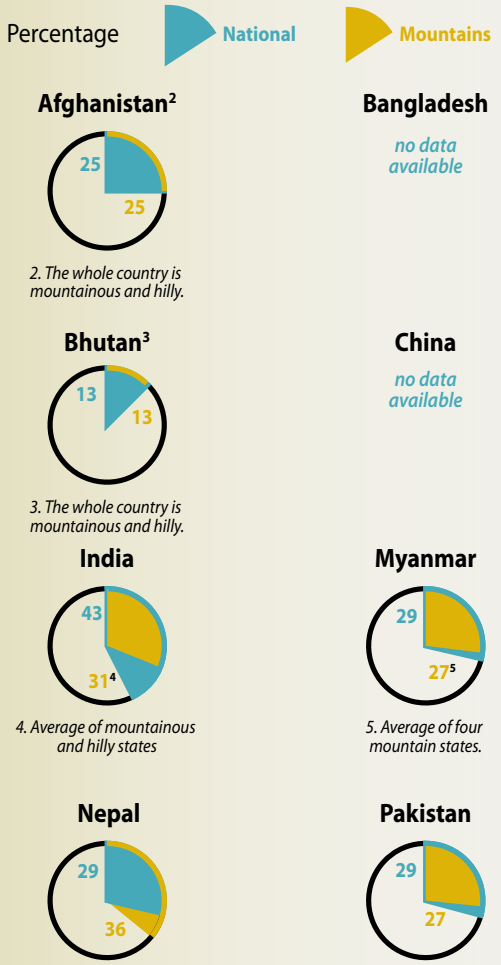
Sources: FAO, IFAD, UNICEF, WFP and WHO, 2018, The State of Food Security and Nutrition in the World 2018, FAO; Rasul G. et al., 2017, Food and Nutrition Security in the Hindu Kush-Himalayan Region, Journal of the Science of Food and Agriculture.

39 per cent. Within the HKH region, one third to a half of children (<5 years of age) suffer from stunting. In some mountainous areas, such as the Meghalaya state in India, the western mountains and far-western hills of Nepal, Balochistan province in Pakistan, eastern Afghanistan and Chin state in Myanmar, stunting and wasting in children is particularly high, and they are often also underweight (Rasul et al., 2017).

Food security is closely linked to climate change, with the IPCC Fifth Assessment Report noting that climate change will potentially affect all aspects of food security (food availability, food accessibility, food utilization and food systems stability) (Porter et al., 2014). Climate change and extreme weather events, such as floods and droughts, are projected to adversely impact food security in mountain regions, including the HKH (see chapter 2 for more details), meaning that those who are already food insecure, including poor rural communities, marginal groups and the urban poor, are likely to suffer the most.

Prevalence of underweight children under 5 years[1]

1. Weight-for-age: children under 5 years < -2 standard deviation from the international reference median value.



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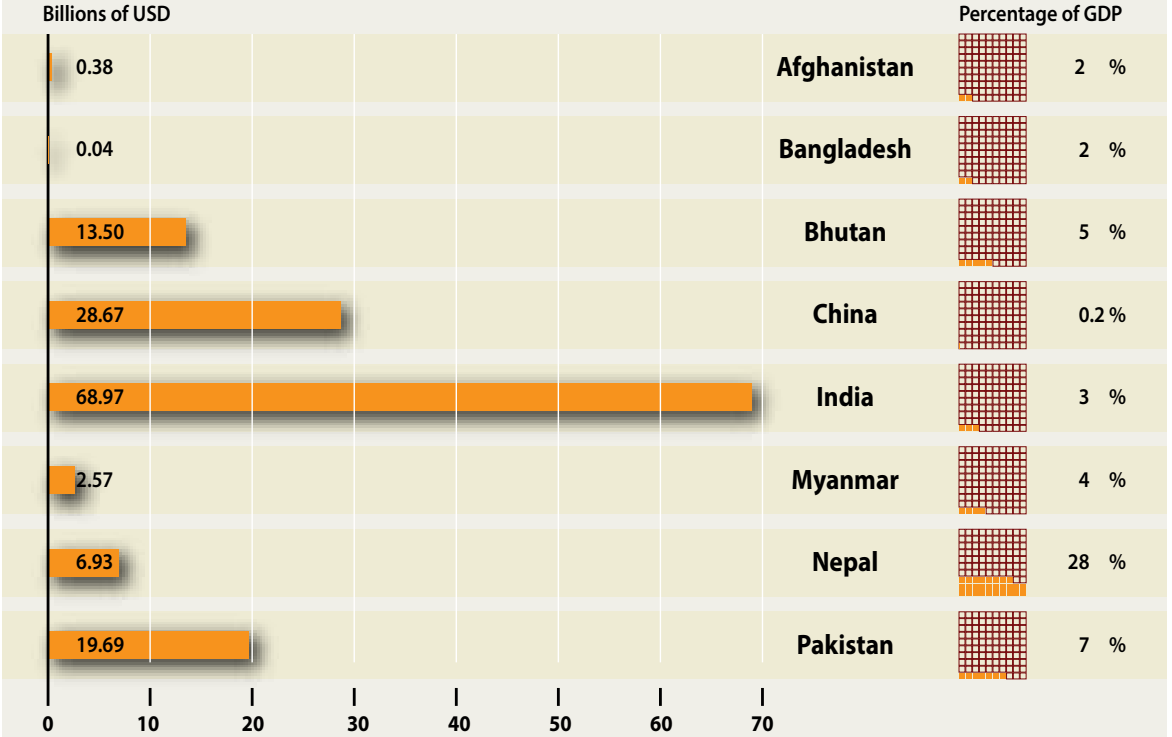
Personal remittances received, 2017



Source: World Bank, Data Bank, (data.worldbank.org, accessed November 2018)

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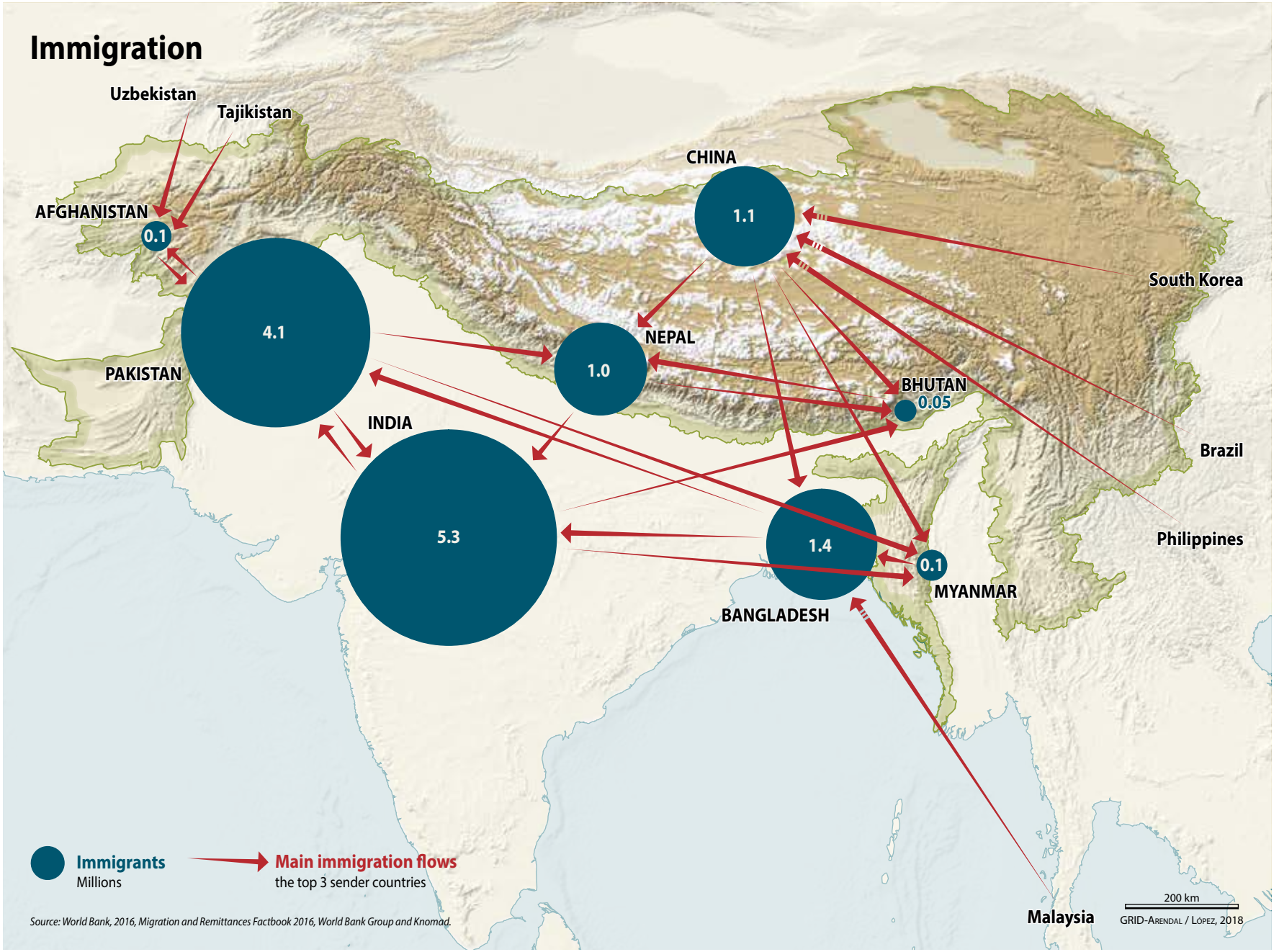
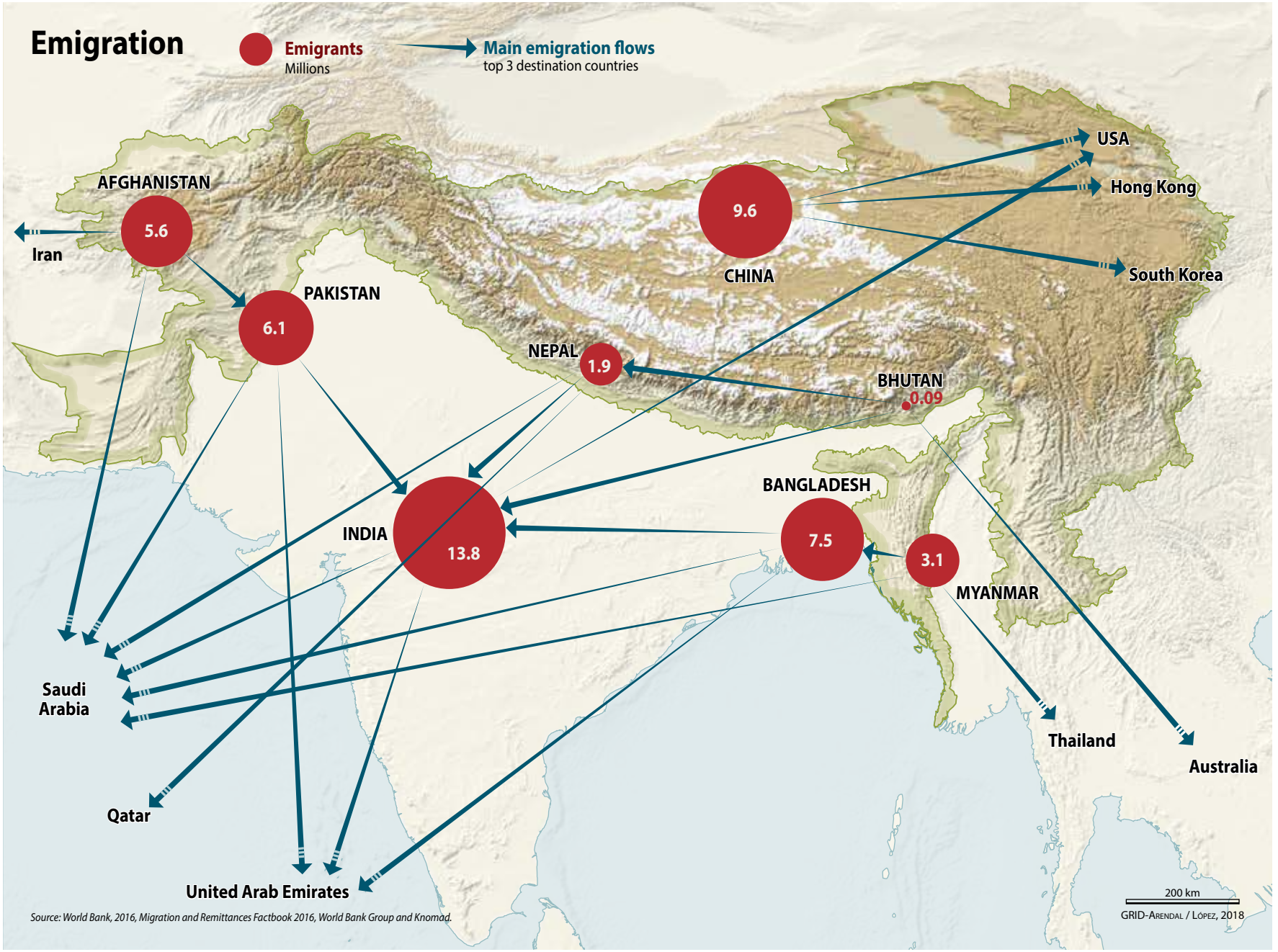
Many individuals from mountainous areas of the HKH have migrated to urban centres and across national borders in order to work and support their households for reasons including low agricultural productivity, limited land, high unemployment levels, population growth and changing aspirations (Hoermann and Kollmair, 2009a; Tiwari and Joshi, 2015). Labour migration provides both opportunities and challenges. Among labour migration opportunities are remittances, which can help households out of poverty (as seen in Nepal, where remittances helped alleviate 20 per cent of the poverty rate between 1995 and 2004 (Lokshin et al., 2007)), support for education and improved health of migrant households. In addition, labour migrants are able to develop new skills and ideas, and gender equality is generally improved in their households (Hoermann and Kollmair 2009a). Although nearly all migrants have been men, this balance is now slowly shifting, with more women migrating in some HKH countries (Hoermann and Kollmair, 2009b). Women who remain behind are


Immigration
Uzbekistan
Tajikistan
AFGHANISTAN
0.1
4.1
PAKISTAN
INDIA
5.3
CHINA
1.1
NEPAL
1.0
BHUTAN
0.05
South Korea
Brazil
Philippines
1.4
0.1
MYANMAR
BANGLADESH
Malaysia
Immigrants
Millions
Main immigration flows
the top 3 sender countries
Source: World Bank, 2016, Migration and Remittances Factbook 2016, World Bank Group and Knomad.
200 km
GRID-Arendal / López, 2018


Emigration
Emigrants
Millions
Main emigration flows
top 3 destination countries
AFGHANISTAN
5.6
Iran
PAKISTAN
6.1
CHINA
9.6
USA
Hong Kong
South Korea
NEPAL
1.9
BHUTAN
0.09
INDIA
13.8
BANGLADESH
7.5
3.1
MYANMAR
Saudi Arabia
Qatar
United Arab Emirates
Thailand
Australia
200 km
GRID-Arendal / Lopez, 2018
Source: World Bank, 2016, Migration and Remittances Factbook 2016, World Bank Group and Knomad.

Shop owner in Rangamati, Bangladesh

not without opportunity, since male outmigration can, for example, increase their decision-making power, though they may also face some challenges, such as a higher workload and drudgery (Banerjee et al., 2011; Pradhan et al., 2012).

Currently, there are approximately 240 million people living in the HKH region and 3.14 billion people living in the eight HKH countries overall (ICIMOD, 2018). The average population growth rate for these countries is about 1.33 per cent per year (World Bank, 2018). Urbanization is also increasing at a steady pace in the region, with the urban population expected to increase from an estimated 1.35 billion in 2015 to 2.2 billion by 2050 (UNDESA, 2014). Given the timescale of climate change, planning for adaptation must consider population growth and urbanization trends and projection, among other demographic factors. Consideration must also be given to ecosystem services threatened by climate change in the region, as demographic changes are likely to increase their demand among populations.

HINDU KUSH HIMALAYAN MOUNTAINS

Climate trends, scenarios and key risks for sectors

Darjeeling, India

Trends and scenarios

Observed changes in climate

The sheer size, diverse topography and varying climate of the Hindu Kush Himalaya (HKH), coupled with a lack of long-term meteorological data from high-altitude areas makes it challenging to collect and analyse data on climate change in the region. Scientists therefore advise that their data be used with caution, underlying that specific figures should only be used as an indicator of increasing or decreasing trends.

Temperature

A growing body of literature confirms that the HKH region is becoming warmer overall and that high-altitude areas are warming significantly faster than the global average (You et al., 2017). However, warming rates differ and vary throughout the region, notably between subregions, seasons and high and low altitudes.

According to Shrestha (2008), the western and eastern Himalayas and plains of the Ganges basin are experiencing lower rates of warming, while the central Himalayas and the Tibetan Plateau are experiencing higher rates, which have been higher in recent decades compared with rates for the twentieth century (Diodato et al., 2011). These findings are in line with a synthesis produced by Gautam et al. (2013), which reviews available studies on climate change in the region. In general, it has been observed that warming is occurring at a more increased rate in the region's higher altitudes than in lower altitude areas (Sharma and Tsering, 2009; Shrestha, 2008; Shrestha and Aryal, 2011).

While data on annual temperature show that warming is consistent throughout the region,

Cryosphere research on a glacier in Langtang, Nepal

Floods in Uttarkashi, India

changes in seasonal temperatures vary within the region (Kulkarni et al., 2013), as does the warming rate between seasons (Gautam et al., 2013). In large parts of the region, and especially in the central Himalayas (the Chinese northwest, Indian and Nepalese Himalayas), winter months have seen a higher warming rate than other seasons (Bhutiyani et al., 2007; Bhutiyani et al., 2010; Shrestha et al., 1999; Shrestha and Devkota, 2010; Shrestha et al., 2012).

Shrestha et al. (2015a) have studied observed and future impacts of climate change in five of the region's major river basins, namely the Brahmaputra, Ganges, Indus, Mekong and Salween basins. They found that in southern HKH areas, minimum temperatures have increased during winter months (December, January and February), whereas higher altitude areas in northern HKH areas have experienced colder winters as minimum temperatures have sharply decreased. Some of these areas have also experienced higher maximum temperatures, indicating that seasonal extremes are increasing, which has been identified as a trend across the region in various reports (Gautam et al., 2013).

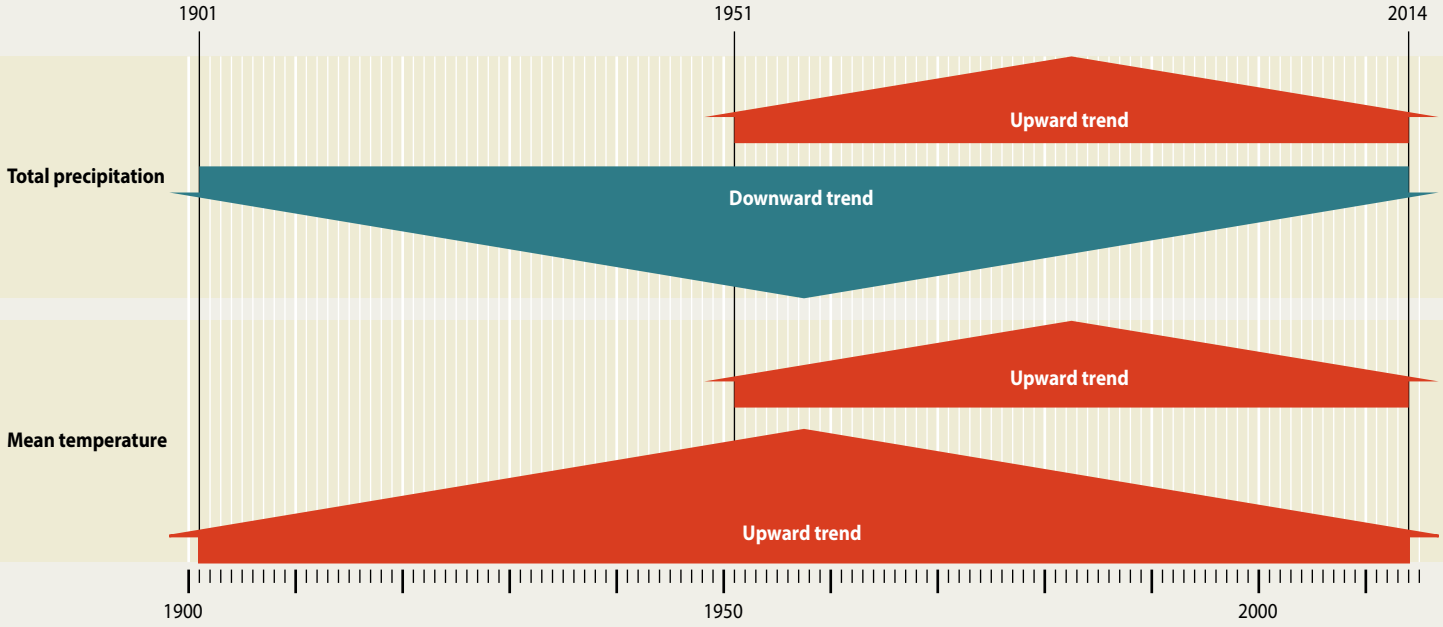
Precipitation

While there is a clear warming trend across the HKH, there has been no consistent long-term trend for precipitation levels since the second half of the twentieth century, as some areas have become drier, while others have become wetter (Singh et al., 2011; Gautam et al., 2013; Shrestha et al., 2015a). The task of identifying which regions have become wetter or drier is further complicated by the different geographic scales through which the studies are conducted. The table below identifies a number of studies from specific subregions, basins and countries, and their conclusions.

Geographic region	Precipitation trend
Northwestern Himalayas	Decreasing monsoon and annual precipitation (Bhutiyani et al., 2010)
Western (Indian) Himalayas	Decreasing but inconsistent winter precipitation (Dimri and Dash, 2012; Guhathakurta and Rajeevan, 2008)
Upper Indus Basin	Increasing annual, winter and summer precipitation (Archer and Fowler, 2004)
Koshi River Basin	Increasing annual precipitation (Shrestha et al., 2016)
Eastern Himalayas	No significant difference in precipitation (Shrestha and Devkota, 2010)
Nepal (whole country)	Mostly insignificant changes; significant increase in pre-monsoon and monsoon precipitation for a few districts; significant increase in winter and post-monsoon precipitation for only a few districts; significant decrease in pre-monsoon precipitation for only one district (DHM, 2017)
Chinese Himalayas	Increasing annual precipitation (You et al., 2007; Xu et al., 2008; Wu et al., 2007; Qin et al., 2010)

Observed climate changes over the HKH

Mean climates



Source: Ren and Shrestha, 2017. Data summarized from Ren et al., 2017; Sun et al., 2017; Zhan et al., 2017

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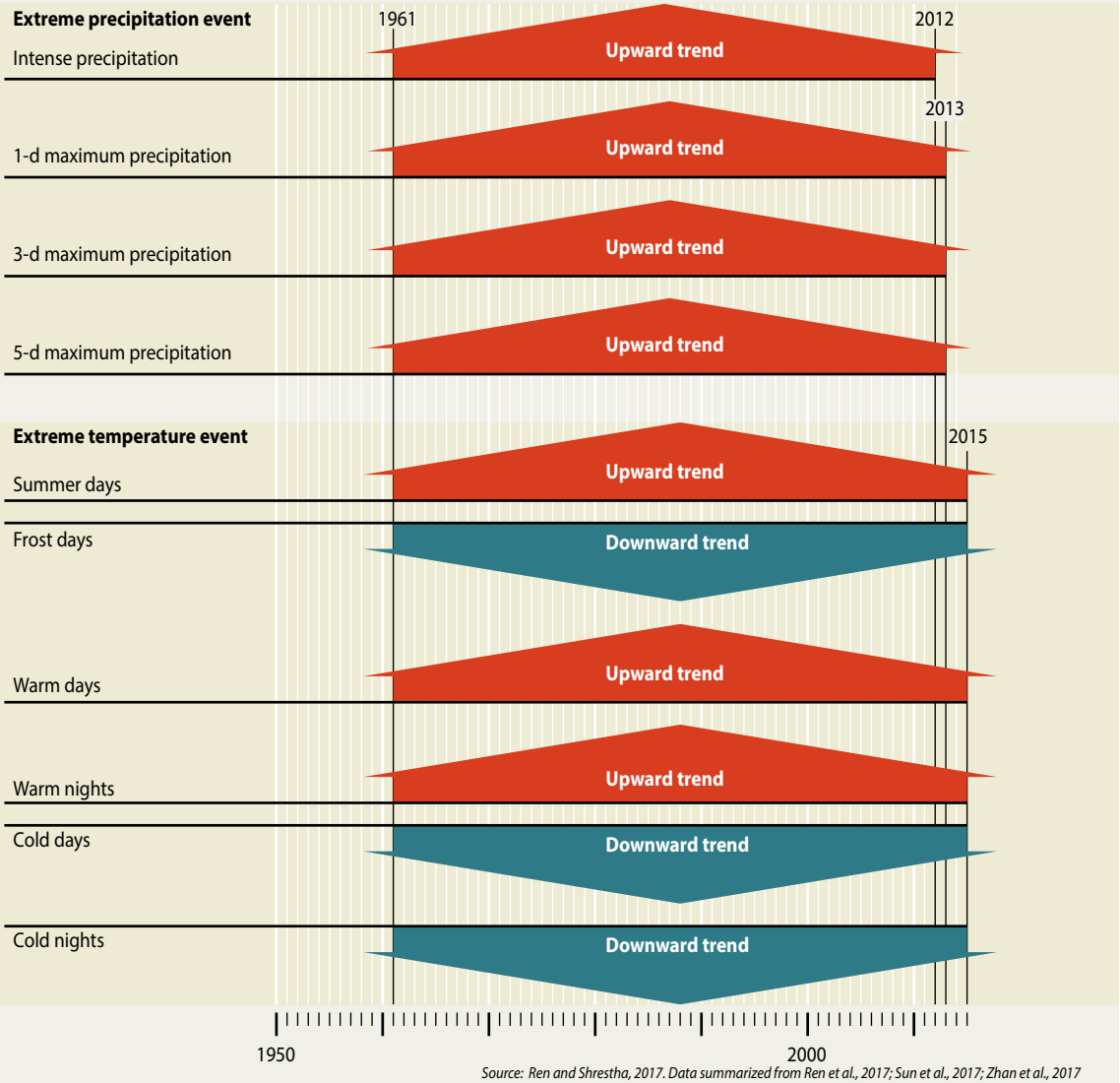
East Chulu Himalayan Peak shrouded in monsoon clouds

Few studies cover the whole HKH region, but a recent regional study (Shrestha et al., 2015a) found some interesting trends across the region: areas along the high mountain belt of the eastern Himalayas in particular have seen monsoon precipitation increase, whereas for other areas the opposite is true, such as those south of the Ganges and Indus basins which have had the greatest decline in monsoon precipitation. The winters of most central and southern areas in the HKH region have been wetter, while northern areas have been drier. Extreme precipitation events have decreased in number, though the amount of precipitation for each extreme event has seemed to increase, especially in the western part of the HKH.

Observed climate changes over the HKH

Extreme climates



Source: Ren and Shrestha, 2017. Data summarized from Ren et al., 2017; Sun et al., 2017; Zhan et al., 2017

GRID-Arendal / López, 2018

Predicted changes

Temperature

Despite difficulties in making predictions for the HKH region due to its complex topography, the general consensus is that the region's observed warming trend will continue throughout the twenty-first century. Regional studies also confirm rising temperatures, greater warming rates at higher altitude areas, and greater warming rates during winter months.

According to the Fifth Assessment Report of the United Nations Intergovernmental Panel on Climate Change (IPCC) (2014), Asia will become warmer during this century. While the report does not look specifically at the HKH region, it suggests that the annual average temperature will increase by 2.1°C in South Asia and 2.6°C on the Tibetan Plateau by 2100. The report also finds that winter months will have a slightly higher warming rate than summer months (Christensen et al., 2013).

Kulkarni et al. (2013) found that the entire HKH region will become gradually warmer by the end of the twenty-first century. When compared with the baseline (1961–1990), the annual average temperature is projected to increase by 1–2°C in the near future (2011–2040), by 1–3°C by the middle of the century (2041–2070) and by 3–5°C by the end of the century (2071–2100). The western Himalayas will likely experience the highest increase in temperatures compared with the central and eastern Himalayas.

Shrestha et al. (2015a) found that across the five of the region's major river basins (Brahmaputra, Ganges, Indus, Mekong and Salween), temperatures will increase by 1–2°C on average by 2050 compared with the baseline (1961–1990). However, mountainous and high-altitude areas are likely to experience even greater warming rates over the same time

period, reaching 4–5°C in some places. As current observations indicate, winters will likely see greater warming rates than summer months in most regions.

Similarly, Wu et al. (2017) analysed the entire HKH region and projected that it will warm significantly under two climate scenarios (Representative Concentration Pathways (RCP) 4.5 and 8.5), with the greatest warming – up to 5°C – occurring under the RCP 8.5 scenario. Geographically, the Tibetan Plateau is predicted to warm the most. Compared with the baseline (1975–2005), warming was projected to be greater towards the latter part of the twenty-first century (2066–2095).

Other studies that have looked specifically at HKH subregions have found similar results (see Rangwala et al., 2013; Panday et al., 2014; Ali et al., 2015).

Precipitation

Asia is likely to see a slight increase in precipitation during this century according to the IPCC Fifth Assessment Report (IPCC, 2014). By 2065, South Asia and the Tibetan Plateau are predicted to have an increase in annual precipitation of 7 per cent, and by 2100, 10 per cent and 9 per cent respectively (Christensen et al., 2013).

Regional studies also find that precipitation will increase towards the end of the twenty-first century, though some areas will also experience less precipitation. Shrestha et al. (2015a) projects an increase in annual precipitation of 5 per cent by 2050 compared with the baseline (1961–1990) across upper parts of five of the major river basins of the HKH (Brahmaputra, Ganges, Indus, Mekong and Salween), while some areas will see an increase of as much as 25 per cent. The monsoon season is likely to start earlier and end later and precipitation will become more erratic throughout the season by 2050. In the Brahmaputra and Ganges river basins, monsoon precipitation is predicted to increase by roughly 10 per cent and 15 per cent respectively. The study also projects that winter precipitation will increase in the Upper Salween and Mekong basins, while some areas within the Brahmaputra, Ganges and Indus basins will have between 5 per cent and 25 per cent less precipitation during the same period.

Palazzi et al. (2013) modelled the evolution of seasonal precipitations in the HKH region following RCP 4.5 and RCP 8.5 scenarios. Under the RCP 8.5 scenario, summer precipitation (June–September) are projected to increase towards 2100, while under RCP 4.5, an increase is predicted until around 2050, with a slight decline expected towards the end of the century.

Kulkarni et al. (2013) assessed changes in summer monsoon (June–September) precipitation across the western, central and eastern Himalayas and has predicted that the entire HKH region will become wetter towards the end of the century. However, this change will be most prominent in the central and eastern Himalayas, where precipitation may increase by 20–40 per cent by 2071–2100 compared with the baseline (1961–1990). A study by Panday et al. (2014) also projects increases in precipitation extremes over the eastern HKH region towards the end of the century. A subregional study of the eastern Himalayas predicts that while summer precipitation is expected to increase, warmer temperatures will result in more water being lost from the atmosphere due to evapotranspiration, thus causing drier and hotter summers. The same study also projects milder and wetter winters in the eastern Himalayas (Tsering et al., 2010)

According to Shrestha et al. (2015a), extreme precipitation events are likely to decrease towards 2050, though the amount of rain during such events may increase.

Impacts of climate change on key sectors and associated risks

As demonstrated in the previous section, the effects of climate change can already be seen throughout the HKH region. These changes are manifesting themselves through severe natural events often with destructive consequences (i.e. rapid and slow onset disasters) and are also having transformative effects on climatic processes that regulate and influence ecosystem services, agricultural outputs and water availability, among others. This section further explores these impacts on several key sectors for the HKH, as well as any current and future risks they may face.

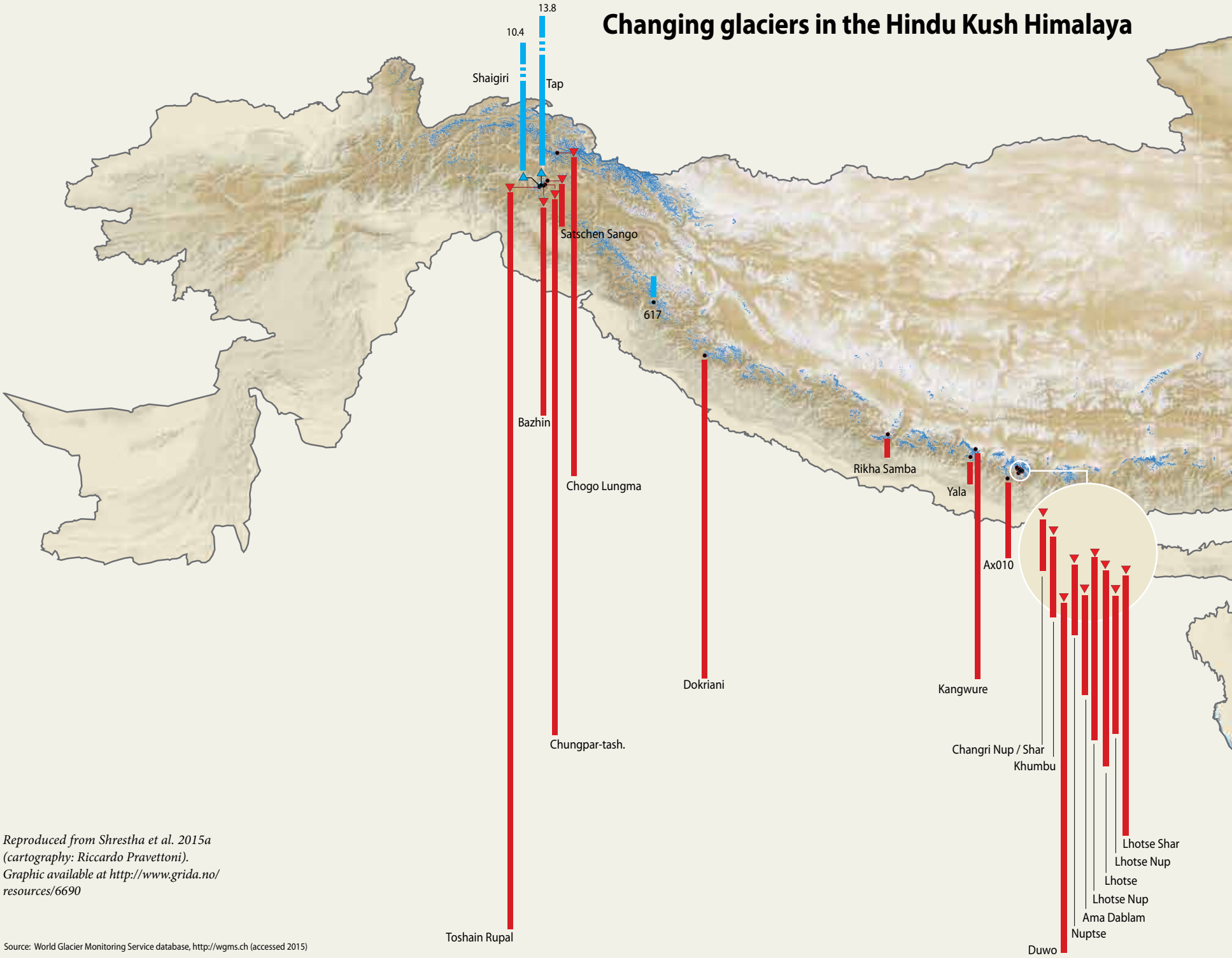
Water

Climate change will increase both water stress and water-related hazards. A major concern for the region is that the amount of water in its rivers will reduce, due to retreating glaciers in the long-term. There are over 54,000 glaciers in the HKH region, covering an area of more than 60,000 km^2, with an ice reserve of 6,000 km^3. There is general agreement among scientists that most HKH glaciers are retreating and have lost mass since the mid-nineteenth century. However, there is one significant exception in the western Himalayas – known as the Karakoram anomaly – where some glaciers in the highest areas of the central Karakoram region have remained stable and even gained mass in the past decades[4] (Gautam et al., 2013; Shrestha et al., 2015a).

Most studies that have assessed the future impact of climate change on glaciers in the region predict that glaciers will continue to decrease and lose mass. Lutz and Immerzeel (2013) found that glacial area in five important upper river basins in the HKH will decrease significantly. Studying the same river basins, Lutz et al. (2014) found that while there will likely be no significant decrease in run-off until 2050, the contribution of water sources (glacial meltwater, snow meltwater and rainfall) will change and there may be some minor changes to the seasonality of the water flow. However, as glaciers continue to melt, run-off will eventually decrease, especially in river basins that receive substantial amounts of water from glaciers, such as the Indus river basin. This is less likely to impact rivers that are more dependent on rainfall, especially as these areas may see an increase in precipitation (Miller et al., 2012). Nonetheless, the increase in evapotranspiration due to warmer temperatures in some areas may outweigh the increase in summer precipitation. For example, in the Koshi basin, evapotranspiration is predicted to increase 4–10 times more than the estimated increase in precipitation. Under such conditions, it is very likely that the frequency of droughts will increase (Tsering et al., 2010).

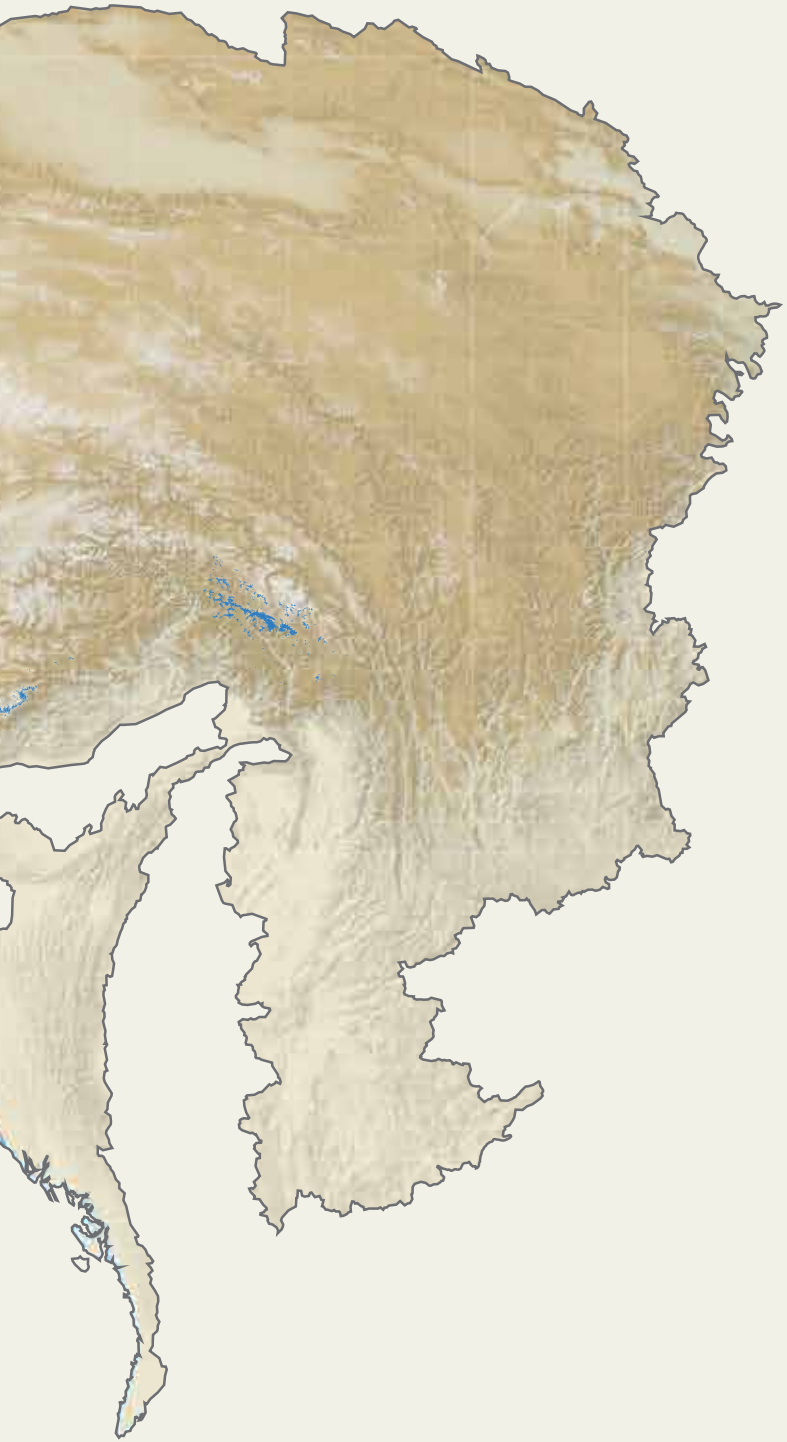
Water is a valuable resource in the region

Changing glaciers in the Hindu Kush Himalaya



Reproduced from Shrestha et al. 2015a (cartography: Riccardo Pravettoni). Graphic available at http://www.grida.no/resources/6690

Source: World Glacier Monitoring Service database, http://wgms.ch (accessed 2015)



Glacier thickness change
Measured over different time ranges for each glacier

Metres*

25
20
15
10
5
0

Thickness reduction

Thickness increase

Elevation
Metres

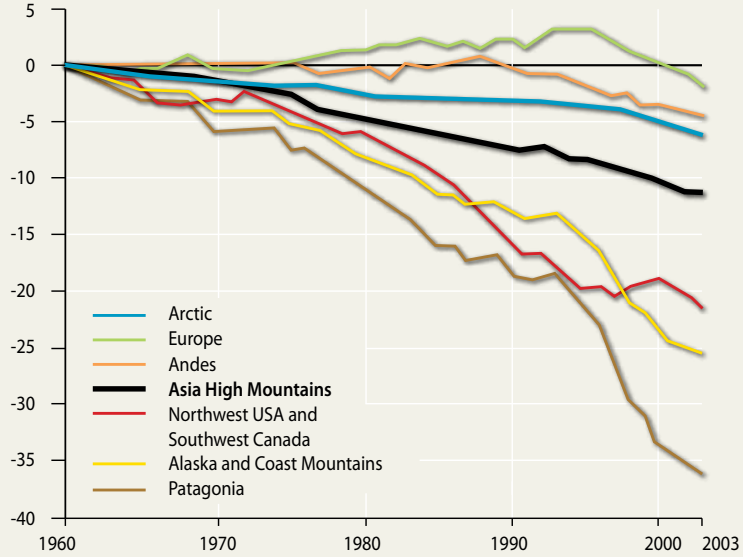
6 000
3 000
1 000
0

Glacier

* Measures the geodetic thickness change between survey and reference year in metres of ice equivalent

Glacier cumulative mass balance

Metres of water equivalent

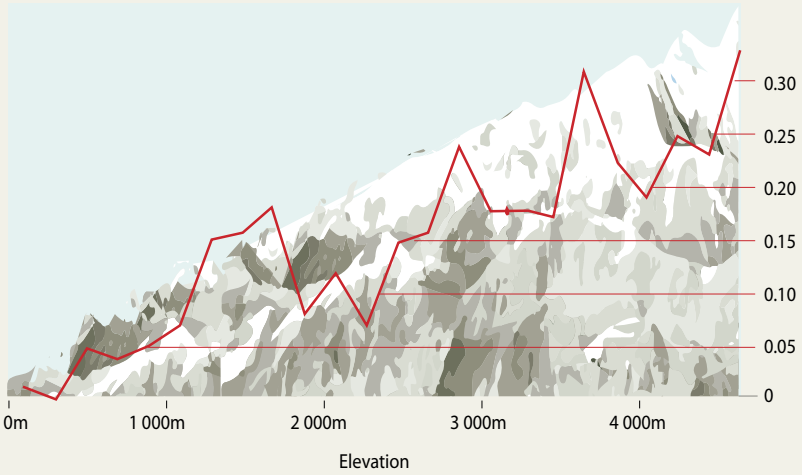


Source: Dyurgerov, M; Meier, M (2005) *Glaciers and the changing earth system: a 2004 snapshot*. Boulder: Institute of Arctic and Alpine Research, University of Colorado

Temperature increased more in high altitude regions

Plateau of Tibet

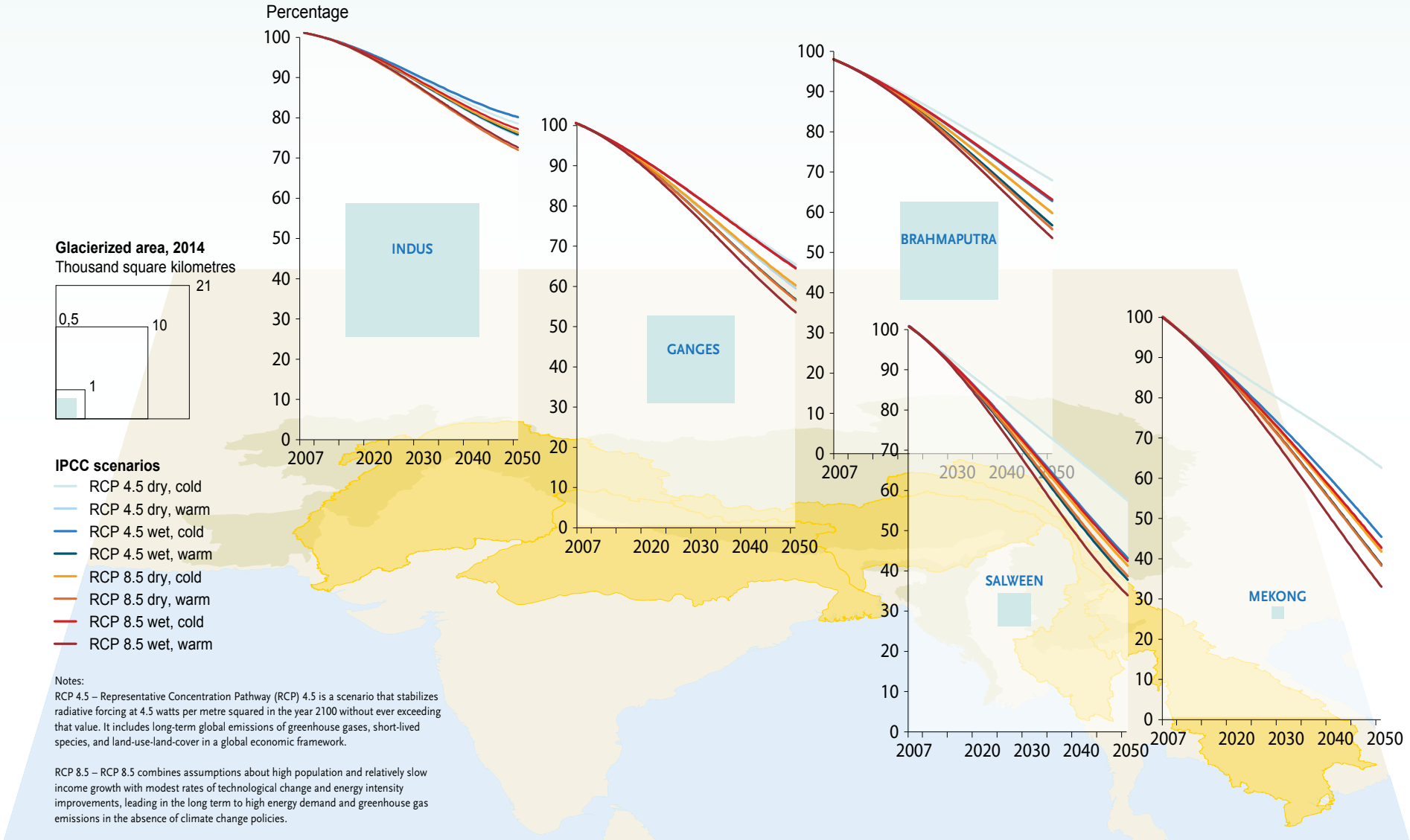
Temperature increase, ºC
1961–1990



Source: Liu, X; Chen, B (2000) 'Climate Warming in the Tibetan Plateau During Recent Decades' *International Journal of Climatology* 20: 1729–1742

Projected glacial area change by 2050

Reproduced from Shrestha et al. 2015a (cartography: Riccardo Pravettoni). Graphic available at http://www.grida.no/resources/6690



Notes:
RCP 4.5 – Representative Concentration Pathway (RCP) 4.5 is a scenario that stabilizes radiative forcing at 4.5 watts per metre squared in the year 2100 without ever exceeding that value. It includes long-term global emissions of greenhouse gases, short-lived species, and land-use-land-cover in a global economic framework.

RCP 8.5 – RCP 8.5 combines assumptions about high population and relatively slow income growth with modest rates of technological change and energy intensity improvements, leading in the long term to high energy demand and greenhouse gas emissions in the absence of climate change policies.

Source: Lutz, AF; Immerzeel, WW (2013) *Water availability analysis for the upper Indus, Ganges, Brahmaputra, Salween and Mekong river basins.* Report submitted to FutureWater

While the projections for future precipitation are somewhat unclear, it is likely that extreme precipitation events will increase during the monsoon season, although the number of wet days is expected to decrease (Palazzi et al., 2013; Shrestha et al., 2015a; Apurv et al., 2015). Large amounts of rainfall over a short period of time will increase the risk of floods and landslides. According to one study on the Brahmaputra basin, floods are likely to increase in the area due to larger volumes of water from more intense precipitation events (Apurv et al., 2015). According to Rajbhandari et al. (2014), the Upper Indus is likely to experience a sharp increase in the amount and intensity of precipitation in the monsoon season, which will further increase the risk of floods and flash floods towards the end of the twentieth century. Precipitation is expected to decrease in the southern plains, which are already water stressed, resulting in an even greater risk of droughts.

A topic that is yet to receive much attention is the impact that climate change will have on groundwater tables and springs fed by groundwater. These water sources are extremely important in areas that lie far away from streams and rivers, and for irrigation throughout the region. Some communities rely entirely on springs for their water needs, for example in Ramche in the mid-hills of Nepal, who are concerned that their springs are becoming drier (Bricker et al., 2014). Studies carried out throughout the HKH region have found that groundwater levels in some areas are increasing, while in others they are decreasing. Xiang et al. (2016) found that between 2003 and 2009 groundwater storage increased in eight basins in the Tibetan Plateau and surrounding areas, mainly due to increased run-off recharges from glacial meltwater and precipitation. The study also found that excessive water use is depleting groundwater in some areas, including Afghanistan, Pakistan, northwest India, north central India and the Bengal basin of Bangladesh. Similar findings have also been documented by Tiwari et al. (2009) and Rodell et al. (2009). The excessive use of groundwater is mainly for irrigation, which will only increase in the future (Archer et al., 2010).

GOOD PRACTICES

The Hindu Kush Himalayan Monitoring and Assessment Programme (HIMAP)

The Hindu Kush Himalayan Monitoring and Assessment Programme (HIMAP), coordinated by ICIMOD, has developed a comprehensive assessment of key issues in the region to identify current knowledge, address gaps and offer recommendations for policy and a way forward for the HKH. The SDGs have been integral in the drafting of key messages, with regional efforts being linked to these goals.

GOOD PRACTICES

Establishment of a Regional Flood Information System in the Hindu Kush Himalayan Region (HKH-HYCOS)

The Regional Flood Information System in the Hindu Kush Himalayan Region (HKH-HYCOS) project promotes the timely exchange of flood data and information to reduce flood vulnerability within and among the participating countries (i.e. Bangladesh, Bhutan, China, India, Nepal and Pakistan) through an established and agreed platform which is accessible and user-friendly. This system has played an important role in minimizing the loss of lives and livelihoods by reducing flood vulnerability in the HKH, particularly within the Ganges-Brahmaputra-Meghna and Indus river basins.

The continued trend of melting glaciers will cause an increase in glacial lake outburst floods (GLOFs), putting mountain and downstream communities at great risk (Khanal et al., 2015). In just 20 years – from 1990 to 2010 – the number of recorded glacial lakes (>0.003 km^2) has increased from 4,600 to 5,700, with almost 40 per cent of these located in the Brahmaputra basin, 28 per cent in the Indus basin and 10 per cent in the Amu Darya basin. (Zhang et al., 2015). Not all glacial lakes are considered dangerous; a study from 2010 estimates that there are roughly 203 potentially dangerous glacial lakes, located in Bhutan, China, India, Nepal and Pakistan are potentially dangerous (Ives et al., 2010). Recent evidence from the Indian Himalayas indicates that warmer temperatures are also increasing the occurrence of avalanches, as well as their size and reach (Ballesteros-Cánovas et al., 2018).

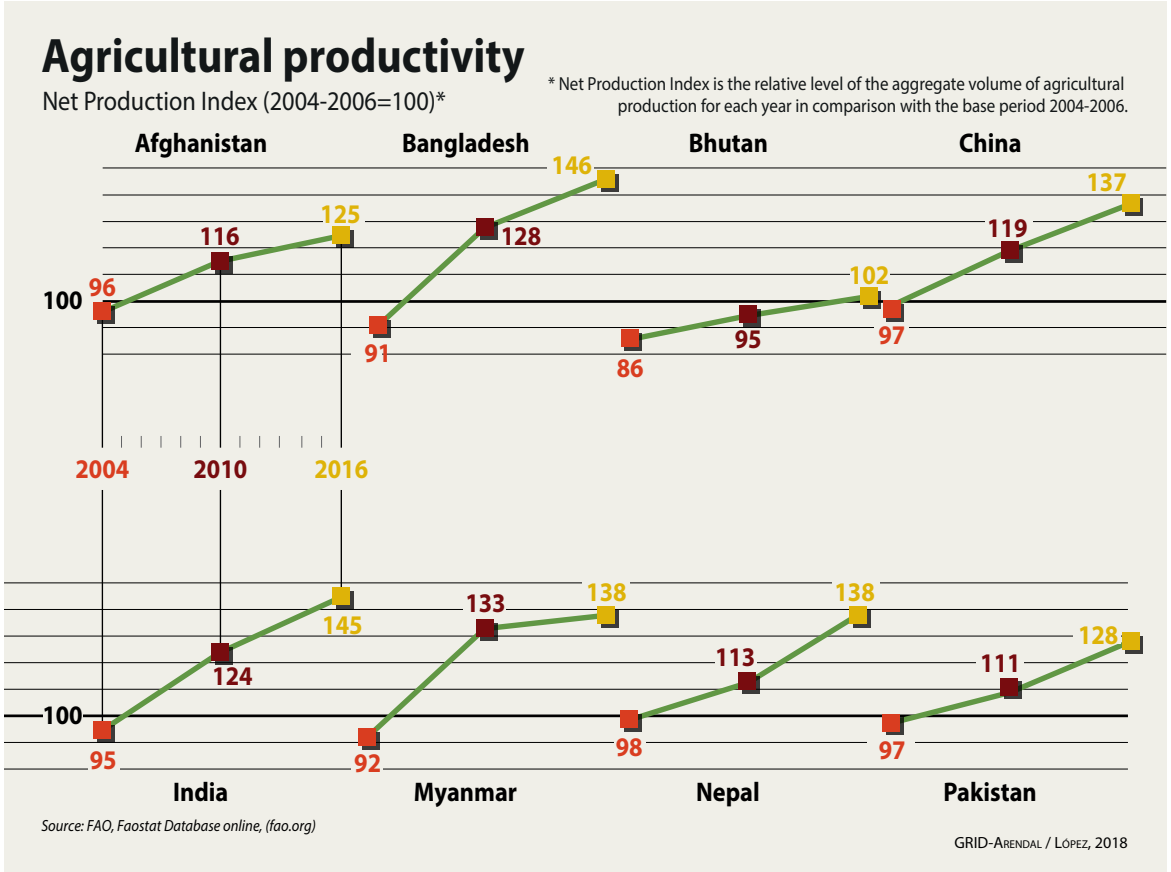
The impact of climate change on water resources in the HKH region affects not only the availability of water, but also the region's food security, energy production, industrial sectors and overall health of its ecosystems and inhabitants. It is important to understand the links between water and these sectors, which will be explored further in the following sections.

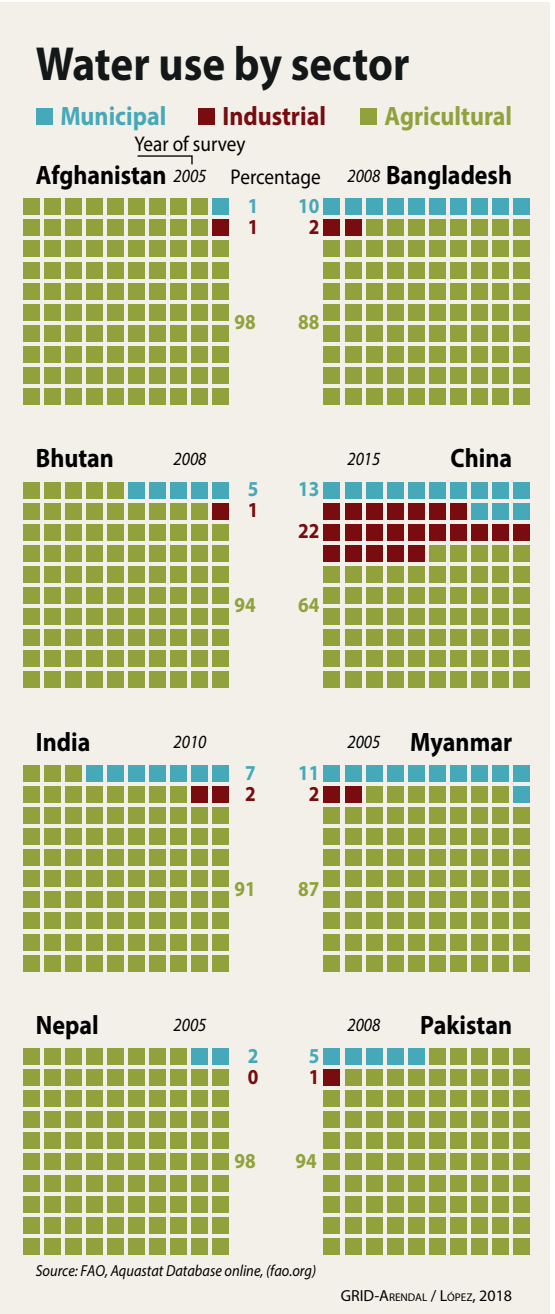
Agriculture, food and nutrition

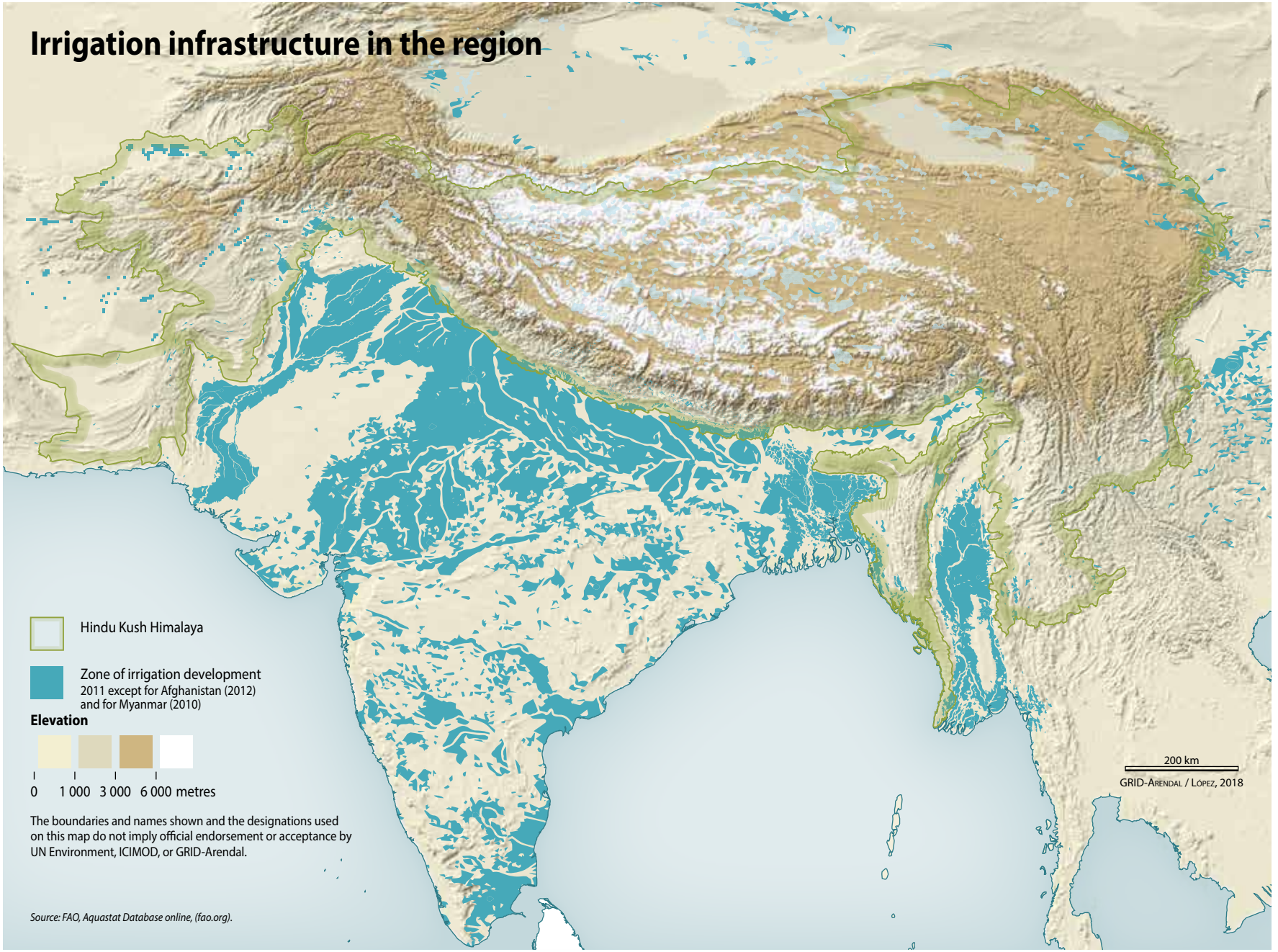
The IPCC Fifth Assessment Report identifies increased food insecurity as a key risk of climate change (IPCC, 2014). By 2050, more severe impacts of reduced crop yields are predicted across the world (Porter et al., 2014). In general, it is expected that food production throughout the HKH region will be negatively affected

through delayed or early onset of monsoons and change in their duration, higher rainfall variability, and increased extreme events, including floods and droughts (Shrestha et al., 2015a). However, agricultural productivity is projected to increase in certain areas. For example, within Chitral district, Pakistan, wheat yields are expected to increase with temperature increases of between 1.50 and 3°C (Hussain & Mudasser, 2007).

Agriculture is very sensitive to climate change and is mainly affected by changes in temperature, precipitation, length of growing season, the timing of extreme or critical threshold events relative to crop development, and atmospheric CO_2 concentrations (Singh et al., 2011). Other factors may include changing conditions which facilitate the spread of pests harmful to agriculture. While all agricultural production depends on water, Asian agricultural especially requires large amounts of this resource to produce its most important staple foods – wheat and rice. Any reductions in water availability could therefore have a devastating effect on the region's food security (Rasul, 2010). HKH countries already rely heavily on water that originates in the region's






Irrigation infrastructure in the region
Hindu Kush Himalaya
Zone of irrigation development
2011 except for Afghanistan (2012)
and for Myanmar (2010)
Elevation
0 1 000 3 000 6 000 metres
The boundaries and names shown and the designations used on this map do not imply official endorsement or acceptance by UN Environment, ICIMOD, or GRID-Arendal.
Source: FAO, Aquastat Database online, (fao.org).
200 km
GRID-Arendal / López, 2018

mountains for irrigation. For example, the Indus irrigation system, the world largest contiguous irrigation system, irrigates roughly 76 per cent of the cultivated area in Pakistan, enabling the production of more than 80 per cent of the country's food grains and cash crops (Rasul, 2014). The Ganges supports approximately 60 per cent of India's irrigated area and the Brahmaputra supports irrigation in large parts of Bangladesh, Bhutan and India (Rasul, 2014). As previously mentioned, the water in the 10 largest river basins that originate in HKH mountains is a combination of rainfall and meltwater from snow and glaciers. According to Immerzeel et al. (2010), the impacts of climate change in the Indus and Brahmaputra basins are likely to be more severe than in the Ganges, Yangtze and Yellow River due to their reliance on glacial meltwater, in addition to the river basins' large populations and irrigation needs. Any changes to monsoon patterns will have a larger effect on agriculture in the eastern Himalayas, which depend on these more than other Himalayan areas.

Farming in Khagrachhari Area, Chittagong Hill District, Bangladesh

Specifically within the HKH region, most agriculture is rain-fed, making it vulnerable to changes in precipitation patterns. The low diversification of the population's livelihoods exacerbates this situation, as a high proportion are reliant on agriculture and are therefore vulnerable. Field studies and household surveys offer insight into households' own experiences on how climate change is affecting agriculture. A recent poverty and vulnerability assessment of HKH populations found that 40 per cent of 8,000 households had experienced decreasing yields in their five most important crops, due to floods, droughts, frost, hail, pests and disease. Specific pests and diseases reported by farmers spread across the Upper Indus, Koshi, Upper Brahmaputra, eastern Brahmaputra and Salween and Mekong river basins include blight and leaf worms in potato and maize; brown leaf spot, leaf roll and stem borer in paddies; loose smut in wheat, barley and maize; white grub and stem borer in millet; and increased liver fluke in livestock at higher altitudes (Gerlitz et al., 2014).

Responses from farmers in Bhutan, India and Nepal for another field study were similar to those recorded by Gerlitz et al. (2014). Although the farmers' perception of climate change varied slightly depending on their location and altitude, all had experienced reduced agricultural productivity, crop failures, increased crop destruction and loss of harvest due to hail storms or wind, and increased pests and diseases. Changes in precipitation patterns were attributed as the main cause of these negative impacts, and include an earlier or delayed onset of the monsoon season (depending on the farmer's location), more erratic precipitation and more frequent dry spells during the monsoon season. However, some benefits were also mentioned, notably the ability to introduce new crops at higher altitudes due to the warmer temperatures (Macchi et al., 2011).

Many households also own livestock as a source of income and food security; at higher altitude, livestock becomes even more significant than agriculture. In Nepal, livestock comprises just over ten percent of the national GDP and just over one quarter of the agriculture GDP. Especially amongst the poorest people in Nepal, of which 43 per cent live

CASE STUDY

Livestock and climate change in Nepal

Extreme events, such as droughts and floods, are expected to increase. Heavy rainfall can have substantial consequences for food security, earlier events have proven (Douglas, 2009). For example, the devastating floods in Pakistan in 2010 damaged or destroyed over 2 million hectares of crops, killed 1.2 million livestock and put a further 14 million livestock at risk due to a shortage of fodder and high risk of disease. In total, the floods made an estimated 7.8 million people in Pakistan vulnerable to long-term food insecurity (WFP, 2010). Although they are not part of the HKH region, low-lying coastal areas are vulnerable to rising sea levels and saltwater intrusion. In Bangladesh, where roughly 80 per cent of the country is low-lying, soil salinity is expected to increase by 39 per cent by 2050 (Dasgupta et al., 2015).

Rice planting in Kathmandu Valley, Nepal

in the Himalayan region, livestock constitutes the highest portion of household income (Neopane et al. 2011). The impact of climate change will increase the vulnerability of livestock because of how climate change affects water availability, forage and the quality of rangelands and pastures. Livestock diseases have also been linked to temperature increases and changed rainfall patterns (Hussain et al., 2016). This vulnerability could be exacerbated by other factors such as population growth, increased demand for food and conflicts over resources. For the already poor, losing the income brought through livestock could trigger a fall into chronic poverty (Koirala and Bhandari, 2018). The Nepalese Himalayas hosts several indigenous livestock breeds and a variety of indigenous pasture grasses and fodder trees (Shaha &Joshi, 2003). The population of indigenous livestock breeds is in sharp decline mainly because of disease outbreaks probably also linked to a changing climate. However, local breeds of goats and yak are more resilient to water and fodder and forage shortages (Koirala and Bhandari, 2018). Some farmers have stopped raising livestock while others prefer to increase the number of animals that need less water and fodder such as goats, at the expense of larger animals such as sheep and cattle (Husain et al., 2016). In addition, farmers sometimes invest in building sheds as a coping mechanism against disasters, have the animals more regularly vaccinated, conservation of rangeland (ibid; Koirala and Bhandari, 2018). Indigenous breeds which are more likely to survive in harsh circumstances are also being promoted.

The effects of climate change on local food production can also contribute to cultural erosion and loss of traditions. For example, yearly food festivals in some areas can no longer continue due to poor crop yields and some traditional diets are being lost and replaced with foreign and processed foods (Devkota, 2013).

The impact of climate change on agriculture in the HKH region affects women and men differently due to distinct socially constructed gender roles. For example, In India and Nepal, women spend more time on agricultural production and animal husbandry

than men and are typically responsible for household work, looking after children and collecting water, fodder and firewood (Nellemann et al., 2011). Climate change is making agricultural production more time-consuming for farmers, who now face challenges such as hardened soil due to longer dry spells, and new varieties of weeds and pests, which increase the need for weeding. Lower agricultural productivity and more attractive opportunities elsewhere have caused an increase in male outmigration to urban areas and overseas. Although remittances contribute significantly to the HKH country economies, rural women left behind bear a significant burden and experience increased levels of mental stress, restricted mobility and decreased social status, indicating that male outmigration does not necessarily empower women (Gurung and Bisht, 2014).

The effects of climate change on agriculture will likely vary across the HKH region, both in terms of positive and negative outcomes, and the degree to which these will be felt. A study of the Indus basin in Pakistan found that cop production may decrease by 13 per cent in the next 80 years, though certain provinces, such as Sindh, are likely to be more severely affected (Yu et al., 2013). Of major crops, irrigated rice, sugarcane and wheat are more vulnerable to climate change than cotton and basmati rice. In addition to adverse effects caused by water scarcity, extreme heat events may pose a significant risk to crops such rice and wheat, which have upper temperature sensitivity thresholds of 35–38°C and 30–35°C respectively (World Bank, 2013).

Extreme events, such as droughts and floods, are expected to increase. Heavy rainfall can have substantial consequences for food security, earlier events have proven (Douglas, 2009). For example, the devastating floods in Pakistan in 2010 damaged or destroyed over 2 million hectares of crops, killed 1.2 million livestock and put a further 14 million livestock at risk due to a shortage of fodder and high risk of disease. In total, the floods made an estimated 7.8 million people in Pakistan vulnerable to long-term food insecurity (WFP, 2010). Although they are not part of the HKH region, low-lying coastal areas are vulnerable to rising sea levels and saltwater intrusion. In Bangladesh, where roughly 80 per cent of the country is low-lying, soil salinity is expected to increase by 39 per cent by 2050 (Dasgupta et al., 2015).

Forests, biodiversity and ecosystems

A close link exists between forests and climate, making them highly sensitive to changes in temperature and precipitation patterns, with the potential to respond within years to a few decades (Upgupta, 2015). Typically, warmer climates cause forest boundaries to shift and treelines to move towards higher altitudes, while also changing the composition of forest species and vegetation types (Tsering et al., 2010; Ravindranath and Bala, 2017). Though few studies have been carried out in this area, some have documented an upward shift of the treeline in the HKH region, including in Yunnan province in China, in the eastern Himalayas (Baker and Moseley, 2007), in central Nepal (Gaire et al., 2014), and in the western Indian Himalayas (Panigraphy et al., 2010; Dubey et al., 2003). Another impact of climate change is the higher risk of forest fires, particularly in Bhutan, due to prolonged dry winter conditions (Biodiversity Action Plan, 2009), which are generally expected to increase in frequency and intensity (Tsering et al., 2010).

A study modelling the future impact of climate change on forests in three river basins (mid-Brahmaputra, Koshi and Upper Indus) found that climate change represents a threat to many forested areas, especially fragmented and isolated forests (Ravindranath and Bala, 2017). The results also suggest that net primary production is expected to increase due to higher fertilization from increased CO_2 levels. However, changes in nutrients and land cover may also reduce net primary production, though these factors were not considered in the modelling. A study on forests in India (Chaturverdi et al., 2010) showed that mountain forests (subalpine and alpine forests, Himalayan dry temperate forests and Himalayan moist temperate forests) are especially vulnerable to climate change, since higher altitude areas will be more affected than areas at lower altitudes. Rashid et al. (2015) analysed projected climate change impacts on vegetation distribution over the Kashmir Himalayas (northwestern Himalayas) and predicted that boreal evergreen forests, tundra and shrublands will have taken over areas covered by ice, rock and polar deserts by 2035. A substantial area that is currently temperate evergreen forest will likely become a deciduous forest. Temperature evergreen broadleaf forests and mixed forest types will take over areas that are currently shrublands.

It is not only forests that will be affected by climate change. Biodiversity in general throughout the HKH region is considered to be vulnerable to temperature and precipitation changes (Singh et al., 2011). The HKH region is of global importance due to its unique biodiversity, and is home to 4 of 34 global biodiversity hotspots, 6 UNESCO natural World Heritage sites, 30 Ramsar sites, 330 Important Bird Areas (IBAs) and 53 Important Plant Areas (IPAs). In total, there are 60 ecoregion types (6 per cent of the world total), of which 30 are critical ecoregions. HKH countries have established roughly 488 protected areas in the region with varying degrees of protection and status, covering 39 per cent of HKH terrestrial land (Chettri et al., 2008; ICIMOD 2009).

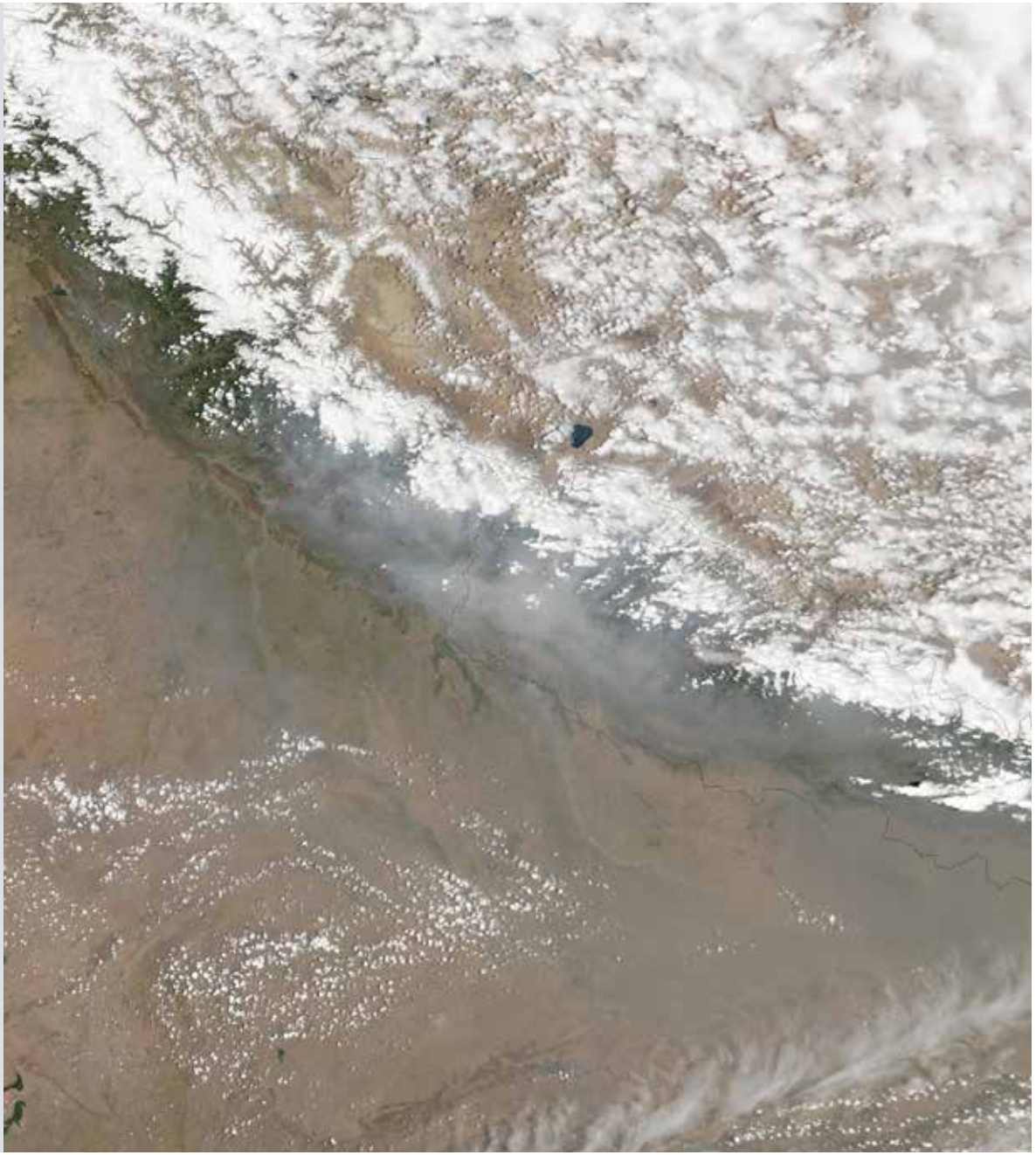
Climate change has already caused significant changes to ecosystems and species in the HKH region. The general issue for biodiversity and climate change is

Forest fires

In April 2016, Nepal and parts of northern India experienced one of the worst forest fires in more than a decade (Menon and Sharma, 2016). In Nepal, the fire destroyed more than 3.5 million hectares of forest, spreading across almost all of the country. Of Nepal's total 75 districts, 72 were affected by forest fires, which continued for around a month, destroyed properties and took at least 12 lives (Kathmandu Post, 2016). Forest fires are common in India and Nepal during the dry months of February to May. Humans cause the majority of these, either intentionally or by accident. Fires are used traditionally for a range of purposes, including as a tool to prepare agricultural land, to clear vegetation and for hunting purposes. During the dry months, these fires can easily become out of control due to dry and windy conditions (Das, n.d.).

Climate change is expected to increase the frequency and intensity of forest fires in the HKH region, particularly during the dry months and hot summer months, when conditions become drier and droughts are more likely (Tsering et al., 2010; Ebi et al., 2007).

For more information on the forest fire in Nepal, see: http://geoportal.icimod.org/?q=21300



Right: A satellite image acquired in April 2016 shows the widespread fire activity across northern India and Nepal. Image courtesy of NASA, by Jeff Schmaltz, LANCE/EOSDIS Rapid Response.

that species have already adjusted to living in certain climates. With a changing climate, species that once were present and had adapted to an area with a specific climatic zone may no longer be able to survive in the area's new conditions (Xu and Grumbine, 2014). Although climate change may cause species disappearance from areas, it can also facilitate the introduction of new species that are accustomed to the new climate conditions. According to a study of the eastern Himalayas, climate change has had various observable impacts, including the loss and fragmentation of habitats, degradation of wetlands and riverine island ecosystems, decrease in agrobiodiversity, increase in invasive alien species and weeds, and degradation of soil fertility, among others (Tsering et al., 2010). Furthermore, the study projects that climate change will cause the vertical migration of some species and loss or extinction of others. Species found in the high mountains are especially vulnerable to the warming climate, as they have limited opportunities to migrate upward (Tsering et al., 2010). For example, snow leopards are believed to be especially threatened by climate change due to shrinking habitats and increased conflicts with humans (Valentová, 2017). In Upper Mustang (Nepal), the shifting treeline has been linked to two connected human–wildlife conflicts: the Himalayan blue sheep (*Pseudos nayaur*) – a major food of the snow leopard – has started to forage in cultivated land at lower altitudes due to the shrinking of high-altitude shrublands and grasslands, which in turn, has led snow leopards to these lower sites, which have then killed livestock (Aryal et al., 2013). In the last two decades in the Indian Himalayan region (1994–2016), field studies have revealed that numerous wild animals have had a negative impact on the well-being of local communities (Gupta et al., 2017).

Afghanistan Mountains

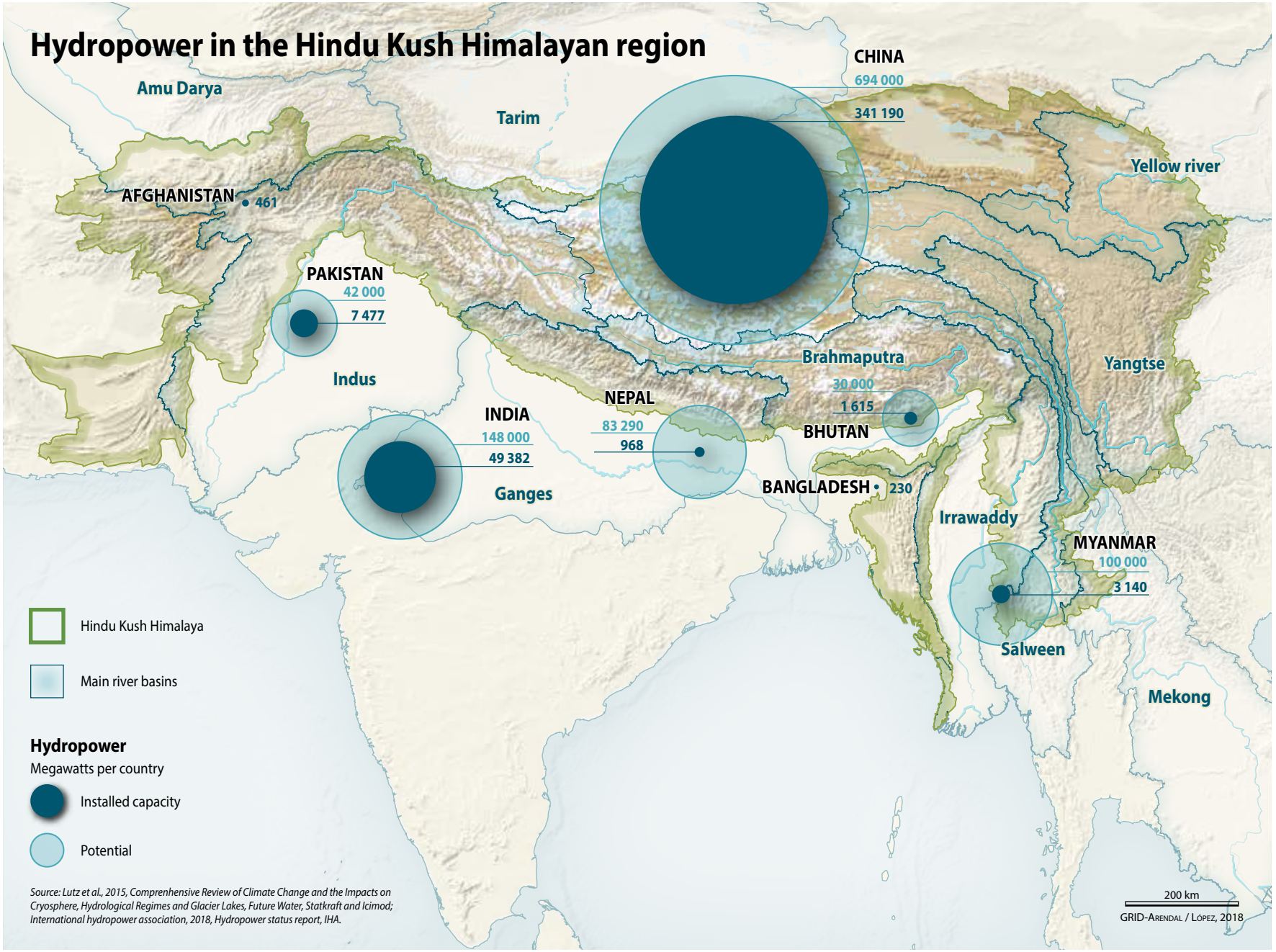
HKH freshwater ecosystems are also likely to be under pressure in the near future. Factors such as water temperature will affect freshwater species, especially those that depend on temperature changes to complete lifecycles (Allen et al., 2010).

Energy

Hydropower generation

Given the significant hydropower opportunities in the region, it crucial to understand how climate change may impact electricity production and hydropower plants and what the potential risks are for surrounding areas. Hydropower is deemed particularly vulnerable to climate change, since it depends on one of the Earth's most threatened natural resources – water. A recent global review of mountainous areas, which included the Himalayas, found that very few, publicly available studies are available that specifically examine the hydropower sector and assess how changing river run-off trends might impact electricity production in existing hydropower plants as well as potential hydropower capacity (Carey et al., 2016.)

Most existing studies examine the potential impacts of climate change on river run-off and infer possible outcomes for hydropower. In general, river run-off is not expected to decline significantly before 2050 (Shrestha et al., 2015a). Most river basins will likely experience an increase in run-off, except the Indus river basin, which may decrease by 5 per cent compared with the reference point (1998–2007) (Shrestha et al., 2015a). River basins in the drier western Himalayas, such as the Indus, where glacial meltwater contributes more significantly to the overall river run-off, are more vulnerable in the longer term as this meltwater decreases. In the central and eastern Himalayas, river run-off is more dependent on monsoon precipitation. In these areas, declining


Hydropower in the Hindu Kush Himalayan region
Amu Darya
Tarim
CHINA
694 000
341 190
Yellow river
AFGHANISTAN
461
PAKISTAN
42 000
7 477
Indus
Brahmaputra
30 000
1 615
Yangtse
NEPAL
83 290
968
BHUTAN
INDIA
148 000
49 382
Ganges
BANGLADESH
230
Irrawaddy
MYANMAR
100 000
3 140
Salween
Mekong
Hindu Kush Himalaya
Main river basins
Hydropower
Megawatts per country
Installed capacity
Potential
Source: Lutz et al., 2015, Comprenhensive Review of Climate Change and the Impacts on Cryosphere, Hydrological Regimes and Glacier Lakes, Future Water, Statkraft and Icimod; International hydropower association, 2018, Hydropower status report, IHA.
200 km
GRID-Arendal / López, 2018

precipitation trends and increased variability is more harmful to river run-off (Immerzeel et al., 2010; Shrestha et al., 2015a) and consequently hydropower electricity production, since less winter precipitation means less water stored within glaciers, reducing the spring and summer run-off (Molden et al., 2014).

More intense precipitation may cause floods and increase the amount of sedimentation in rivers, severely damaging and shortening the life of hydropower plants (Tsering et al., 2010), which are also at risk of impacts caused by increased climate variability. Among such impacts are more frequent droughts, floods and landslides, and an increase in the volume of glacial lakes, which are more prone to GLOFs (Khanal et al., 2015). These phenomena have the potential to decrease electricity production over a given time and also pose a risk to the hydropower facilities themselves, including dams, powerhouses and tunnels. A study assessing the risk of 257 hydropower plants being hit by a GLOF in Bhutan, India and Nepal found that 66 per cent are at risk. In addition, the study found that new hydropower plants are planned to be built close to glacial lakes, increasing their risk of being hit (Schwanghart et al., 2016). A further issue for hydropower plants is the increasing temperature, since increased evapotranspiration may prove problematic for dams (Tsering et al., 2010).

Infrastructure including urban areas

Infrastructure refers to the physical, fixed installations that a society needs to function, ranging from buildings (residential housing, offices, etc.) through to critical infrastructure, such as dams (including hydropower), water pipelines, electrical grids and communication systems to access infrastructure (such as roads, rail networks, etc.), and has tended to be designed based on historical weather and climate patterns. In many poor and underdeveloped areas, infrastructure has not been developed to meet current needs, and the important infrastructure that does exist in the HKH region will be increasingly at risk due to the changing climate (Eriksson et al., 2009), which has the potential to affect its operational, financial, environmental and social performance. The impact of climate change on infrastructure depends on its geographical exposure to hazards and whether any preventive measures have been established to address these and future threats. Among the main climate hazards are extreme weather events, especially heavy rainfall, which can trigger floods and landslides (European Commission, 2013) and are responsible for frequently damaging or destroying infrastructure in the region, costing HKH countries significant amounts in repairs (Ghatak et al., 2012). In 2013, a flood in Uttarakhand severely damaged and destroyed the state's infrastructure, which affected an estimated 2,174 roads, 85 motor bridges, 140 bridle bridges, and consequently the connectivity of 4,200 villages. The total cost to reconstruct or repair damaged infrastructure was estimated at US$ 577 million (World Bank et al., 2013).

CASE STUDY

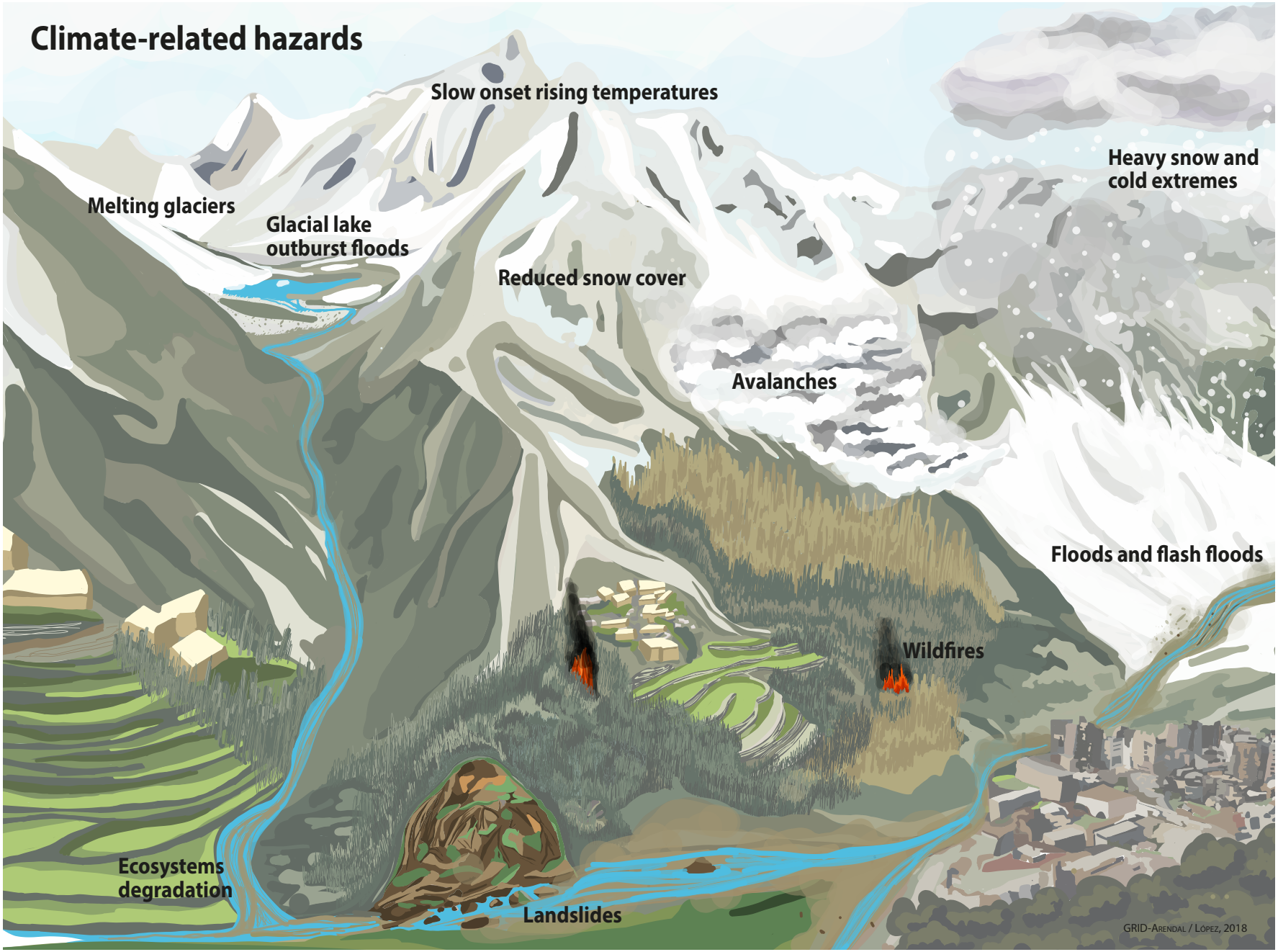
Uttarakhand's ghost villages

In Pauri Garhwal, India, most young people have left their homes in search of work. Only the elderly and those without options remain. The past few years have witnessed a steady stream of residents migrating to bigger cities in search of employment, better education and health care. Across the region, the same story is playing out. Villages have more abandoned homes than occupied structures. These are the same villages that once produced plentiful harvests of wheat, rice, mandua and varieties of pulses and vegetables that provided farmers with a decent living. However, as farming here was always entirely dependent on rainfall and its vagaries and lacked irrigation facilities, the fertile lands turned barren at an unprecedented rate. Today, the green pastures are no more, and only wild shrubs remain, forcing residents to migrate in search of work and leaving some settlements inhabited by just a single resident. The dwindling village populations are only offset by one factor: the steady migration of people from Nepal who come to settle in these parts or work here for a few months every year. They make a living as daily wage labourers in the nearest towns and take shelter in the abandoned houses.

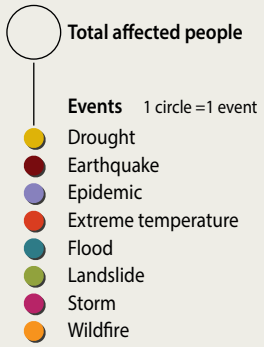
Data on natural hazards show that these are increasing in the region, with 52 events recorded in 2015, up from 11 events in 1970 (Guha-Sapir et al., 2016). South Asia is the most exposed region in the world to floods and flash floods, which are by far the most frequent natural disaster in the region (World Bank, 2012).

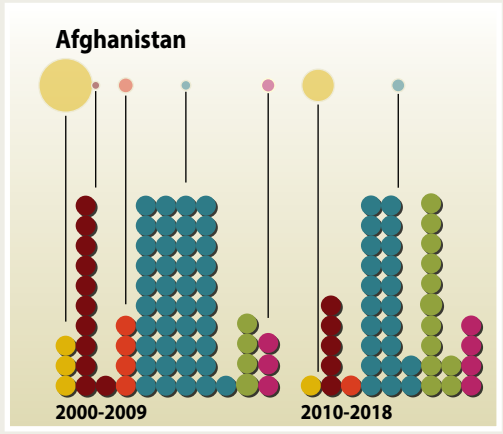
Warmer temperatures can also pose a risk to infrastructure built on permafrost[5] within the region (Arent et al., 2014). This was a particular challenge when developing parts of the Qinghai-Tiber railroad, specifically the stretch from Golmud to Lhasa, which opened in 2006, and the stretch from Lhasa to Shigaste, which opened in 2014, since almost 50 per cent of the tracks were laid on permafrost (Xin, 2006; The Economist, 2014). Projected permafrost melting on the Tibetan Plateau may threaten railroad services, for example, if the soil becomes too muddy (Nan et al., 2005). However, despite permafrost areas exceeding glacial areas in nearly all Himalayan countries, little is known about it and the potential impacts of its thaw (Gruber et al., 2017).

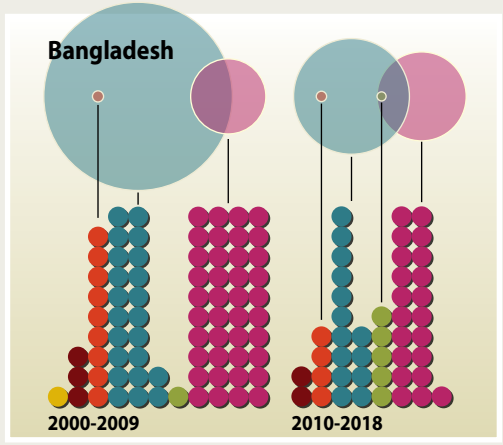
In the HKH region, infrastructure is more concentrated in urban areas. Many HKH cities are located in areas especially prone to climate-related hazards, the most

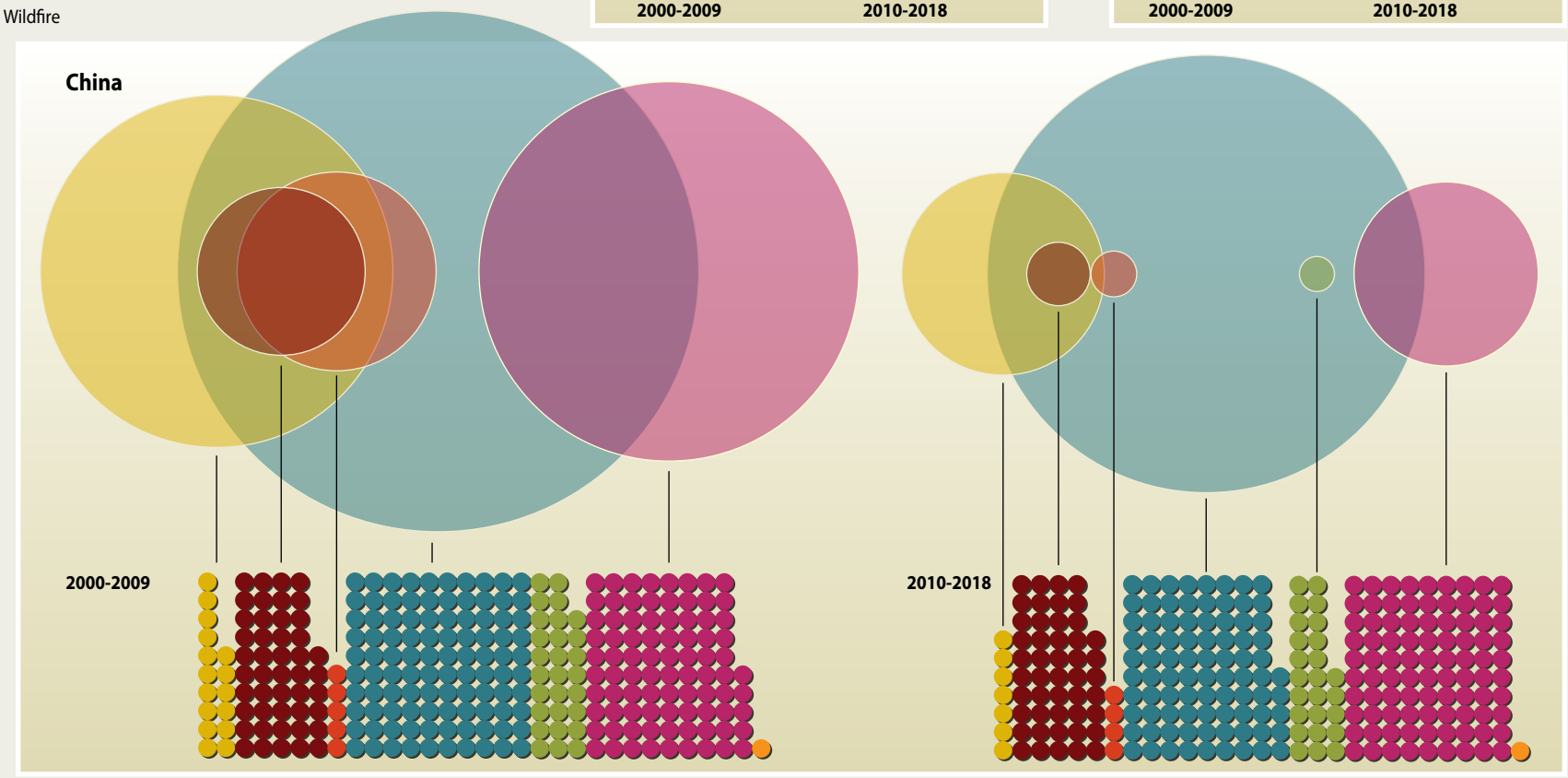

Climate-related hazards
Slow onset rising temperatures
Heavy snow and cold extremes
Melting glaciers
Glacial lake outburst floods
Reduced snow cover
Avalanches
Floods and flash floods
Wildfires
Ecosystems degradation
Landslides
GRID-Arendal / López, 2018

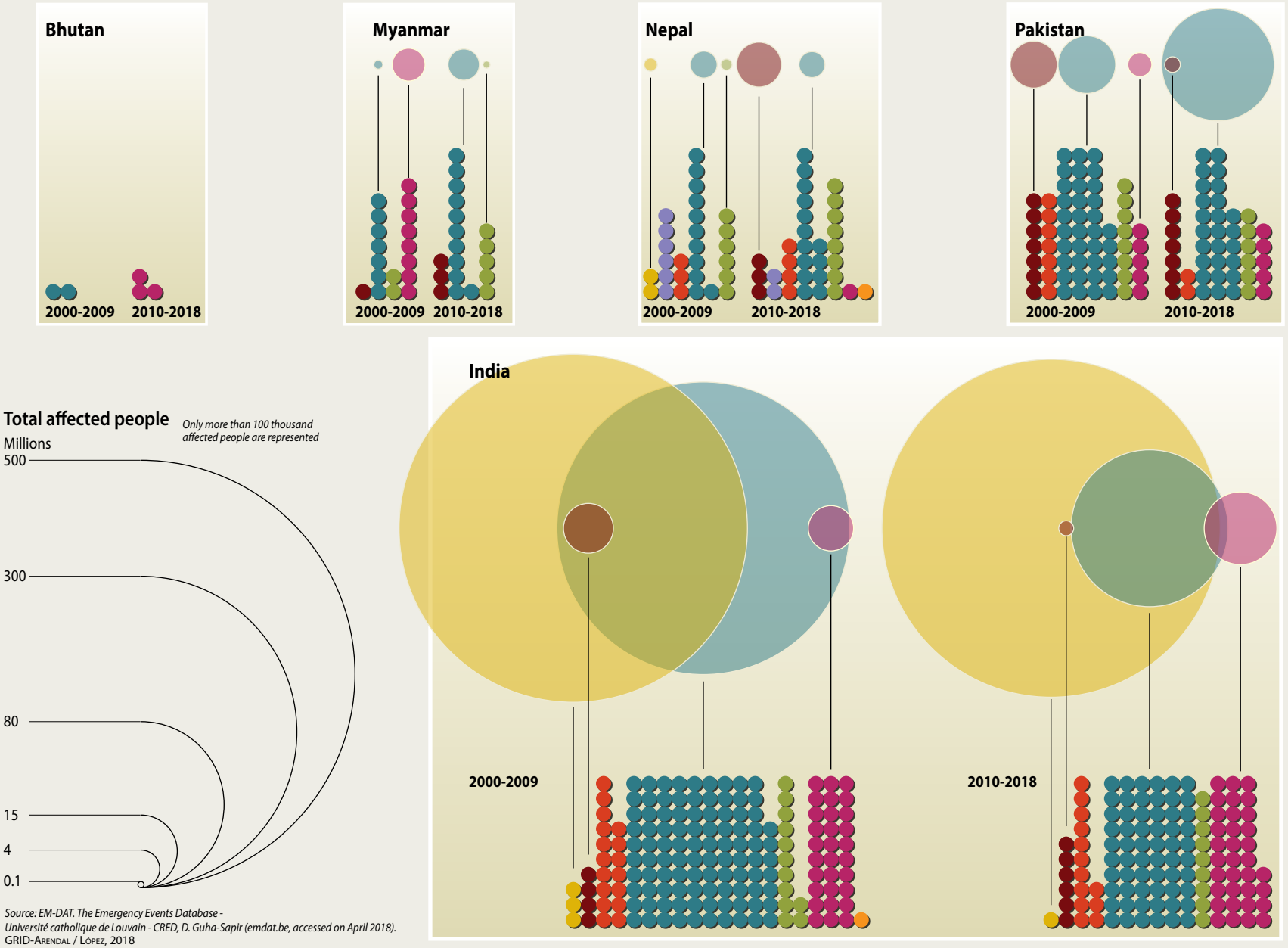
Natural disasters











Source: EM-DAT. The Emergency Events Database - Université catholique de Louvain - CRED, D. Guha-Sapir (emdat.be, accessed on April 2018).
GRID-Arendal / López, 2018

significant being floods, landslides and droughts (UN-Habitat, 2015). These hazards are not new in the region, and local knowledge and disaster risk reduction in urban planning has been developed over the past centuries as a result. However, today's rapid population growth and high influx of migrants from rural areas have led to the uncontrolled expansion of many Himalayan urban areas. This includes the development of informal, poor settlements and slums in areas at high risk of flooding and landslides (Rautela, 2005). In the case of the Kathmandu Valley, the population of squatter settlements increased from roughly 7,800 settlement units in 2000 to almost 17,000 between 2000 and 2010, with 85 per cent living along or in close proximity to a river or on the flood plain (UN-Habitat, 2015).

The risks linked to this unplanned growth are exacerbated by natural disasters (Acharya et al., 2012; Rautela, 2005; UN-Habitat, 2015). In poor settlement areas, houses and shelters are particularly exposed, due to the fragility of the material used, such as bamboo, cardboard, galvanized iron sheets and used wooden boxes, among others (UN-Habitat, 2015). For example, in August 2010, flash floods and debris flows affected a total of 71 villages and destroyed over 1,450 houses around the city of Leh (Ladakh, India), where the booming tourism sector and influx of people from rural areas had driven urban development into areas at of such disasters (Ziegler et al., 2016).

Tourism

Tourism is considered to be highly sensitive to climate change, which impacts the sector both directly and indirectly. Direct impacts on tourism include the changing length and quality of climate-dependent tourism seasons, while indirect impacts may affect the appeal of a location due to reduced water quality, loss of biodiversity, reduced landscape aesthetics, altered agricultural production (including availability and quality of food) damage to infrastructure, and the presence or appearance of new vector-borne and zoonotic diseases (Simpson et al., 2008).

At present, there is little information on the impact of climate change on tourism in the HKH region, with only a few studies available on the topic, which mainly focus on Nepal (Nyaupane and Chhetri, 2009; Nepal, 2011; Rayamajhi, 2012, Anup and Parajuli, 2015). However, the findings from these studies – to some extent – can be generalized for other HKH countries. Nyaupane and Chhetri (2009) examine the vulnerability of nature-based tourism due to climate change in the Nepalese Himalayas across three different physiographic zones (high mountains, hills, and the Terai lowlands), represented by some of the country's most popular tourist destinations: Sagarmatha National Park (home to Mount Everest), Annapurna Conservation Area and Chitwan National Park. Due to climate change, the high mountains are projected to be more exposed to avalanches and GLOFs, hills to landslides, flash floods and debris flows and the Terai lowlands to floods. Such natural hazards can damage and destroy infrastructure crucial for tourism, such as roads, bridges and mountain trails, in addition to posing a significant risk to human lives and religious sites (Nyaupane and Chhetri, 2009). For example, in 1994, a GLOF in Bhutan severely damaged the Punakha Dzong[6] and smaller dzongs (Higgins-Zogib et al., 2011). In 2014, unusually severe snowstorms and avalanches killed at least 43 people, including many tourists who were trekking the Annapurna Circuit (Sharma, 2014).

After a country experiences a natural disaster, the number of tourists visiting unsurprisingly usually decreases. Though not linked to climate change, Nepal saw a drop in tourists following two terrible earthquakes in 2015, from 790,000 visitors in 2014 to 550,000 in 2015 (UNWTO, 2016). A study examining stakeholders' perceptions of climate change and tourism found that tourists would be reluctant to travel to Annapurna if the area becomes more prone to flooding, landslides and heavy rainfall (Rayamajhi, 2012). Stakeholders in Annapurna, including tour guides and lodge owners, believe that climate change will mainly have negative impacts on the tourism sector (Rayamajhi, 2012). Similarly, local residents in the Mount Yulong snow region of the southeastern Tibetan Plateau believe that climate change will

Uttarakhand flood and its impact on tourism

The devastating 2013 flood in Uttarakhand greatly affected the tourism sector, with tourists and pilgrims among the 580 confirmed dead and an additional 5,400 people reported as missing (presumed to have perished). Important infrastructure (including hydropower plants, water supply, sewage, roads and bridges) was severely damaged or destroyed, routes to pilgrim sites were damaged or blocked and over 70,000 tourists and 100,000 locals were stranded in the upper reaches of the mountain terrains. Tourism supported many households in the state and the damage to the sector resulted in the loss of numerous livelihoods of people working as petty traders, in hotels and restaurants and as taxi and bus operators (World Bank et al., 2013; NIDM, 2015; Shrestha et al., 2015a). One estimate suggests that it would cost US$ 19 million to reconstruct tourism infrastructure that was destroyed in the flood, and that the economic loss from tourism revenues that year totalled US$ 1 billion. By the time the area has recovered, losses from tourism are expected to reach more than US$ 3.8 million (World Bank et al., 2013).

seriously affect mountain tourism to the region (Wang and Cao, 2014). However, stakeholders in Annapurna also see some positive outcomes of climate change, as warmer temperatures have made the trekking season slightly longer and more comfortable for a wider group of people (Rayamajhi, 2012).

Tourism that depends on certain weather, such as nature-based tourism (e.g. trekking, mountaineering, safari) will likely be impacted by changing monsoon patterns, since these will determine when and where tourists travel. In Nepal, the tourism season peaks in the dry autumn and spring months when temperatures are pleasant and there is little precipitation. Changing monsoon patterns could therefore impact when tourists arrive (Nyaupane and Chhetri, 2009; Rayamajhi, 2012).

Access to and availability of water will likely impact tourism in the HKH region, whether it is climate-linked or not. Tourists can increase the demand for water substantially, which may become unsustainable in water scarce areas. In Ladakh, India, tourists are asked to bring water from lower sources to cope with acute water scarcity (Karki, 2014). Sacred springs have also been affected and reportedly dried up in some locations, such as in Sikkim and above the Tiger's Nest monastery in Bhutan, which can cause water-driven prayer wheels to stop spinning (Higgins-Zogib et al., 2011). Changes in the ecological characteristics of wetlands, lakes and rivers can change their significance as cultural and religious tourism sites (Tsering et al., 2010). For example, the Modi and Kali Gandaki river corridor in Nepal has 22 traditional sites, known as ghats, which are used for religious bathing and cremation. Changes in the water flow can increase the risk of using these ghats and inconvenience the people who use them (Shrestha and Aryal, 2011). Reduced water flow in rivers can have a negative impact on activities such as rafting and canoeing (Nyaupane and Chhetri, 2009).

South Asian floods of 2017

During August 2017, Bangladesh, India, Nepal and Pakistan were hit by heavy monsoons that caused devastating floods across the countries. An estimated 1,288 people died and around 40 million people were affected by the devastation, including 16 million children (UNICEF, 2017). Although floods occur yearly between July and September in the monsoon season, the South Asian floods of 2017 were the worst in many years (the Guardian, 2017).

Human health

Climate change can directly and indirectly affect human health in various ways. Among direct impacts of climate change on health is extreme weather, which can lead to sickness from heatwaves or cold episodes, drowning or hypothermia due to floods, or exposure to infectious diseases, such as cholera. Indirect impacts include those resulting from changes in ecosystems, such as temperature, precipitation and humidity, which can facilitate the spread of infectious diseases, such as malaria, dengue fever, and food and waterborne diseases, or affect the air quality and spread of allergic diseases. Climate change is also a contributing factor for other health issues, including undernutrition and occupational health hazards, such as heat exhaustion and heat stroke from working outside for extended periods (Smith et al., 2014). Additional indirect impacts on human health include climate-driven changes to the health of livestock, since humans can become exposed to and catch climate-sensitive zoonotic diseases, such as bird flu and swine flu. Even when diseases are not transmissible from animals to humans (for example, foot and mouth disease), communities can suffer severe economic losses from the loss of livestock to the disease.

As is the case for other sectors, exposure to climate change and the ability of people and systems to respond to this will greatly determine its impact on human health. In economic terms, health can be seen as an input to human capital (the attributes of a human population that contribute to economic productivity). Thus, reduced health leads to reduced human capital, impacting economic productivity and development.

In the HKH region, climate change will mostly affect the poor, those from low social classes, women, children and the elderly, since these groups are most vulnerable and are less able to cope (Sharma, 2012). Mountain communities in most HKH countries already suffer from food insecurity and malnutrition more than communities in the plains (with the exception of India), and higher malnutrition and micronutrient deficiency rates are especially common among poorer mountain communities (Rasul et al., 2017). In addition, poorer people in HKH mountainous areas are far more likely to experience more health shocks than non-poor counterparts and are much less likely to be able to afford professional health services (Mohanty et al., 2017). These factors undermine their resilience to climate shocks and their ability to adapt.

In general, there is not much knowledge available on the specific impacts of climate change on human health in the HKH region, possibly due to the difficulty in differentiating climate change impacts from non-climatic factors, including economic, social and public health issues. However, some studies are available which examine both observed impacts and/or projections of future impacts on HKH populations (Ebi et al., 2007; Singh et al., 2011; Sharma, 2012; Gautam et al., 2013).

Though the situation varies between countries (see Sharma, 2012), HKH mountainous populations are vulnerable to increases in the frequency and/or intensity of heatwaves, GLOFs, flash floods, waterborne diseases, vector-borne diseases (especially malaria), water scarcity and drought-related food insecurity. With the current projected increase in temperatures and increased variability and intensity of precipitation, Ebi et al. (2007) claim that HKH countries are likely to experience more climate-related health impacts in the future.

The HKH region and its downstream areas are very familiar with extreme events, many of which cause natural disasters with very significant health impacts. An estimated average of 76 disaster events occurred in the region every year between 1990 and 2012, with about one third of these related to flooding (Guha-Sapir et al., 2016). Throughout 2000–2013, flooding also affected the most people in the region compared with extreme heat and droughts (Shrestha et al., 2015a). The four largest floods in the region during the same period killed more than 10,000 people and displaced over 50 million (Shrestha et al., 2015b).

Although not as impactful as floods, according to Miyan (2015), Afghanistan, Bangladesh, Bhutan and Nepal have all experienced increased droughts due to changing precipitation distribution patterns. Droughts are expected to become more frequent in drought-prone areas, as dry areas become drier (Shrestha et al., 2015a), and are likely to result in poor agricultural production which will consequently threaten food and nutrition security (Ebi et al., 2007).

Climate change has also been linked to changes in the distribution and seasonality of vector-borne diseases. Some areas in the HKH region have already recorded increased incidents of vector-borne diseases, which will likely spread to higher altitudes as temperatures become warmer (Ebi et al., 2007; Gautam et al., 2013; Dhimal et al., 2015). For example, in Nepal, vector-borne diseases, including malaria, Japanese encephalitis, dengue fever, visceral leishmaniasis and lymphatic filariasis have all spread to areas considered non-endemic, including hill and mountain regions. Climate change is believed to be an important reason for this spread, along with other factors, such as increased movement of people, trade, land-use changes, urbanization and access to medical care (Dhimal et al., 2015). Bhattacharya et al. (2006) and Dhiman et al. (2011) both find that the Indian Himalayas region will become more vulnerable to malaria towards the mid-twenty-first century, as more months and areas develop conditions favourable for malaria (Dhiman et al., 2011). Increases in floods and droughts are expected to influence the prevalence of water-related diseases, such as diarrhoea and water-washed diseases, due to the contamination of water sources and lack of water for hygiene purposes (Ebi et al., 2007).

A study from 2011–2012 that included over 8,000 households around the Upper Indus, Koshi, eastern Brahmaputra and Salween and Mekong rivers found that the majority had experienced climate-induced health risks in the last 12 months. These included an increase in family sickness (44 per cent) and livestock diseases (25 per cent). Another survey of 576 households in the communities of the Kangchenjunga area (eastern Indian and Nepalese border) noted increases in skin-related diseases such as ringworm, measles or prickly heat (likely due to hotter climates), which were virtually non-existent 5–10 years ago (Chaudhary et al., 2011).

While the impacts of climate change on human health are estimated to be negative overall, there are some positive impacts. For example, elderly people in the high mountains and herders in the Tibetan Plateau have reported that winters have been more comfortable during the past decades due to milder temperatures (Eriksson et al., 2008). In addition, mountain communities are less likely to be affected by hazards such as heatwaves (Sharma, 2012).

Relationship between climate change and water-borne diarrhoea in northern India

India has one of the world's highest rates of child mortality due to diarrhoeal disease, with over 200,000 deaths reported in 2010.

Most outbreaks of diarrhoea in India occur during the hot summer months (March–May) and the wet and humid monsoon months (June–September).

Above a minimum threshold, there is a linear relationship between diarrhoea incidences and rises in temperature or days of precipitation/an extreme event. For example:

- per 1°C rise in temperature, incidences increase up to 6 per cent
- for each day of extreme rainfall (above 64.5 mm/day), incidences increase up to 2 per cent.

Above a minimum threshold, there is a linear relationship between diarrhoea incidences and decreases in precipitation and relative humidity. For example:

- per mm/month decrease in rainfall, there is an increase of 0.4 per cent
- for each 1 per cent decrease in relative humidity, gastroenteritis incidences by more than 2 per cent.

Adapted from Moors et al., 2013.

Summary of key hazards, vulnerabilities and risks

Climate Hazards[7]	Key Vulnerability	Key Risk
Floods and flash floods	• Dependency on agriculture or other industries vulnerable to flooding • Poor land management and spatial planning practices • Communities and infrastructure located in flood plains and other geographically exposed areas • Poor drainage infrastructure • Limited capacity of local and national public institutions to respond and adapt • Dams at risk of failure due to flooding • Limited access to insurance against climate-related losses • Limited capacity of local and national public institutions to respond to natural disasters and adapt to increased floods	• Death and injury • Displacement of people • Destruction of infrastructure, including hydropower facilities • Erosion of agricultural land and crop failures • Loss of land productivity due to sludge • Destruction of cultural heritage • Disturbance of trade routes • Increased risk of landslides and landslide dam outburst floods • Shallow water table pollution • Increase in waterborne diseases (kala-azar, cholera, diarrhoea etc.) • Damages to forest, riparian, aquatic and other ecosystems • Changing course of river basins • Contamination of water sources • Eroded and degraded hillsides and watersheds • Damage to aquatic ecosystems
Landslides	• People living on or below steep hillsides • Communities with weak infrastructure and housing • Degraded ecosystems, for example, due to land-use changes	• Death and injury • Displacement of people • Destruction of infrastructure and housing
Heavy snow and cold extremes	• Rural mountain communities, particularly the elderly and children, located in high altitudes with poor road access, housing and infrastructure • Limited access to insurance against climate-related losses • Dependency on livestock vulnerable to cold extremes	• Inaccessibility of essential services (e.g. emergency health care) and reduced communication due to heavy snow precipitation and cold extremes • Increased cold-related mortality and morbidity, especially among vulnerable sectors of the population • Economic and livelihood losses due to loss of livestock • Changes in ecological characteristics caused by climate change may affect the significance of sites of cultural and religious tourism • Loss of agricultural crops

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Summary of key hazards, vulnerabilities and risks *(continued)*

Climate Hazards[7]	Key Vulnerability	Key Risk
Avalanches	• Communities, property and infrastructure in avalanche-prone areas • Poor avalanche monitoring • Insufficient nature-based and man-made protection infrastructure • Poorly trained mountaineers and guides	• Death and injury • Damage to property and infrastructure
Heatwaves	• The elderly are more likely to experience respiratory and cardiovascular problems during heatwaves	• Deaths and injury from cardiovascular diseases in vulnerable populations • Death and injury from lung inflammation • Increased asthma attacks
Wildfires	• High exposure of forests, agricultural land and other important habitats • High exposure of settlements and physical assets, including tourism operations, in wildfire-prone areas • Lack of early warning and firefighting capacities • Limited access to insurance against climate-related losses • People, including urban communities, living in the vicinity of wildfire areas and also communities further away exposed to gas and particulate matter from wildfire smoke	• Loss of biodiversity, habitats and ecosystem services • Land degradation • Economic losses and disruptions to livelihoods with high rehabilitation costs • Displacement of people and communities • Death or injury through direct or indirect health impacts, e.g. respiratory health problems
Glacial lake outburst floods (GLOFs)	• People, animals and property located below unstable glacial lakes • Limited access to insurance against climate-related losses • Lack of infrastructure such as drainage, early warning systems and water management systems	• Death and injury • Economic and livelihood losses • Widespread impacts on socioeconomic systems, hydrology and ecosystems • Possible dam breaches causing flooding downstream • Risk to hydropower plants, irrigation infrastructures, drainage systems and municipal and industrial water supplies
Reduced snow cover	• Reliance of tourism economy on dramatic mountainous setting, including snow cover	• Economic losses for mountain communities reliant on snow-based tourism • Loss of ecosystems dependent on current snow dynamics

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Summary of key hazards, vulnerabilities and risks *(continued)*

Climate Hazards[7]	Key Vulnerability	Key Risk
Melting glaciers	• Large number of glaciers sensitive to climate change • Communities and cities dependent on glacial meltwater for at least some of the year • Communities with insufficient water storage infrastructure • Ecosystems dependent on glaciers and historical melting rates	• Water insecurity • Crop failure • Degradation of ecosystems • Formation and expansion of glacial lakes and wetlands at high altitude, raising risks of GLOFs
Droughts and erratic precipitation patterns	• Hydro- and thermal power facilities exposed to decreases in annual river discharge and changing seasonality of flows • Irrigation and water supply needs of agriculture and farming • Limited access to insurance against climate-related losses • Poor water infrastructure, such as with high losses in the system • Ecosystems dependent on current water dynamics, such as aquatic ecosystems	• Decreased security of energy supplies, which are unable to meet energy demands during months when output is lowest • Loss of crops and livestock • Reduced forage availability due to changing from dzos to horses as pack animals • Delayed and shorter farming season in some areas • Water shortages in major urban areas • Increased sediment loading and erosion, degraded hillsides and watersheds, reduced water quality and increased salinity of groundwater • Reduced productivity and biodiversity in streams and rivers with risks to aquatic ecosystems • Loss or degradation of natural scenic beauty, with impacts on economy and livelihoods
Slow onset rising temperatures (Temperature rising at a faster rate in higher altitudes)	• Agricultural crops maladapted to particular temperature ranges to grow productively • Famers with limited resources to adapt agricultural practices	• Changes in crop patterns and seasons • Soil fertility degradation • Lower productivity leading to economic losses (e.g. decline in orange yields in north-eastern India) • Decline in other resources such as forage and fodder, leading to resource conflicts

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Summary of key hazards, vulnerabilities and risks *(continued)*

Climate Hazards[7]	Key Vulnerability	Key Risk
Slow onset rising temperatures *(continued)*	• Ecosystems and water bodies vulnerable to increased evapotranspiration	• Progressive decline in soil moisture leading to increased fire risks, reduced agricultural productivity and ecosystem functions, and economic losses • Less infiltration affecting groundwater recharges • Invasion by xeric (dry area) species (e.g. mikania, eupatorium, lantana) • Change in utility values of alpine and subalpine meadows • Increased degradation and destruction of peatlands (bogs, marshlands, swamps, bayous) • Increased evapotranspiration and reduced moisture content will reduce the area of wetlands at low altitudes (such as Loktak Lake, Deepor Beel) • Drying and desertification of alpine zones
	• Human health dependent on environment and ecosystem services • Communities not accustomed to vector-borne diseases, which could rise in higher altitudes • People with limited experience with vector-borne diseases such as dengue fever, Chikungunya and tick-borne diseases, which may spread to higher altitude areas due to increasing temperatures • Limited capacities and funds for health sectors and communities to adapt	• Reduced availability of medicinal plants for traditional health care • Increase in vector-borne diseases (e.g. malaria and dengue) • New diseases and disease vectors • Morbidity, illness and increased burden on health-care systems • Epidemics • Climate change may exacerbate pests and diseases in plants, animals and humans
	• Permafrost sufficiently close to melting points • Buildings and infrastructure built on such permafrost	• Release of greenhouse gases and positive feedback loops for climate change • Appearance and disappearance of new water bodies (positive and negative) • Damage to infrastructure and buildings from permafrost thawing • Enhanced risks from climate hazards or earthquakes, leading to, for example, mudslides and landslides
Ecosystems degradation	• Rare, endemic and vulnerable species and habitats that are sensitive to temperature changes, such as ecosystem types near the edges of their historical distributions • Ecosystems/species unable to migrate to suitable climate conditions • Ecosystems vulnerable to changes in water bodies and soil moisture • Communities that depend on vulnerable ecosystem processes, species or services • Vulnerable migratory species due to discrepancies between migration patterns and available food	• Habitat loss and fragmentation • Loss of species and genetic diversity • Reduction and/or loss of ecosystem services, resources and livelihoods • Increase in undesirable and invasive species (e.g. mimosa in Kaziranga) • Changes in biomass productivity • Ecological shifts – changes in species persistence and distribution of ecological zones (e.g. migration to higher altitudes) • Non-native fungal diseases and invasive species (including insect pests) may damage forests and other ecosystems

HINDU KUSH HIMALAYAN MOUNTAINS

Adaptation policies

Farm in Punakha Valley, Bhutan

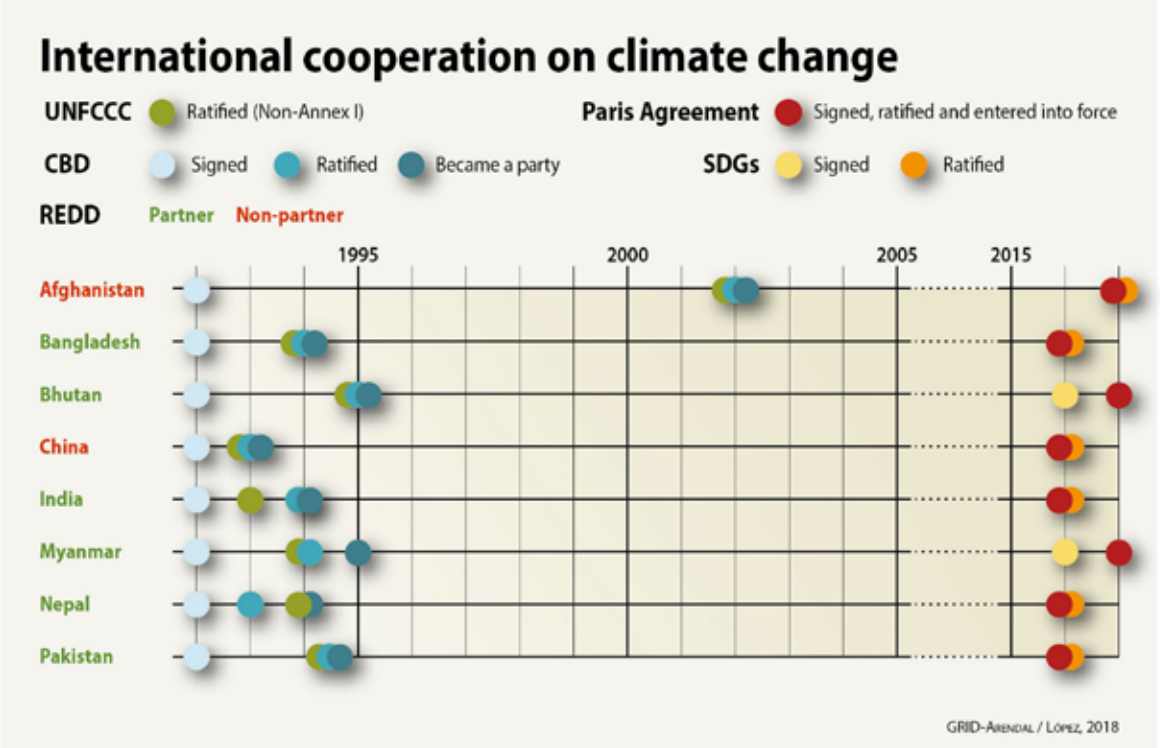
Adaptation policy responses for vulnerable sectors

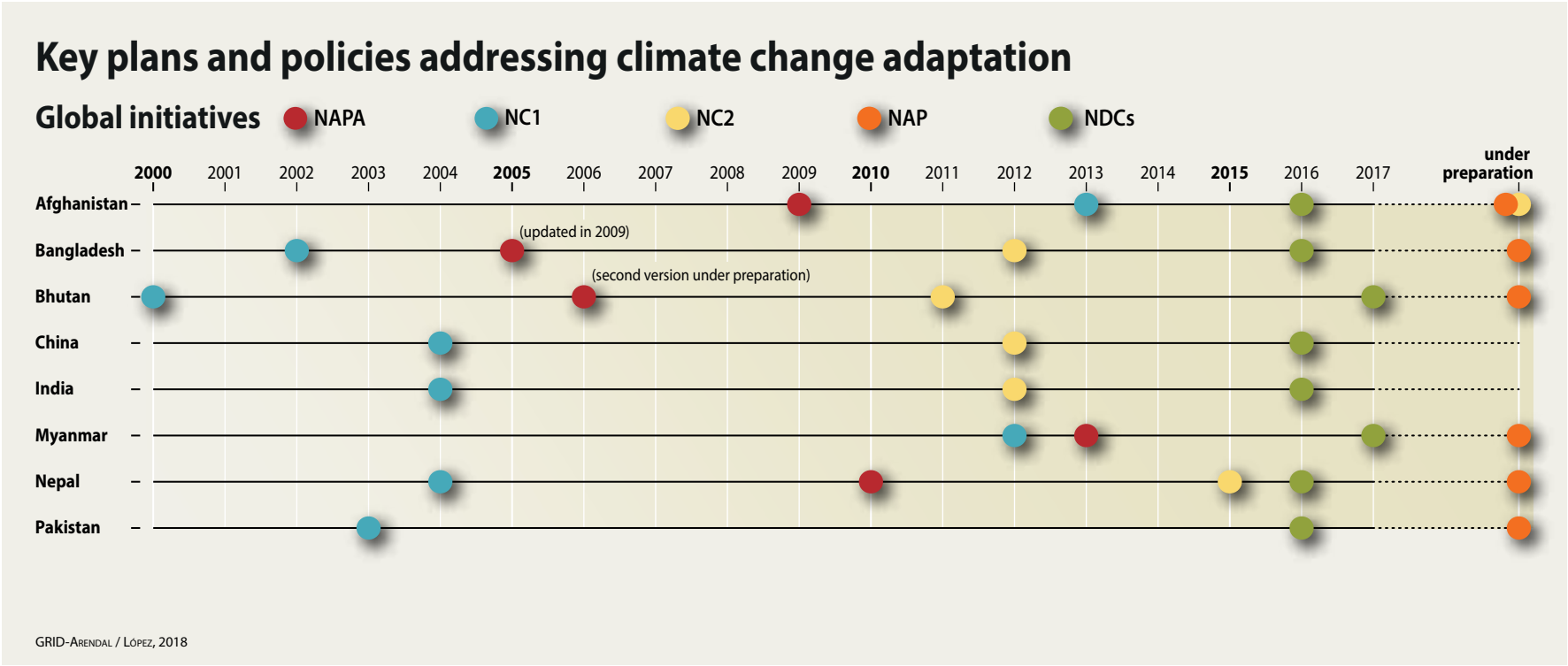
According to the Asian Development Bank (ADB), under a business as usual scenario (which uses high emission scenario trajectories from the Fourth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC) and assumes no mitigation or adaptation efforts beyond the current levels), climate change is projected to cost the South Asian region up to 2 per cent of its gross domestic product (GDP) by 2050 and up to 9 per cent by 2100 (Ahmed et al., 2014). In the projected worst-case scenario, the region could lose up to 24 per cent of its annual GDP by 2100. These figures stress the need for national policies that consider climate change impacts and promote strategies that include mitigation and adaptation actions. Adapting to climate change is a complex process and includes a number of activities, from risk reduction and early warning systems to capacity-building and livelihood diversification, in addition to policies that recognize interactions between different sectors. Moreover, national policies should provide long-term predictability and certainty and ensure coordination between local and central governments. Greater regional cooperation is needed, as is coherence between the policies of different countries to tackle transboundary climate change impacts. Given the global nature of climate change, international cooperation and agreements should also be reflected in national and regional policies.

Rice production in Bhutan

Adaptation efforts at the global level

The United Nations Framework Convention on Climate Change (UNFCCC) is the leading mechanism in global cooperation on climate change, with the Kyoto Protocol, adopted in 1997, and the Paris Agreement, adopted in 2015, as its main agreements. The Paris Agreement supports countries' adaptation efforts in line with their national objectives and nationally determined contributions (NDCs), which include the country's specific capabilities, priorities and actions towards addressing climate change. More specific action on adaptation under the UNFCCC include the Nairobi work programme (NWP), established in 2005 to help Parties, and particularly least developed countries (LDCs), establish policies and practices through the development, dissemination and use of knowledge, and the Cancun Adaptation Framework (CAF) adopted in 2010, which includes the Adaptation Committee (AC). The AC is tasked with supporting Parties' adaptation efforts through the following functions: providing technical support and guidance to the Parties; sharing relevant information, experiences and good practices; promoting cooperation between international, national and regional organizations, centres and networks; providing information and recommendations to the Conference of the Parties (COP) on adaptation-related issues; and considering information from Parties on their monitoring and review of adaptation actions, and on support provided and received. Additional adaptation-related initiatives under the UNFCCC include the Adaptation Knowledge Portal (AKP), a product of the NWP, which has been established as an open access knowledge hub for climate change adaptation-related information, methods and tools.





Other United Nations organizations, including FAO, UN Environment, the United Nations Development Programme (UNDP), the United Nations International Strategy for Disaster Reduction (UNISDR) and the World Health Organization (WHO) also support international cooperation and adaptation efforts, and multilateral processes such as the Convention on Biological Diversity (CBD), the United Nations Convention to Combat Desertification (UNCCD), the Sendai Framework for Disaster Risk Reduction 2015–2030 (Sendai Framework) and the Sustainable Development Goals (SDGs), are relevant in this respect. The ongoing process to achieve the SDGs provides an important strategic foundation for adaptation-related policy discussions, since it encompasses all elements of sustainable development and areas central for climate change adaptation, with SDG 13 on combating climate change the most relevant.

All HKH countries have ratified the Paris Agreement and adopted the Sendai Framework and SDG's in their national development agendas. In addition, all HKH countries have ratified the CBD and most are also involved in the United Nations Reducing Emissions from Deforestation and Forest Degradation (REDD+) programme, thus providing a strong foundation for national and regional policy development in the region.

Existing regional and subregional cooperation mechanisms for adaptation

Given that climate change impacts often cut across borders, it is crucial that existing strategies and mechanisms to address hazards and possible adaptation actions include regional collaboration. Some of the leading organizations supporting regional cooperation and promoting platforms for key stakeholders to address the region's needs and demands include the South Asian Association for Regional Cooperation (SAARC), the International Centre for Integrated Mountain Development (ICIMOD), the Bangladesh, Bhutan, India and Nepal (BBIN) initiative, the Bay of Bengal Initiative for Multi-Sectoral Technical and Economic Cooperation (BIMSTEC) and the South Asia Co-operative Environment Programme (SACEP).

ICIMOD is a regional intergovernmental learning and knowledge-sharing centre based in Kathmandu, Nepal, serving the eight regional HKH countries – Afghanistan, Bangladesh, Bhutan, China, India, Myanmar, Nepal and Pakistan. It aims to help mountain people understand and adapt to the changes caused by globalization and climate change, through making the most of new opportunities, while addressing upstream and downstream issues. As a regional platform, the centre facilitates knowledge exchanges throughout the region, tailors international knowledge to the region's needs and puts regional issues on the global stage. In addition, ICIMOD supports various transboundary programmes through partnerships with institutions and regional and global centres of excellence and works to promote regional cooperation on climate change issues.

Of the eight HKH countries, six (excluding China and Myanmar) belong to SAARC, which was established to strengthen and intensify regional cooperation, promote peace, stability and progress throughout the region, including environmental protection, and to address the challenges of climate change and natural disasters. Due to the bilateral issues between some SAARC member countries, SAARC has not yet been able to achieve the full extent of its mandate (Dhungel, 2004). In 2014, the eighteenth SAARC summit adopted the Kathmandu Declaration taking into account the threats posed by climate change and were directed to initiate an intergovernmental process to appropriately contextualize the SDGs at the regional level. The SAARC Agreement on Rapid Response to Natural Disasters has been ratified by all member countries and entered into force in September 2016.

Another organization working more specifically on environmental issues is SACEP, which was established as an intergovernmental organization in 1982 by Afghanistan, Bangladesh, Bhutan, India, the Maldives, Nepal, Pakistan and Sri Lanka. SACEP have

GOOD PRACTICES

The Arctic Council

The Arctic Council is the leading inter-governmental forum promoting cooperation, coordination and interaction among the Arctic States, Arctic indigenous communities and other Arctic inhabitants on common Arctic issues, particularly sustainable development and environmental protection in the Arctic. The Ottawa Declaration lists the following countries as Members of the Arctic Council: Canada, the Kingdom of Denmark, Finland, Iceland, Norway, the Russian Federation, Sweden and the United States. In addition, six organizations representing Arctic indigenous peoples have status as Permanent Participants. The Arctic Council regularly produces comprehensive, cutting-edge environmental, ecological and social assessments through its Working Groups. The Council has also provided a forum for the negotiation of important legally binding agreements among the eight Arctic States.

GOOD PRACTICES

The Eminent Persons' Group on India-Nepal relations

The Eminent Persons' Group (EPG) is a joint mechanism with four members from Nepal and four from India that looks over existing bilateral treaties and agreements to evaluate whether they require any revision. This includes reviewing the India-Nepal Peace and Friendship Treaty of 1950, the existing trade regime, and cooperation in sharing water resources. The EPG meets every three months in India and Nepal, alternately.

a wide range of programmes and collaborate with agencies, including United Nations organizations. Although not directly involved in policy development, SACEP does help member countries build and exchange knowledge and provides support for implementing relevant programmes related to climate change issues.

BIMSTEC is a regional organization comprising seven member states: Bangladesh, Bhutan, India, Myanmar, Nepal, Sri Lanka and Thailand. Its aim is to enable economic growth and development in sectors identified as priority areas of cooperation, including trade and investment, transport and communication, energy, agriculture and public health, among others. In recent years, BIMSTEC has focused on the impact of climate change on its priority sectors. During the Fourth BIMSTEC Summit in August 2018, the organization's member countries committed to forming an Intergovernmental Expert Group to develop a plan for collective action on climate change.

Although not specifically focused on climate change issues, the BBIN initiative is also a key player in regional cooperation in the HKH. The initiative in particular promotes cooperation between countries on cross-border issue, such as infrastructure, transport, water management and electricity, through data-sharing and exchanges of experiences and best practices in these areas.

Mountains of the Everest region, Nepal

National plans and policies for climate change adaptation

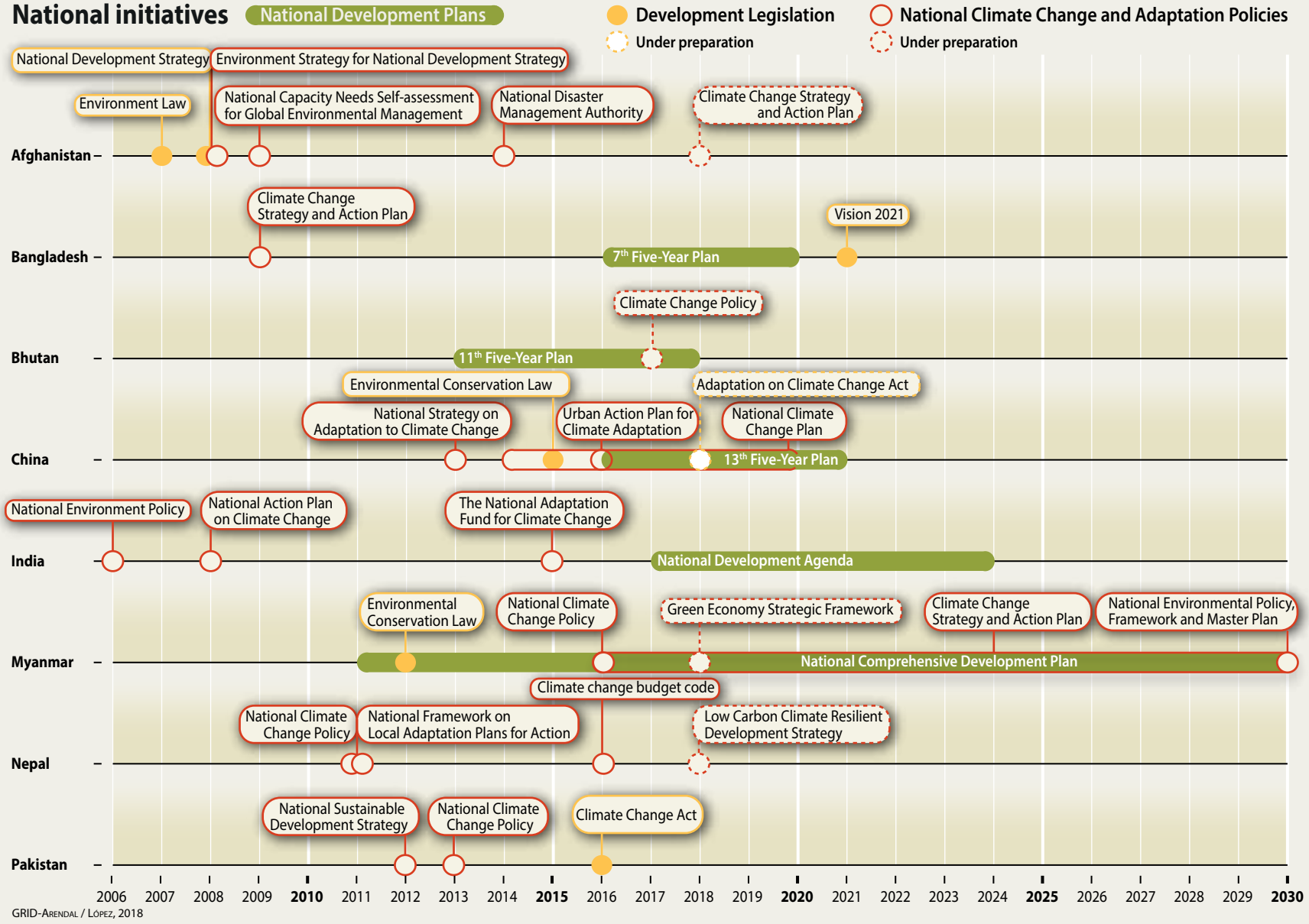
At the national level, all HKH countries have ongoing National Adaptation Plans (NAPs), and the region's LDCs have developed National Adaptation Programmes of Action (NAPAs), excluding China, India and Pakistan. Some HKH countries have adopted or are currently developing policies and strategic instruments specifically designed to address climate change adaptation, while others are relying on National Communications (NC) to the UNFCCC and sectoral measures beneficial to adaptation. Most HKH countries have national disaster management committees, which have modified their disaster response from rescue and relief efforts to focusing on preparedness, through risk mitigation, reconstruction, sustainable development and early warning systems.

In its National Development Strategy, Afghanistan identifies the environment as a cross-cutting issue and targets water, natural resource management, agriculture, energy and rural development as priority areas. As part of its seventh Five-Year Plan, Bangladesh provides strategic directions and a policy framework that considers climate change adaptation efforts to accelerate economic growth and reduce poverty. Bhutan is the first carbon-negative country in the world and has identified water, agriculture, forests, disasters and health as areas that could be impacted by climate change. China outlines long-term approaches for addressing climate change in its National Climate Change Programme and National Climate Change Adaptation Strategy, which include implementing mitigation and adaptation efforts, researching science and technology, increasing public awareness and focusing on the monitoring, warning and response system for emergency events. India includes the environment and climate change in the framework of its National Environmental Policy, promoting sustainable development and social justice. Myanmar has a National Climate Policy and a Climate Change Strategy and Action Plan, and is currently awaiting the approval of six sectoral action plans from the President's Office. Nepal launched its NAP development process in 2015 to address the country's medium- and long-term adaptation needs, and is in the process of drafting its Environment and Climate Change Act. Through its Climate Change Act, Pakistan aims to establish a Climate Change Council to implement policies on climate change.

To link national and global efforts, all HKH countries prepared intended nationally determined contributions (INDCs) for the COP 21 in Paris in 2015. The INDCs comprised each countries' planned efforts to mitigate climate change and strategies to adapt to climate change impacts. The INDCs were integral to the negotiation of the Paris Agreement. Through adopting the agreement, countries have committed to submitting NDCs to the UNFCCC Secretariat every five years, with the next submission due in 2020. In their NDCs, all HKH countries point out that the socioeconomic conditions, varied topography and existing climate of the region makes them especially vulnerable to climate change and related hazards. Furthermore, they all note flood and water management as climate change issues that particularly require adaptation measures, and drought is mentioned by all countries, except Bhutan. Given their high dependence on agriculture, all countries also stress the need for better climate and resilience of sectors that influence food production. In their NDCs Afghanistan, Bhutan, Nepal and Pakistan include glacial lake outburst floods (GLOFs), India and Nepal address heavy snow and cold extremes, and Bhutan and Nepal express concern for mountainous areas. To achieve mitigation targets and adaptation measures, all countries – except China – rely heavily on foreign investment and grant support.

It is important to note that the above-mentioned central policies provide "umbrella" coverage and support to the specific sectoral policies analysed below. However, there is a need to also examine all the existing policies and mechanisms that provide commendable support to the various sectors.

Key plans and policies addressing climate change



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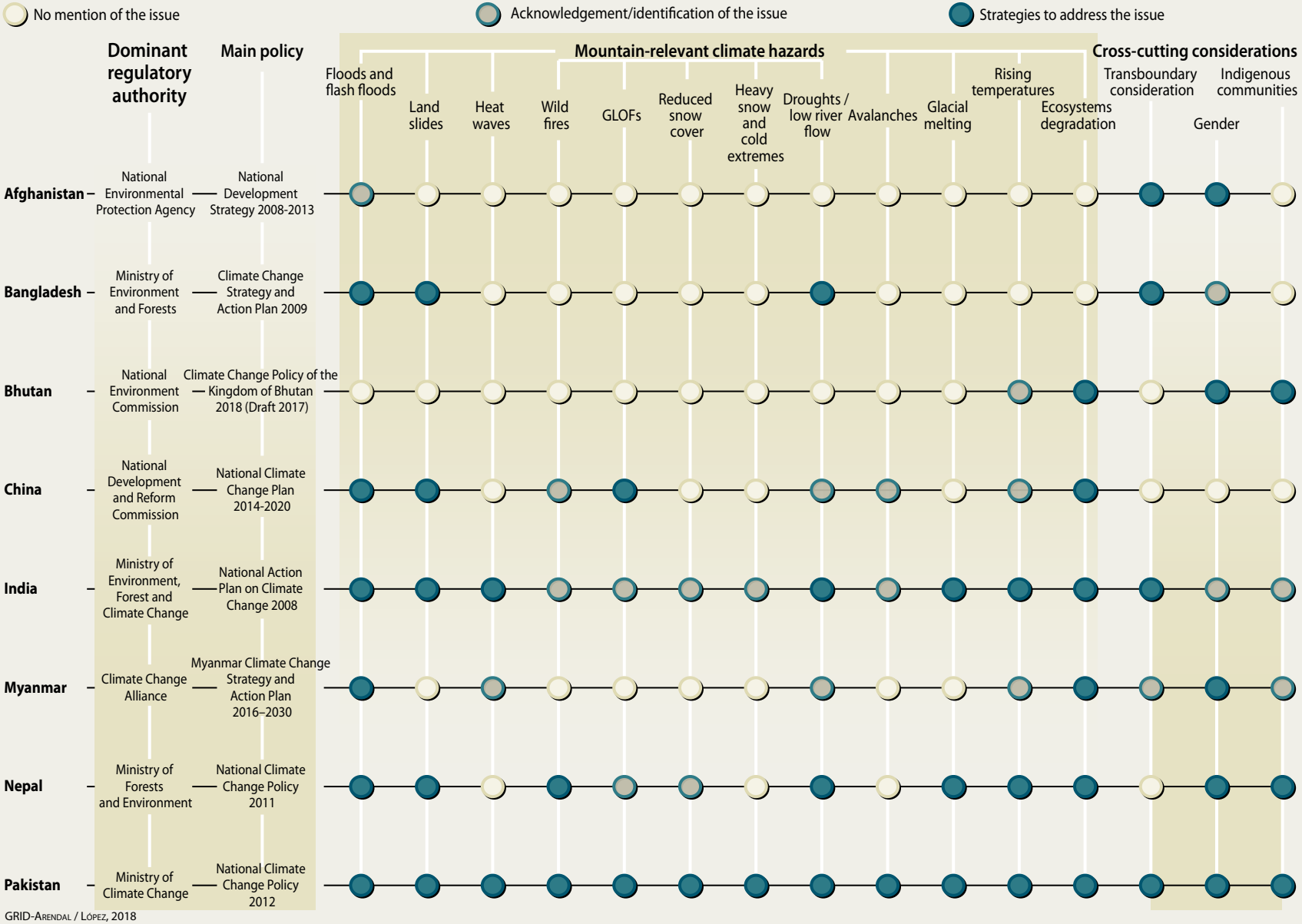
Key sectors addressed in the NDCs of the HKH countries

Key sectors	HKH countries							
	Afghanistan	**Bangladesh**	**Bhutan**	**China**	**India**	**Myanmar**	**Nepal**	**Pakistan**
Water	Addressed under Climate Change Trends, Impacts, and Vulnerabilities; and Climate Change Adaptation	Mentioned under Mitigation, Addressed under Adaptation	Included under Mitigation and Addressed under Adaptation	Addressed under Policies and Measures to Implement Enhanced Actions on Climate Change	Addressed under Mitigation Strategies and Adaptation Strategies	Addressed under Adaptation	Addressed under Policies, Strategies and Frameworks; and Building Climate Resilience	Included under Policy Initiatives; Addressed under Adaptation; and Mitigation
Agriculture, food and nutrition	Addressed under Climate Change Adaptation; and Climate Change Mitigation	Included under Mitigation	Addressed under Mitigation and Adaptation	Addressed under Policies and Measures to Implement Enhanced Actions on Climate Change	Addressed under Adaptation Strategies	Addressed under Mitigation Contribution and Adaptation	Included under Policies, Strategies and Frameworks; Adaptation Actions; and Mitigation Actions	Addressed under Policy Initiatives; Adaptation; and Mitigation
Forests, biodiversity and ecosystems	Addressed under Climate Change Adaptation; and Climate Change Mitigation	Addressed under Mitigation and Adaptation	Addressed under Mitigation and Adaptation and Means of Implementation	Addressed under Policies and Measures to Implement Enhanced Actions on Climate Change	Addressed under Mitigation Strategies; Adaptation Strategies; and India's Climate Change Finance Instruments	Addressed throughout the NDC	Addressed throughout the NDC	Addressed under Policy Initiatives; and Mitigation
Energy	Addressed under Climate Change Adaptation; and Climate Change Mitigation	Addressed under Mitigation	Addressed under Mitigation and Adaptation	Addressed under Enhanced Actions on Climate Change; and Policies and Measures to Implement Enhanced Actions on Climate Change	Addressed under Mitigation Strategies; and India's Climate Change Finance Instruments	Addressed throughout the NDC	Addressed under Policies, Strategies and Frameworks; Mitigation Actions; and Nepal's NDC	Addressed throughout the NDC
Infrastructure and urban areas	Mentioned	Included under Mitigation and Addressed under Adaptation	Included under Mitigation and Adaptation	Addressed under Policies and Measures to Implement Enhanced Actions on Climate Change	Addressed under Mitigation Strategies, and included under Adaptation Strategies	Addressed under Mitigation Contribution, Included under Adaptation	Mentioned under Institutions and Mitigation Actions	Included under Policy Initiatives; Addressed under Adaptation
Human health	Mentioned	Included under Adaptation	Included under Adaptation	Mentioned	Addressed under Adaptation Strategies	Mentioned under Adaptation	X	Mentioned
Tourism	X	X	X	Mentioned	X	X	Mentioned	X

Addressed = explicit strategies to address the issue; Included = issue is taken into consideration; Mentioned = issue mentioned but no defined considerations or strategies; X = not addressed, included or mentioned

Langtang Valley, Nepal

Consideration of mountain-relevant hazards in climate change policies



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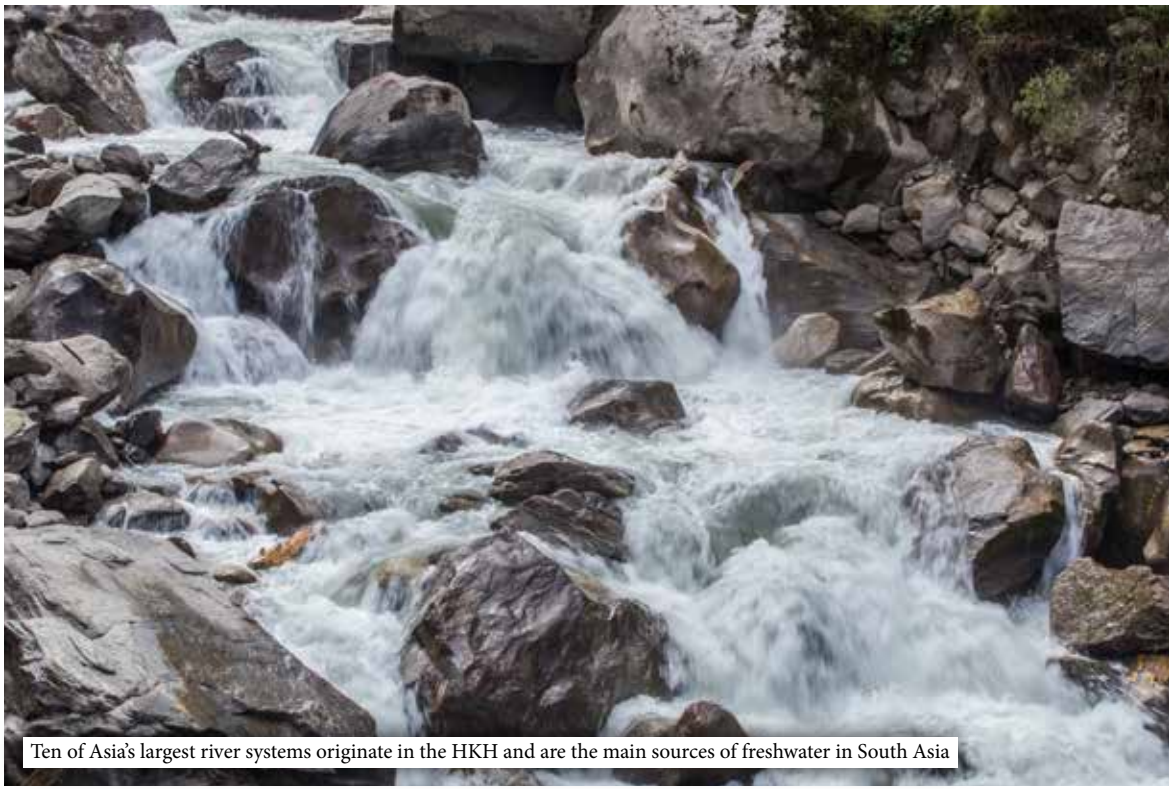
Sectoral strategies within the HKH countries

Water

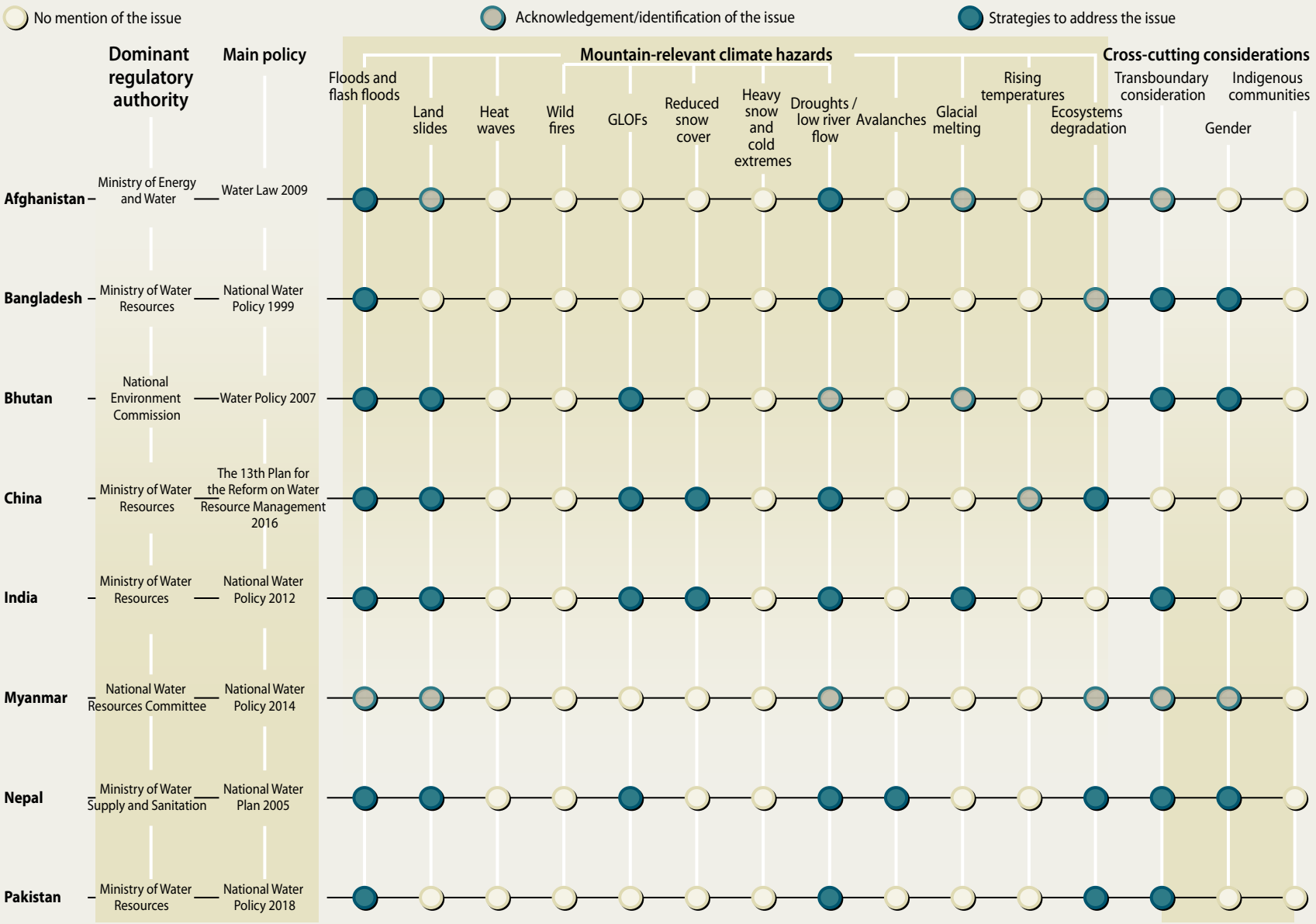
Numerous authorities, acts and policies within each HKH country address the water sector in relation to climate change adaptation, but the analysis examines only the main policy for each country. The central governments are responsible for adopting legislation and for the planning and development of the sector, whereas the regulation of the sector takes place at the subnational/state level in some countries.

Afghanistan's National Capacity Needs Self-Assessment for Global Environmental Management identifies water as one of the sectors most vulnerable to the impacts of climate change, and its Strategic Policy Framework aims to sustainably develop and manage the country's water resources by actively involving user organizations, institutions and the private sector. Bangladesh is seeking to build cross-country collaborations; to develop regional action plans to address water security, integrated river basin management, GLOF hazard zoning, early warning systems, flood prevention and management; and to strengthen hydrological and meteorological networks. The Water Act of Bhutan focuses on integrated water resources management, and its National Integrated Water Resources Management Plan aims to use climatic, hydrological, social and institutional assessments to avert water crises in the future. China's Opinions of the State Council on Implementing the Strictest Water Resources Management System, and Opinions of the State Council on Accelerating Progress in Water Ecological Construction aim to address issues such as water-resource development and utilization control, water-use efficiency control, and pollutant-load control in water function zones. India's National Water Mission aims to ensure integrated water resources management and equitable distribution of water, whereas the National Water Policy takes cognizance of the current water situation. Myanmar's Water Vision aims to make water resources sustainable by 2030. In 2014, the country drafted its National Water Policy to transform governance of water resources from a sectoral approach to one of integrated river basin management. Nepal's Rural Water Supply and Sanitation Sector Policy addresses the need for a safe, convenient and adequate water supply, with a specific focus on disadvantaged groups. Meanwhile, its National Water Plan aims to maximize the benefits of sustainable water use. Finally, Pakistan's National Drinking Water Policy aims to provide safe drinking water to the entire population by 2025; its National Climate Change Policy recommends the formulation and enforcement of river floodplain regulations and laws; and its Water Vision 2025 aims to generate hydroelectricity, prevent water shortages, limit drought and increase water storage.



Ten of Asia's largest river systems originate in the HKH and are the main sources of freshwater in South Asia

Consideration of mountain-relevant hazards in water policies



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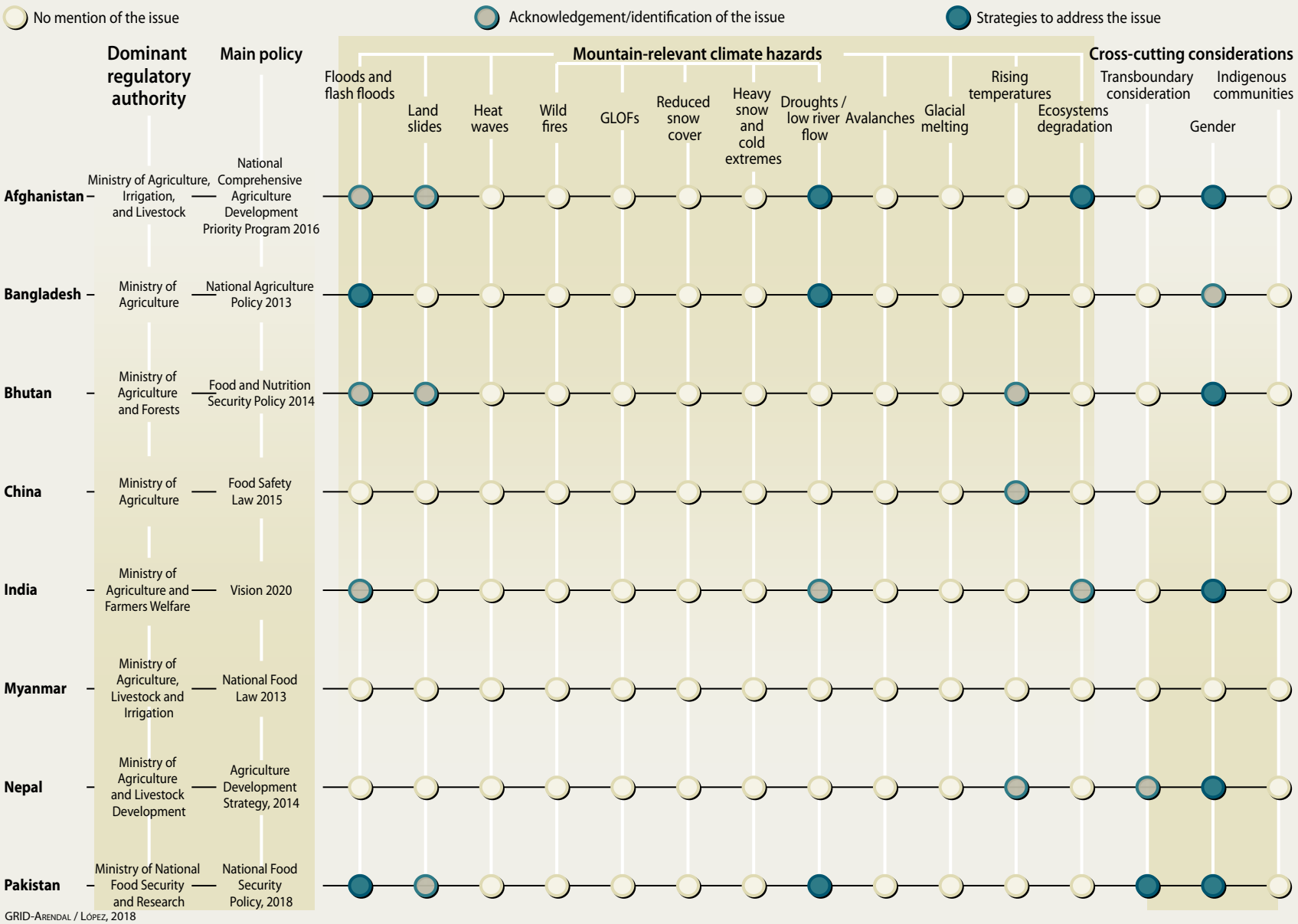
Strawberry farming in Bhutan

Agriculture, food and nutrition

Agricultural legislation underpins sustainable farming in most of the HKH countries. Local, short-term impacts such as flash floods and unexpected drought seasons have adverse impacts on this sector. In addition, the projected increases in temperature and precipitation are expected to produce long-term impacts such as loss of livelihoods and worsening nutritional security. It is therefore unsurprising that Afghanistan's National Agricultural Development Framework emphasizes the importance of environmental sustainability, while India's National Mission for Sustainable Agriculture aims to enhance food security, and focuses on new technologies and practices in cultivation and crop genotyping. India is also leading a National Food Security Mission (launched in October 2007), which is continuing during the country's twelfth Five-Year Plan, with new targets of an additional production of 25 million tons of food grains (10 million tons of rice, 8 million tons of wheat, 4 million tons of pulses and 3 million tons of coarse cereals). Afghanistan, Bangladesh, India, Myanmar and Nepal all indirectly mention food security in their constitutions, either through the duty of the State to ensure the nutrition and health of its citizens, or as one of their fundamental rights. Although all the countries have regulations on food quality and hygiene, only Bangladesh, Bhutan, China and Pakistan have proper strategies to enforce these regulations.

Consideration of mountain-relevant hazards in agriculture, food and nutrition policies



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Forests, biodiversity and ecosystems

Most of the HKH countries have adopted new forest legislation to introduce multifunctional and sustainable forest management, and have integrated a number of comprehensive nature protection regulations and programmes within this legislation.

Bangladesh's Climate Resilient Participatory Afforestation and Reforestation Project is also aligned with its seventh Five-Year Plan (2016–2020) to conduct climate-resilient afforestation and reforestation, and Bhutan's eleventh Five-Year Plan (2013–2018) aims to conserve and promote the sustainable utilization of forest resources. In China, the Wildlife Protection Law (2016) aims to protect its wild animals, and maintain biodiversity and ecological balance, while the Forestry Climate Change Adaptation Action Plan (2016–2020) promotes climate change adaptation in forests through pilot projects, and evaluates the effect of climate change on biodiversity.

Meanwhile, India's National Mission for Sustaining the Himalayan Ecosystem addresses glacier-associated hydrological, biodiversity and wildlife conservation consequences of climate change, and its National Mission on Himalayan Studies aims to build on scientific and traditional knowledge for climate change adaptation. Myanmar's National Biodiversity Strategy and Action Plan (2012) contains strategic directions to improve the conservation of priority sites, and to educate and raise public awareness on biodiversity conservation. In Nepal, the Climate Change Policy (2011) promotes the proper utilization and conservation of forest resources to support alternative livelihoods, while the country's Forest Policy (2000) guides subsectoral programmes relating to forests, wildlife and biodiversity. Pakistan's National Forest Policy (2015) and Forestry Sector Strategy 2016–2025 aims to expand the coverage of forests, protected areas, natural habitats and green areas to restore ecological functions and maximize economic benefits.

All HKH countries are also signatories to the Convention on Biological Diversity (CBD) and have a National Biodiversity Strategy and Action Plan. In addition, the United Nations Development Programme (UNDP) helps manage and expand protected areas in Afghanistan, and supports the establishment of its Parks and Wildlife Authority. In Bangladesh, the National Forest Policy (1994) on resource conservation and development constitutes the basis for responsive legislation and establishes the administrative authority for protected areas (PAs). In India, all Government-owned forests and other important ecosystems that are outside the legally designated PA network, but occupy ca. 20 per cent of the geographical area of the country, are covered by some form of conservation planning and managed for biodiversity conservation. In addition, the country's National Environmental Policy (2006) advises that human activities around PAs should be monitored to minimize their adverse impact, while Myanmar's National Forestry Master Plan of the Ministry of Environmental Conservation and Forestry mandates increasing PAs to cover 10 per cent of the country's total land.

Altogether, the HKH region comprises 500 PAs, covering 39 per cent of the total land area (including 40 per cent of the land covering critical ecoregions), and fosters transboundary cooperation on biodiversity/landscape conservation, for example through the work promoted by ICIMOD. Globally, PAs are recognized as important tools for sustainable development and climate change adaptation: beyond conserving species and ecosystems, they provide essential ecological, social, and economic services – such as clean water, carbon storage, genetic reservoirs, disaster mitigation, and soil stabilization – and opportunities for preserving the region's cultural heritage. If well managed, PA networks can improve resilience to disasters and foster transboundary connections.

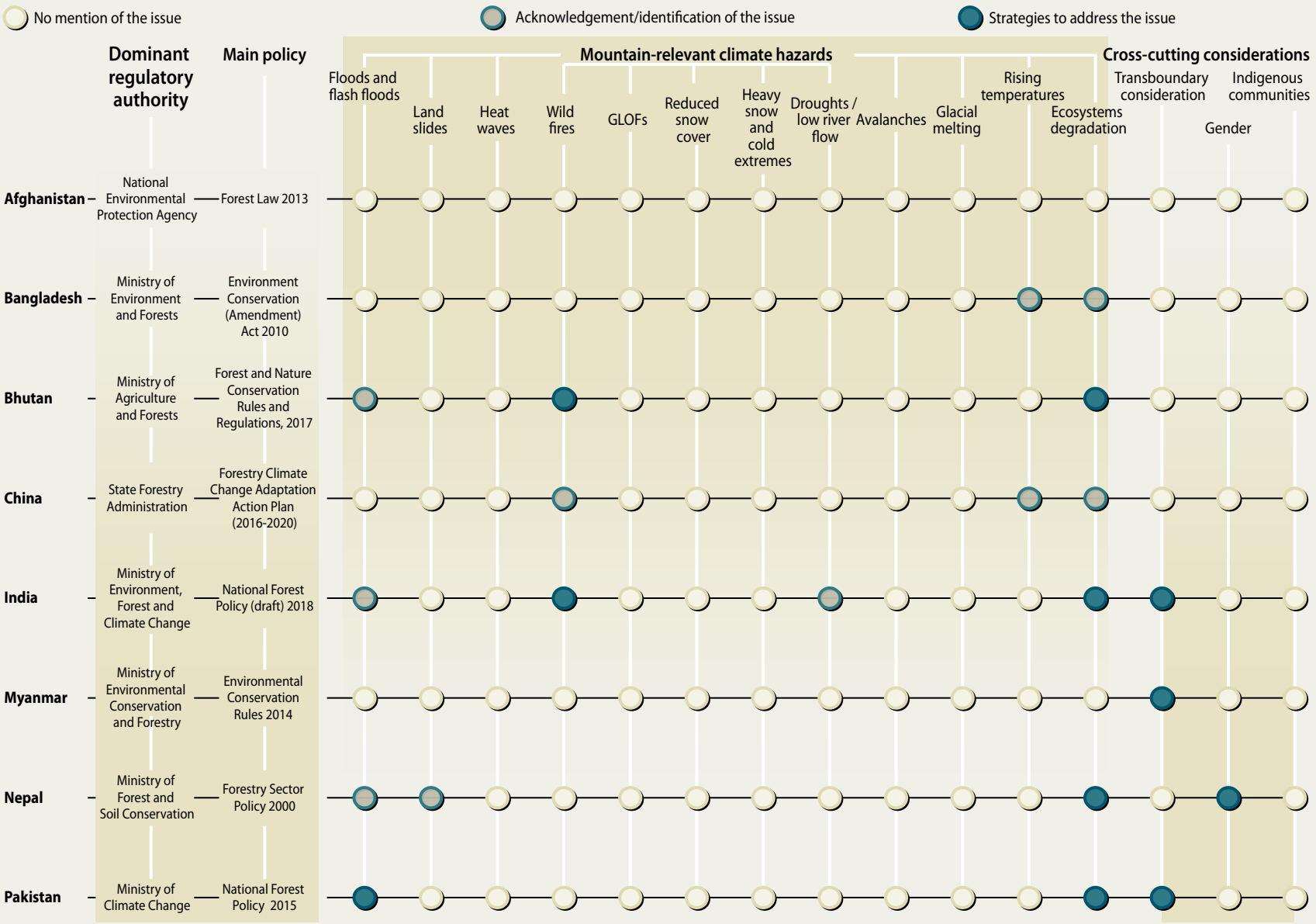
There has also been reasonable progress towards adopting an ecosystem approach in conservation planning, sustainable use of recourses and value chain creation for mountain niche products, and towards developing national and regional policy innovations for access and benefit-sharing.

GOOD PRACTICES

Bhutan for Life

Bhutan for Life is an initiative by the Government of Bhutan and the World Wildlife Fund (WWF). It is an innovative financing mechanism which aims to generate funds that will be used to maintain and manage the country's protected area network forever. The funding mechanism is "project finance for permanence", which effectively means full and permanent funding for protected areas. The approach starts with the development and agreement of a conservation plan which has well-defined targets and goals, and includes a financial plan. Donors are then invited to contribute to the fund, which are held back until a certain funding amount is reached, and all legal and financial obligations are met. Money from donors (USD $43 million) is then placed into a transition fund, and payments progressively decrease to zero over a period of 14 years, as the Government of Bhutan progressively steps up its own contribution to the fund (totaling USD $75 million) over the same time period until it fully funds all protected areas. This is the first initiative of its kind in Asia, launched in November 2017.

Consideration of mountain-relevant hazards in forest policies



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However, PA governance systems need to be further refined to respect traditional knowledge and also to address tangible and intangible benefits for traditional societies living in and around a PA. Based on interdisciplinary research findings, the traditional knowledge systems therefore need to be cautiously integrated into new technologies.

Energy

The emerging energy policies and actions in the HKH countries aim to make production and consumption more efficient, and to promote a transition to low- or zero-carbon energy sources. In general, the energy policies address electricity, gas and petroleum, and several countries have adopted plans to ensure that their population has access to electricity. For instance, Bangladesh has committed to provide affordable and reliable electricity for all of its citizens by 2021, and Myanmar has developed a National Electrification Plan in response to the increased demand for energy. Additionally, Afghanistan has developed a Rural Renewable Energy Strategy Action Plan (2018), China a Renewable Energy Law (amended in 2009), and Bhutan has a Renewable Energy Policy (2011) with a vision of a 100 per cent renewable energy supply based on hydropower. Some countries also have specific policies on nuclear energy, namely India (Atomic Energy Act (1962, amended 1987) and Regulations (1996)) and Afghanistan (Nuclear Energy Law (2015)).

At the regional level, during the eighteenth SAARC summit in Kathmandu in 2014, the member countries signed a Framework Agreement for Energy Cooperation. This agreement opened up the energy market and possibilities for cooperation, and recognized the importance of electricity in promoting economic growth and improving quality of life. The SAARC Member States also agreed that the common benefits of cross-border electricity exchanges and trade among them could optimize the use of regional electricity-generating resources.

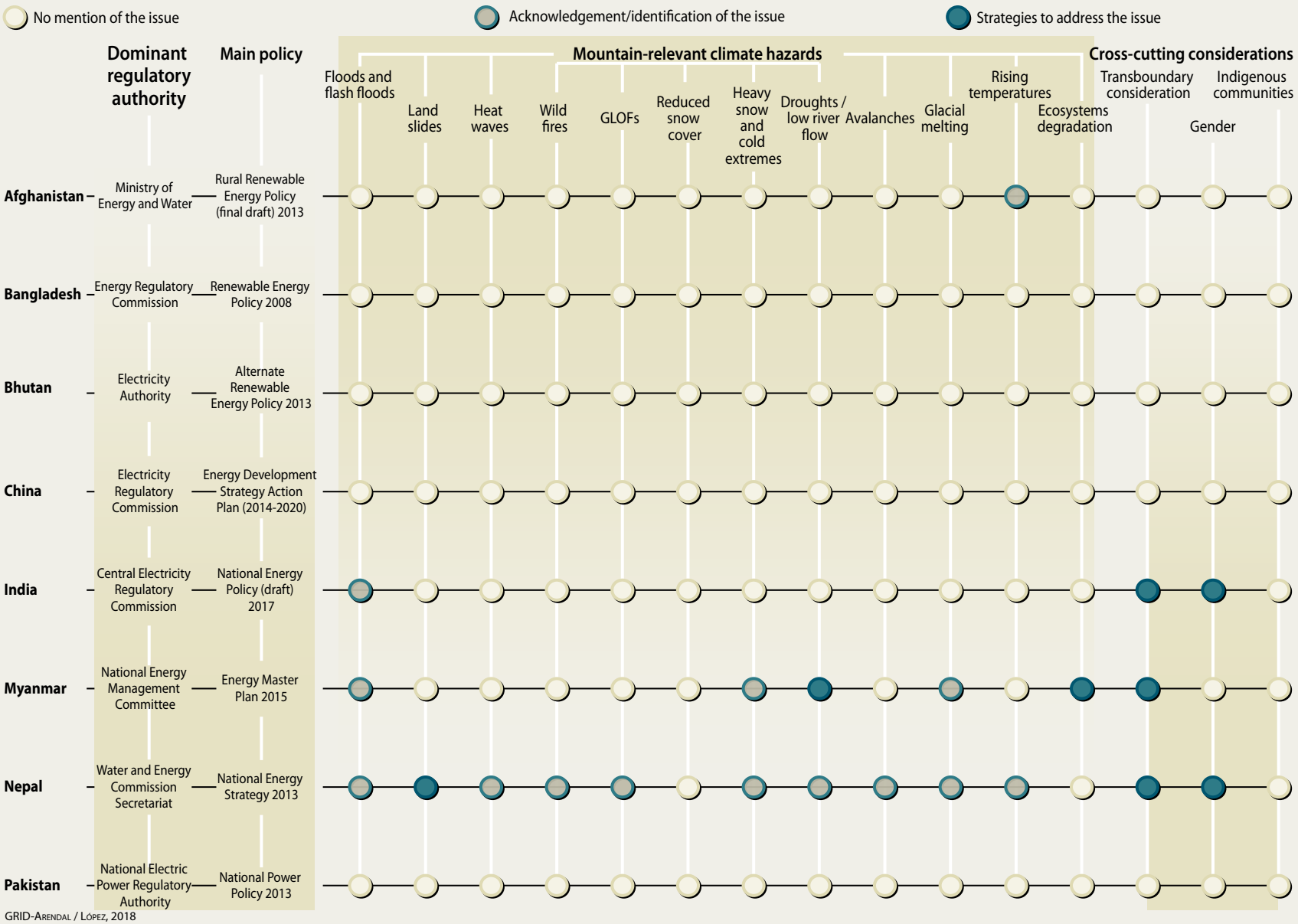
Shimla, India

GOOD PRACTICES

South-South Cooperation Training Programme on Climate Change Adaptation

The South-South Cooperation Training Programme on Climate Change Adaptation is an initiative financed by the Government of China through the Department of Climate Change of the National Development and Reform Commission (NDRC). The program had its first training in August 2017, which included participants from 57 countries including from the HKH region. The trainings aim to share knowledge about China's measures and achievements in addressing climate change and low-carbon development, to examine the policy and technology requirements of participants' countries, to help foster cooperation opportunities between Chinese enterprises, research institutes and organizations from developing countries, and to promote the application of energy conservation and low-carbon technologies.

Consideration of mountain-relevant hazards in energy policies



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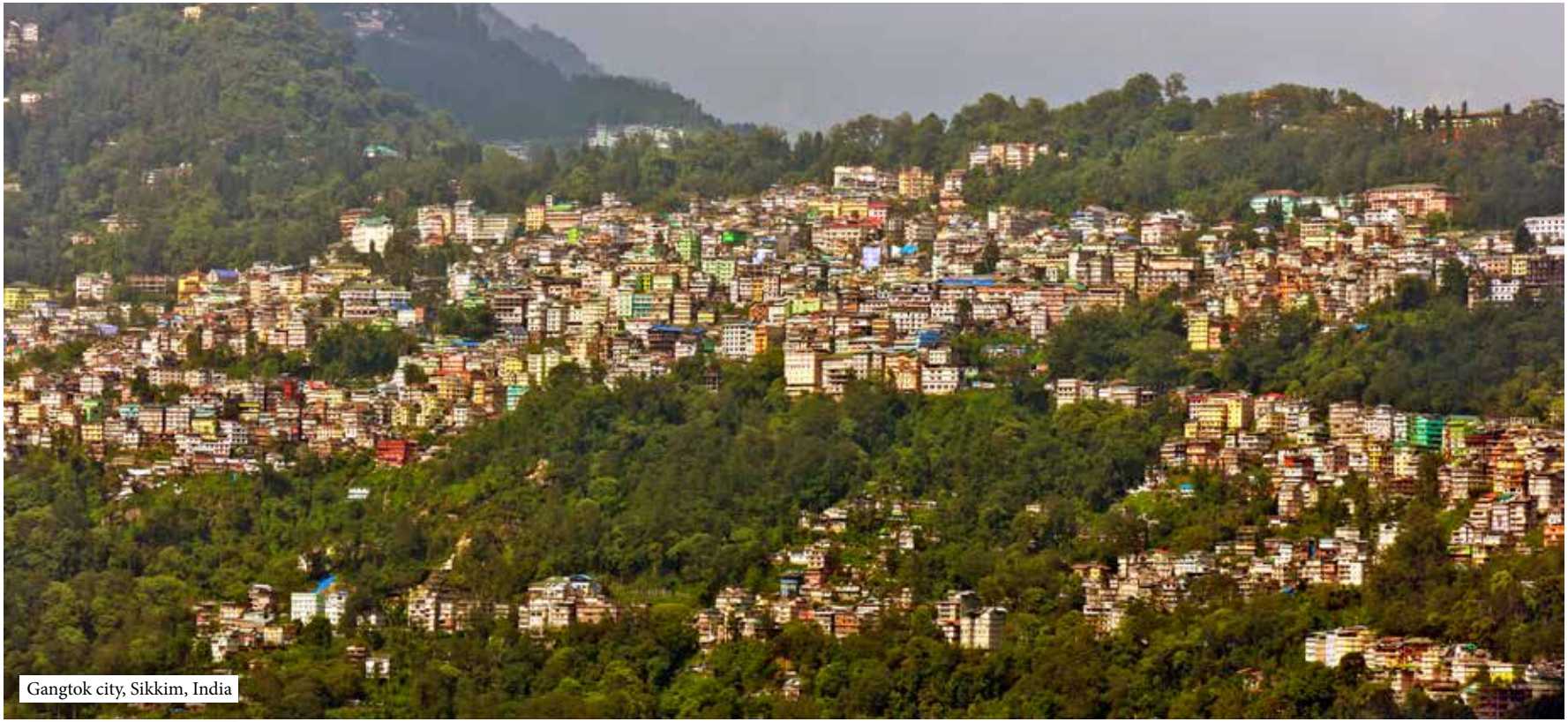


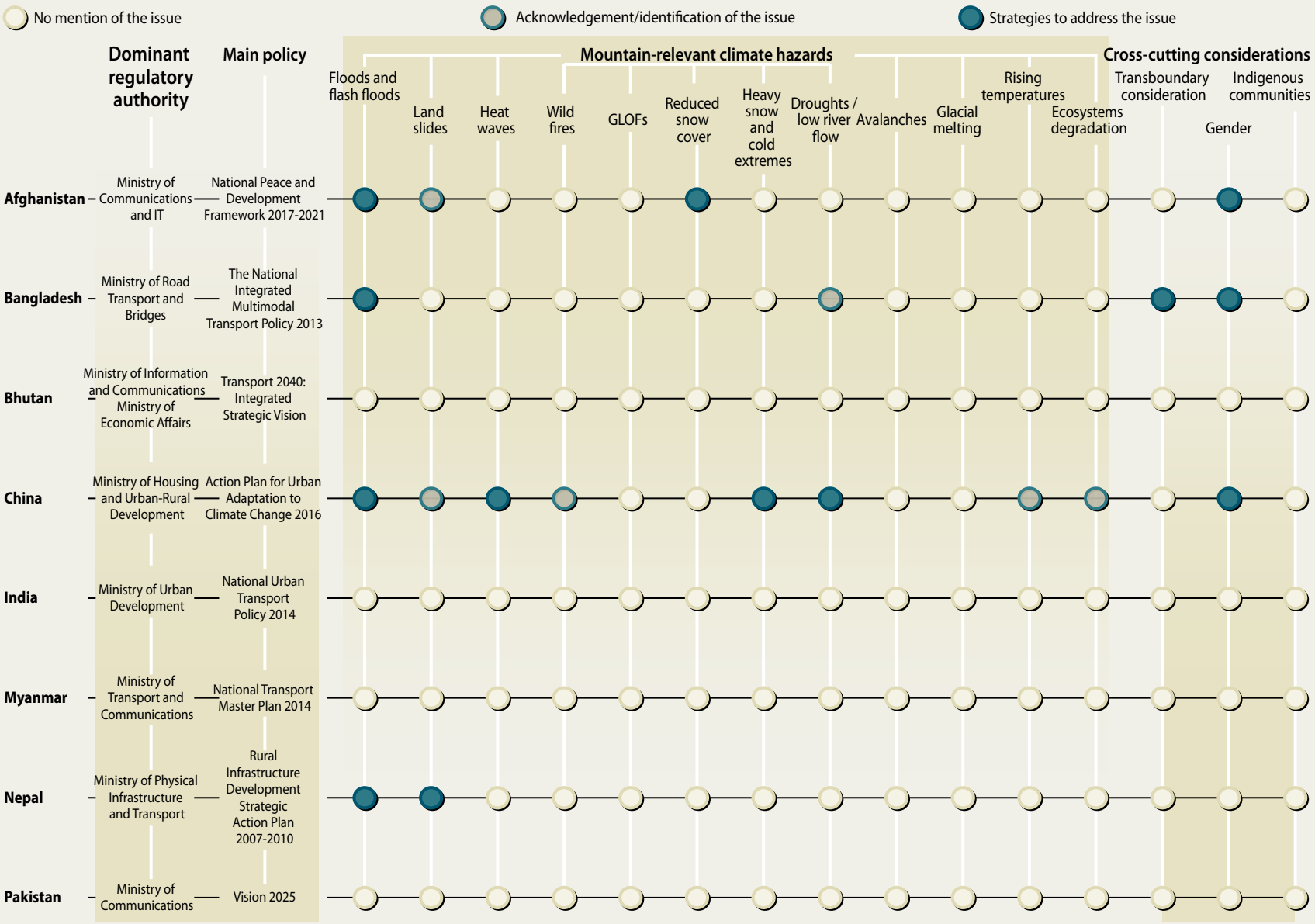
Gangtok city, Sikkim, India

Infrastructure and urban areas

The legislation governing transportation, infrastructure and communication in the HKH countries mainly focuses on building connectivity and improving accessibility. In most cases, climate change impacts on this sector are given only limited consideration, although there is a focus on making the transport sector less polluting. For example, Bangladesh's Land Transport Policy of 2004 supports the establishment of an environmentally friendly transport system. Similarly, Bhutan's Transport 2040: Integrated Strategic Vision aims for more energy-efficient transport modes, and cleaner fuels and technologies. Both of these countries have mitigation strategies to address increasing pollution, while China's Action Plan for Urban Adaptation to Climate Change includes developing pilot initiatives to adapt cities to climate change.

At the North East Connectivity Summit in the city of Agartala, India in September 2016, Bangladesh spoke of its desire to improve connectivity with India, while BIMSTEC leaders discussed accelerating the construction of physical multi-modal connectivity in the region. Taken together, these initiatives also open up the possibility of extending port connectivity from the Bay of Bengal to the landlocked north-eastern states via transit through Bangladesh. India is also looking at expanding subregional cooperation among BBIN (Bhutan-Bangladesh-India-Nepal) countries to cover initiatives in rail and air connectivity and the power sector. In addition, China unveiled the One Belt and One Road initiative (OBOR) in 2013, a development strategy that focuses on connectivity and cooperation between China and Eurasian countries via the land-based Silk Road Economic Belt (SREB) and the ocean-going Maritime Silk Road (MSR). In mid-2016, the name was changed to the Belt and Road Initiative (BRI), with a focus mainly on infrastructure investment, construction materials, railways and highways, cars, real estate, the power grid, and iron and steel.

Consideration of mountain-relevant hazards in infrastructure/urban policies



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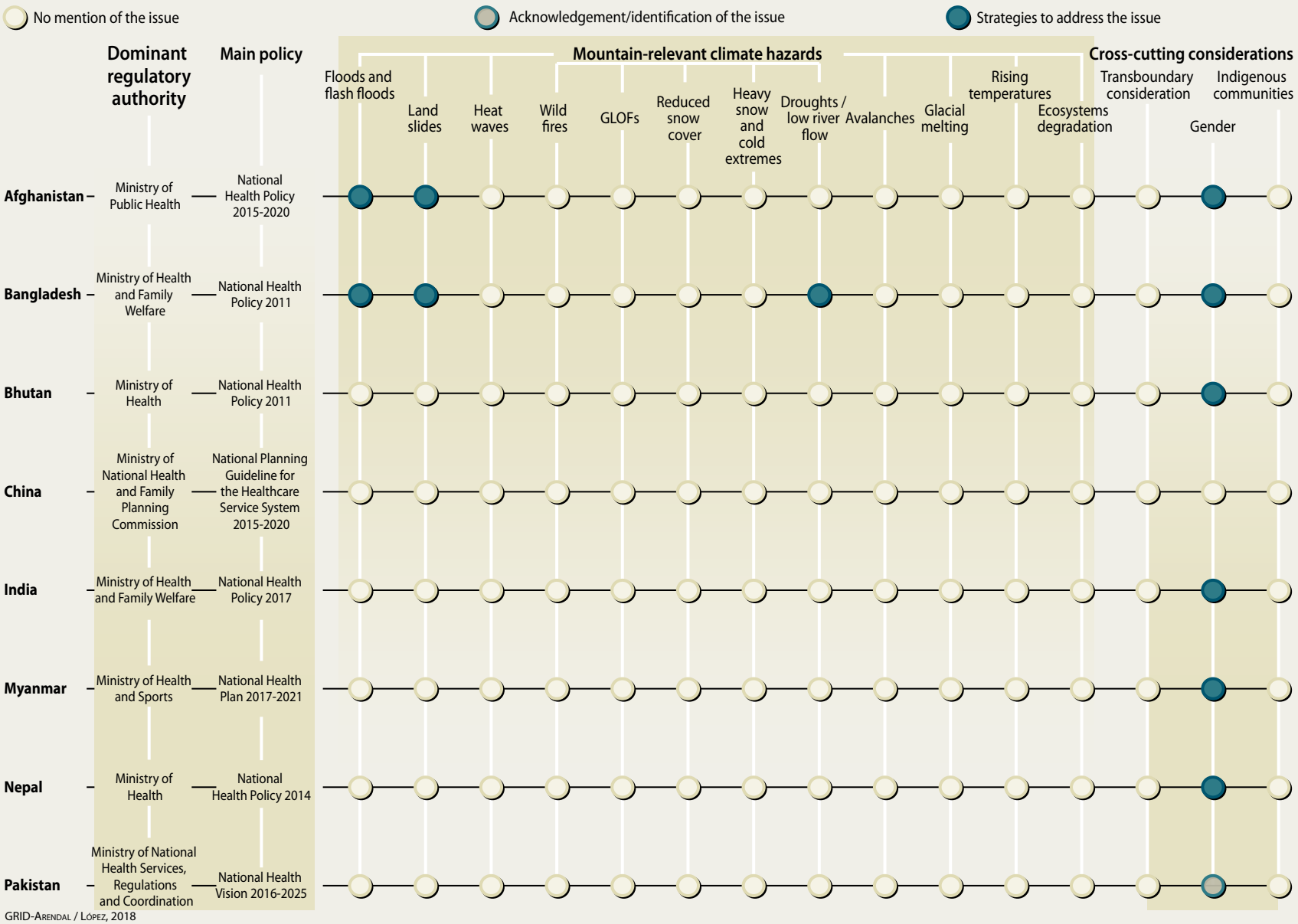
Man feeding doves, Afghanistan

Human health

The development of national health policies, strategies and plans is a complex and dynamic process that varies from country to country according to the political, historical and socioeconomic context. Nonetheless, it is important to point out that the HKH countries are increasingly working to strengthen their health systems, with an emphasis on public health in their policies.

Through its National Health Policy, Afghanistan is aiming to strengthen its authorities' capacities in emergency preparedness and their response to recurrent natural disasters. Bhutan's policy focus has been on improving its population's health and well-being by achieving its Millennium Development Goals (MDGs) for 2015, and subsequently working towards achieving its SDGs. Meanwhile, India is focusing on reducing the impact of climate change and natural disasters on the health of its population. Many international donors, including the Japan International Cooperation Agency, are supporting health in Myanmar.

Consideration of mountain-relevant hazards in health policies



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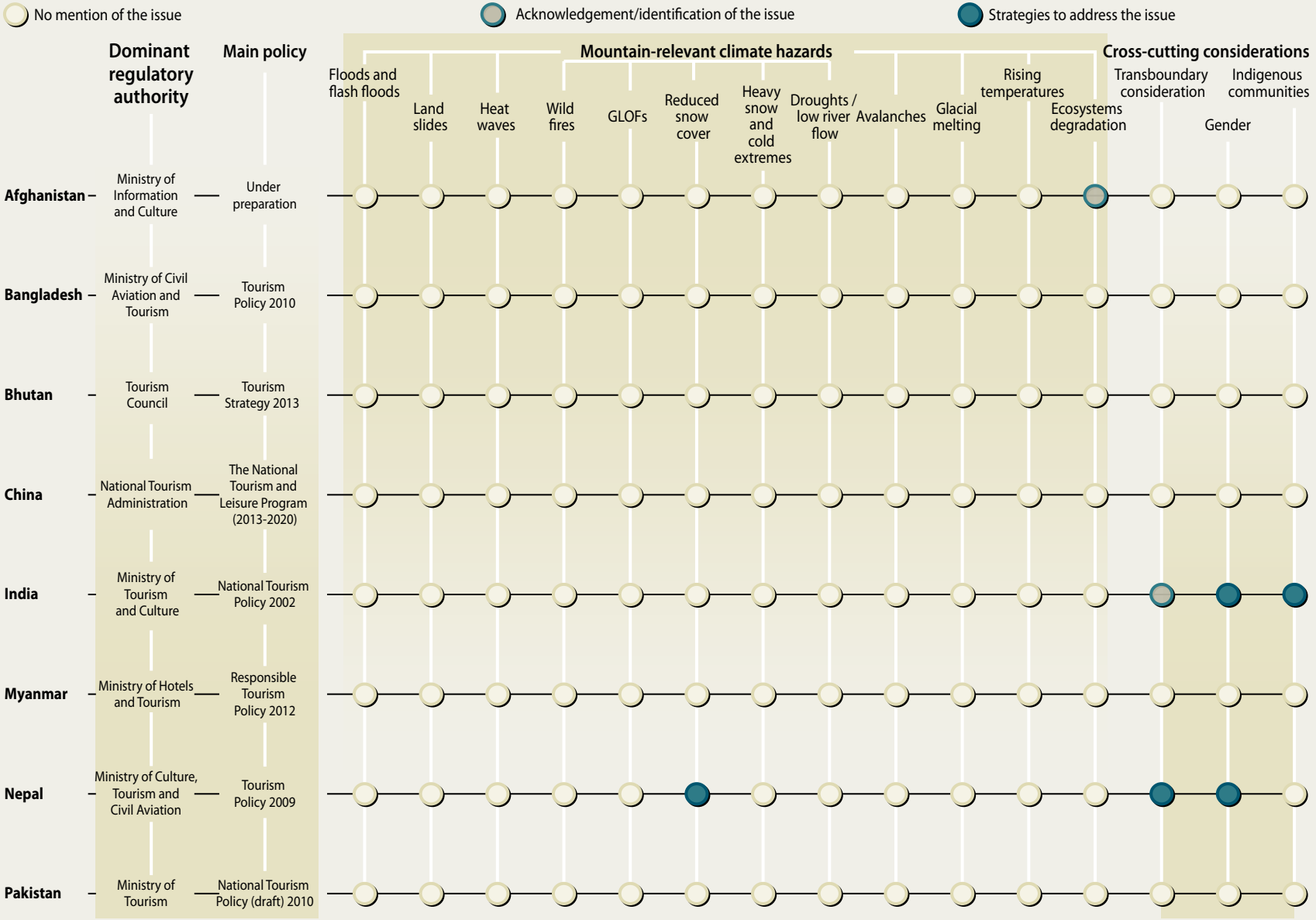
Consideration of mountain-relevant hazards in tourism policies



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Tourism

Some HKH countries – Bangladesh, China and Nepal – have begun to recognize climate change related impacts as limiting factors for the tourism sector, although the focus is mainly on improving the sector's environmental sustainability, rather than 'climate-proofing' it from the adverse impacts of climate change (see chapter 2). For example, Bhutan's High Value, Low Impact Policy uses financial mechanisms to control the volume of tourists and protect fragile local environments. Meanwhile, China's Tourism Policy (2013–2020) aims to provide a better setting for national tourism and leisure, whereas Myanmar's Responsible Tourism Policy and Tourism Master Plan (2013–2020) focus on environmental protection. In addition, Nepal's Tourism Policy promotes the sustainable use of national heritage (i.e. natural and cultural places) and its Tourism Vision 2020 emphasizes that women and marginalized groups should also benefit from the sector.

Climbers on Stok Kangri Mountain, Ladakh, India

Chapter 3 has described the numerous global agreements and programmes to address climate change, including efforts to increase communities' resilience and their ability to adapt to the adverse impacts of climate change. Discussions on adaptation-related policies have also underlined the importance of multilateral processes such as the SDGs. However, the policy analysis in this chapter reveals that many mountain-relevant issues are poorly represented in existing country-led processes and policies for the HKH countries, including their NAPs and INDCs.

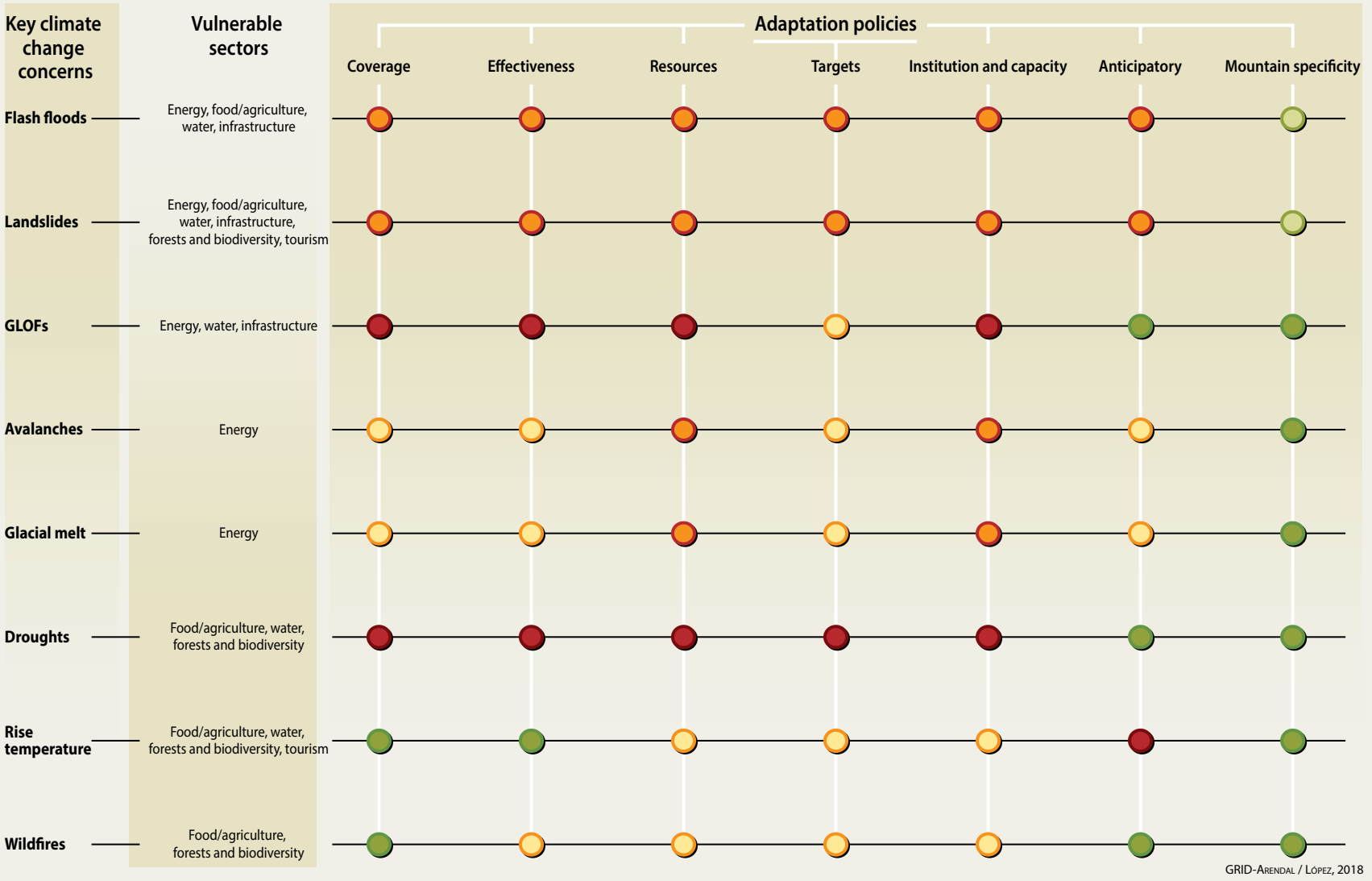
One obvious explanation is that policies that affect mountain communities are often formulated outside the mountainous area, while the entire HKH region struggles to be appropriately represented in the IPCC and other global forums. For example, scientists from the region represented less than 6 per cent of all expert reviewers of the AR4 assessment reports (IPCC, 2014). Hence, there is a need for broader inclusion of scientists from these countries on global platforms and initiatives to advocate for the region. Such participation can provide the opportunity to highlight mountain-relevant issues and the need to include them as a key consideration in planning for future practices and global action on climate change adaptation in the HKH.

The policy analysis underlines the need to strengthen mechanisms within the HKH countries themselves to address climate change hazards and adaptation specifically for mountain areas, by revealing several sector-relevant adaptation gaps (a detailed gap analysis is provided in chapter 4). The analysis has not attempted to investigate each and every existing policy in terms of its effectiveness. However, expert opinion gathered in the process of producing this Outlook[8] indicates that adaptation policies across the HKH vary greatly in terms of their coverage, effectiveness, resources, targets, institution and capacity, anticipatory approach, and mountain specificity. As the table on the next page is based only on the respondents' feedback, the key climate concerns are not the same as the complete list provided in the tables in this chapter.

Key climate concerns for vulnerable sectors

Applicability of existing adaptation policies in the HKH countries*

This table was developed based on collective analysis of information obtained from the Regional Policy Workshop on Adaptation Outlook for the Hindu Kush Himalaya, 02-03 February 2017, and feedback from policy experts.



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HINDU KUSH HIMALAYAN MOUNTAINS

Gap analysis

Mountains in Yunnan, China

Introduction to the analysis

This chapter identifies existing gaps in the aforementioned policies, as well as providing key recommendations for adaptation and outlining existing good practices. One important tool linking national and global efforts on climate change are the respective countries' NDCs, which address the key sectors well overall. Even the hitherto neglected areas of tourism and human health are now beginning to gain due attention and importance from both the scientific community and policymakers. However, more concrete steps need to be taken towards addressing adaptation in these two sectors, given their critical importance for community livelihoods and overall well-being in the HKH.

Our analysis has also revealed that there are two areas that require immediate attention and strengthening throughout the HKH region – gender and indigenous communities (see chapter 3). Despite gender discrimination being a critical issue in the region, gender mainstreaming in policy documents is weak in the majority of HKH countries. Additionally, gender-relevant vulnerabilities are not adequately addressed, and there is no specific strategy regarding the impacts of climate change on women, who are disproportionately affected. Furthermore, Mishra et al. (2017) point out the limited participation of women in key decision-making and policy processes. This is a major obstacle to facilitating women's safety and productivity, and identifying them as distinct stakeholders in adaptation action planning.

Further, the participation of indigenous communities in climate change adaptation is almost non-existent in the HKH countries. Research literature suggests that these communities are socially discriminated against, especially in terms of access to land. Also, some HKH countries do not recognize indigenous peoples as indigenous, leading to the non-applicability of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP).

As Mishra et al. (2017) show, climate variability already influences water availability, ecosystem services, and agricultural production in the HKH. Women's livelihood options, adaptive capacities, roles in decision-making, and access to and control over resources are further constrained by structural and gendered inequalities, which increase their vulnerability to climate change. Despite high levels of male outmigration for work, women still operate within a highly patriarchal system that denies their full participation. Although remittances from migration have raised household finances generally in rural areas, women often lack the financial literacy necessary for money management, or they are denied power to make decisions regarding this income.

To increase community and household resilience to climatic and socioeconomic changes, it is therefore crucial to invest in strengthening women's capacities to manage the associated risks through, for example, financial literacy training and skills training on resilient agricultural practices. Policymakers and decision makers need to recognize women's increasing roles and responsibilities in agriculture, food security and natural resource management in order to create enabling policies and institutions that acknowledge women as vital agents of change and adaptation.

Basket Fisherman fishing in Inle Lake, Myanmar

Analysis of sectoral level gaps in HKH countries

Water

With climate change projected to increase water stress and water-related hazards, the impact on HKH's water resources will not only affect water availability, but also influence the overall health of the ecosystems and people's access to food, energy production and the viability of industrial sectors. At present, all the HKH countries have acts and policies that address the water sector in terms of climate change adaptation, and most of the HKH countries recognize the scale of operation for water-resource management to be at the river basin or watershed level.

All the HKH countries, except China, consider transboundary cooperation in their main policy document, in order to strengthen existing water-sharing treaties for better cooperation and to integrate transboundary water management in view of a changing climate (Sinha, 2016). Nonetheless, not all countries adequately address many mountain-relevant hazards (i.e. no direct strategies, sometimes despite recognizing these hazards). Only China identify rising temperatures, and none of the countries address the impact of heatwaves on the water sector. Furthermore, there are gaps between current and best practices. For instance, flood policies do not specifically address the contributing factors (such as deforestation due to wildfires, and embankments) and resulting landslides, and generally cater to the urban sector with a focus on preparedness or disaster response, and little attention to mitigation or limiting exposure to it. Upstream and downstream linkages are not given appropriate priority, and there are no direct references within the existing policies to link climate change in mountain regions specifically to water management.

None of the HKH countries' water policies that have been examined address the mountain-relevant hazards of wildfires (leading to loss of forest cover and resulting erosion and siltation), heavy snow and cold extremes. This might be because they are not considered the most significant hazards for this sector. Meanwhile, the significant hazard of reduced snow cover is only addressed by India and China, and Nepal is the only country considering avalanches. On a positive note, a critical hazard – ecosystems degradation – is acknowledged or addressed by the majority of HKH countries.

Policies in the water sector are relatively advanced in terms of climate change adaptation. However, more focus should be placed on both local and regional preventive measures when addressing relevant hazards, and enhancing transboundary cooperation among countries could be a way forward.

With the projected climate uncertainty and uneven spatial and temporal water availability, innovative water storage and management solutions are needed to balance the times of plenty with those of scarcity.

Agriculture, food and nutrition

As agriculture is very sensitive to climate change due to its reliance on stable temperature conditions and water availability, any climatic change will have an effect on people's livelihoods, not only affecting local food production, but also contributing to the loss of traditional practices. Despite the presence of dominant regulatory authorities and key policies, mountain-relevant hazards for this sector are not adequately addressed (i.e. no targeted strategies for identified hazards) by any of the HKH countries, and China, Myanmar and Nepal do not even mention these hazards in their key policy documents.

Although the HKH countries have regulations on food quality and hygiene, and indirectly mention food security in their respective constitutions, their existing legislation does not specifically integrate climate change adaptation. For example, it does not include provisions to regularly update information on emerging drought-affected areas and associated male outmigration, or the adverse impacts of erratic rainfall and rising temperatures on agriculture, food and nutrition. Furthermore, important hazards such as heatwaves, reduced snow cover, and avalanches are not mentioned by any of the HKH countries' main policies related to agriculture, food and nutrition. Only Bangladesh and Pakistan have strategies in place to address floods, and together with Afghanistan their policies also address droughts. Afghanistan also have strategies to address ecosystems degradation for the sector.

More attention must be paid to making agriculture more resilient in terms of the water available for irrigation purposes. Food quality, with a strong focus on nutrition, also requires consideration.

Current agricultural policies rarely consider the specific impact of climate change on women, children and the elderly. The connection between climate change risks, farming practices, and policies needs to be strengthened. Good practices on the ground that have been autonomously adopted need to be backed up by appropriate research, policies and extension services.

Forests, biodiversity and ecosystems

Most of the HKH countries have adopted new forest legislation that aims to introduce multifunctional and sustainable forest management while integrating a number of global nature protection regulations and programmes. However, mountain-relevant hazards for the sector are inadequately addressed, and Afghanistan and Myanmar do not consider any of these in their key policy document.

Even where legislation to address forest-related issues and conflicts exists, adaptation efforts and mechanisms for the sector are weak and underdeveloped. In addition, the existing policies do not appropriately address altitudinal shifts of vegetation and species leading to the loss of biodiversity and livelihoods. As for critical hazards, heatwaves are not addressed by any of the HKH countries' policies, and only Nepal mentions landslides within its key policy document.

As forest fires are rapidly emerging as a concern for the region, legislation and management policies need to be strengthened to provide targeted solutions such as fire alerts.

Policies need to better consider the current and projected vegetation and species range shift due to increasing temperatures, as this shift has the potential to adversely impact local livelihoods, ecosystem services, and human–wildlife conflicts.

Energy

The energy policies in the HKH aim to make production and consumption more efficient, and promote a transition to low- or zero-carbon energy sources. Despite this, energy is one of the most polluting sectors, and a major source of greenhouse gas emissions. All HKH countries have energy development strategies at the national level, but these have limited consideration of adaptation measures for mountain-relevant hazards that can adversely affect this sector. Although Nepal recognizes most of the identified hazards for the sector, Bangladesh, Bhutan, China and Pakistan do not mention any of them. Furthermore, targeted policies for renewable energy are lacking in several HKH countries. The HKH's hydropower potential is primarily concentrated in the mountain regions. As hydropower's dependence on water makes it vulnerable to climate change impacts such as declining precipitation or increased intensity of rainfall, appropriate policies are pivotal in developing the region's potential. However, along with insufficiencies in policies, there are strong technical and political barriers between countries (Sinha, 2016). Moreover, apart from India, Myanmar and Nepal, the countries do not address transboundary consideration and cooperation among each other, which is critical for the region's prosperity, and to address the slow progress in its hydropower development. Key mountain-relevant hazards such as reduced snow cover are not taken into account by any of these countries. Even the critical hazards of landslides, GLOFs and avalanches are mentioned only in Nepal's policy document.

Policies seeking to promote hydropower development need to consider the changing hydrological regimes, extreme climate and other events such as earthquakes, and transboundary collaboration to share the relevant critical information must improve.

Policies need to address the existing barriers for uptake by decentralizing clean energy options such as micro-hydro, solar, wind and biomass via small businesses.

Infrastructure and urban areas

Infrastructure and urban areas are vulnerable to climate change impacts such as heavy rainfall, which can trigger floods and landslides, affecting roads, bridges, communication systems and hydropower plants. The majority of the HKH countries have developed policies to regulate and guide the development of infrastructure and urban areas. However, aside from basic statements on climate-induced impacts, the policy documents offer little information about adaptation measures or goals. Of the identified hazards, Afghanistan, China and Nepal address landslides, and together with Bangladesh they also address floods. The other HKH countries – Bhutan, India, Myanmar and Pakistan – do not mention any of these as hazards in their policy documents. Furthermore, it is concerning that out of all the HKH countries, only China address the key mountain-relevant climate hazards of heatwaves, droughts and heavy snow and cold extremes.

Policies need to ensure that any infrastructure development considers the projected risks from climate hazards, for example by integrating vulnerability assessments and timely sharing of updated information on potential risk zones.

Human health

The linkage between human health and climate change, and the potential health impacts of mountain-relevant hazards, are not considered as an adaptation priority by the HKH countries, despite the projected increase in the burden of climate-related health impacts. Only the key policy documents of Afghanistan, Bangladesh recognize flash floods and landslides as hazards

that might impact human health, and Bangladesh additionally have strategies to address drought. There has been an increase in heatwaves, and water- and vector-borne diseases (especially malaria) that require timely attention (INCCA, 2010). Additionally, poor access to health services, low quality health care, and poor child and maternal health remain key challenges in the HKH countries (Mohanty et al., 2017). Key health risks arising from potential hazards such as reduced snow cover, glacial melting and ecosystems degradation are not mentioned by any of the HKH countries in their policy documents.

In order to make informed policy decisions, there is a need for targeted research and better understanding of the direct and indirect links between climate change and human health. This includes the policies taking better account of the impacts of the slow or sudden onset of climate and extreme events on human health. Furthermore, there is a need for better post-disaster recovery measures to prevent the spread of diseases and reduce the vulnerabilities to trafficking and violence, especially of/towards women and children.

Tourism

The majority of the HKH countries have tourism policies and strategies in place, and some countries have also begun to recognize that the impact of climate change can be a limiting factor for this sector. For example, climate change may increase the frequency of mountain-relevant hazards such as avalanches, GLOFs and landslides in mountain areas, thereby destroying infrastructure essential for tourism more regularly, including roads, bridges and mountain trails, in addition to posing a risk to religious sites and human life.

However, climate-related issues are not specifically considered in existing policy documents. Apart from Nepal, that address reduced snow cover, and Bangladesh that recognizes that tourism can aggravate ecosystems degradation, adaptation measures are not present in the strategies of the HKH countries. Furthermore, existing security issues and budget limitations are also a major hindrance to the sector's development in some countries. Although the sector could benefit greatly from transboundary cooperation (e.g. pilgrim routes through neighbouring countries to religious sites/locations), only India and Nepal highlight this as a need.


Monks in Thimphu, Bhutan

The tourism policies acknowledge the negative impact of an influx of tourists on the mountain environment and the ensuing need for sustainable management. However, there is a gap in terms of anticipating the potential adverse impacts of climate hazards on this sector. Furthermore, the sector needs to be better prepared for the increasing number of tourists visiting the mountains due to frequent heatwaves in lowlands.

The policies also need to have a mechanism in place to take care of tourists when extreme events occur.

Notes

1. The United Nations Committee on World Food Security defines food security as the condition in which all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their dietary needs and food preferences for an active and healthy life. Food insecurity exists when people do not have adequate physical, social or economic access to food, as defined above.
2. For the purposes of this Outlook, "poor people" are defined as those living below the income poverty line for each country.
3. Comprising Arunachal Pradesh, Himachal Pradesh, Jammu and Kashmir, Nagaland, Manipur, Meghalaya, Mizoram, Sikkim, Tripura, Uttarakhand and the hill regions of Assam and West Bengal.
4. The higher average altitude of the glaciers, heavier winter snowfalls and larger number of surging glaciers and debris covered glaciers in the Karakoram region are possible explanations for this anomaly. However, no definitive reasons have yet been given (Shrestha, et al., 2015a). Bolch et al. (2012) explain that despite the scientific uncertainties, it is unlikely that dramatic changes in the Karakoram glaciers' contribution to the total run-off will occur soon.
5. Permafrost is defined as frozen ground that remains at or below 0°C for two or more years.
6. A dzong is a type of fortress mainly found in Bhutan.
7. For the purpose of this list, climate change hazards include events or trends relevant for people, including hazards that are also indirectly caused by climate change. For example, higher temperatures is a hazard increasing the risk of ecosystem degradation. Ecosystem degradation is an indirect hazard that creates risks for communities, such as loss of pasture land.
8. Expert opinion was gathered during the Regional Policy Workshop on Adaptation Outlook for the Hindu Kush Himalaya which took place on 2-3 February 2017.

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