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Disaster risk and response in the Himalayan region: The cases of Nepal and Bhutan

Kensuke Molnar-Tanaka and Peter Sammonds

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Director, OECD Development Centre

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Abstract

The Himalayan region stretches across several South Asian countries and its glaciers and annual monsoon rains provide a water source and way of life for millions of people. However, the area is prone to various disasters that disrupt these communities, the severity and frequency of which are increasing, partly due to climate change. It is therefore crucial to consider resilience against disasters in development planning.

This paper focuses on policy challenges in Nepal and Bhutan, with insight on potential solutions. Coping with disaster risk will require a holistic policy approach. It should include elements across multiple policy areas such as strong institutional frameworks, education, adequate budget and financing options and technology. Strengthening policies towards disaster-resilient development is critical.

JEL classification: Q54, O53, R58, Q01
Keywords: Himalaya, disaster risk, Nepal, Bhutan, mountain region, climate change

Foreword

The Himalayan region stretches across several South Asian countries and provides a water source and way of life for the population. The glaciers of the Himalaya and the annual monsoon rains in the region provide water to millions of people. However, the Himalaya is prone to disasters that disrupt the communities living in the region. Furthermore, climate change is increasing the severity and frequency of several types of disasters the region faces, and it is therefore crucial to consider resilience against disasters in development planning.

Coping with climate change requires a global effort. The sheer scale of the endeavour, to say nothing of the uncertainty surrounding it, means that it will take time. Therefore, policies towards disaster resilience should be pursued urgently. Earlier OECD work in the *Economic Outlook for Southeast Asia, China and India 2024: Developing Amid Disasters* proposed a framework for how to develop resilience to disasters before and after they happen and while they are in progress. Referencing this publication, this paper discusses policy challenges in Nepal and Bhutan – two small landlocked countries bordered by the People's Republic of China and India – with insight on successes, gaps, and potential solutions.

Tackling disaster risk will require a holistic policy approach that incorporates elements from multiple policy areas in a cohesive way. It is also important that policy makers consider how the development of resilience will be financed. With this in mind, this paper explores what kinds of disaster risks Nepal and Bhutan face and how these two countries can pursue disaster-resilient development.

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*Authors: Kensuke Molnar-Tanaka, OECD Development Centre, France, and Peter Sammonds, University College London, Department of Risk and Disaster Reduction, UK. The views expressed in in this paper are those of the authors and do not necessarily reflect the views and opinions of their organisations. Any remaining errors are the responsibility of the authors. Corresponding author: kensuke.molnar-tanaka@oecd.org.

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1 Introduction

This paper discusses disaster challenges caused by natural hazard risks that threaten the development of the Himalayan region in South Asia. The Himalayan region is one of the most fragile and geologically and meteorologically dynamic regions of the world, and home to 240 million people. The arc of the Himalaya runs 2 400 km from Nanga Parbat, where the Indus River turns south, to Namcha Barwa, where the Yarlung Tsangpo in Tibet turns south to become the Brahmaputra. The plains of the Indus and Ganges River systems stretch out to the south. The arid Tibetan Plateau covering 2.5 million km^2 with an average elevation of about 4 500 m lies to the north. The region contains the largest volumes of snow and ice outside of the polar regions, storing over 6 000 km^3 of fresh water (Bajracharya et al., 2015[1]). The mountains and glaciers are the source of major rivers of Asia which support 1.3 billion people and have important seasonal roles in releasing melt water (Box 1) (Azam et al., 2018[2]).

The landscape of the Himalaya is a result of continuing competition between plate tectonics on the one hand, with the collision of the Indian and Eurasian tectonic plates uplifting the Himalaya as the highest mountains on Earth, and erosion and gravity, washing eroded sediments into the oceans on the other. Mount Everest has the highest elevation above sea level on Earth at 8 848 m. The westernmost major peak in the Himalaya, the Nanga Parbat massif in Kashmir, at 8 126 m high, is uplifting at 14-16 mm per year (Kaukab, Raza and Mahmood, 2018[3]; Zeitler et al., 1982[4]) and has the highest uplift rate on Earth, while the easternmost major peak, Namcha Barwa massif in Tibet is 7 782 m high and is uplifting at 9 mm per year (Govin et al., 2020[5]). These rapid uplifts are compensated for by rapid erosion. One billion tonnes of eroded sediments per year from the Himalaya alone feed the Bengal submarine fan, which is 18 km thick at the coast. The processes of crustal deformation, uplift, erosion and sedimentation create a highly dynamic environment which causes earthquakes, landslides and floods. The Himalaya, with the Earth's greatest continental relief (6 930 m), experiences a vast range of climatic conditions from tropical to alpine and range of land cover from dense forest to glaciers and bare rock. The dynamic mountain environment causes cloudbursts, floods, glacial outburst floods, extreme temperatures, strong winds, snowstorms and droughts. To the north of the Himalaya, the Tibetan Plateau is the most extensive elevated surface on Earth. As the Himalaya rose past 5 000 m in height, this created a rain shadow on the Plateau. Tibet is extremely dry for nine months of the year. To the south of the Himalaya is the wettest region on Earth in Meghalaya, India, which receives 11.9 m of rainfall per year.

As in other parts of the world, the Himalaya suffers from the increasing frequency of extreme weather events and the resulting destruction of capacity to mitigate future disaster risks, but the effects are uniquely intensified by the mountainous nature of the region. Natural hazard risks from earthquakes, weather extremes, flooding, landslides, wildfires, declining biodiversity, increasing water insecurity, rapid population growth, uneven development, changing lifestyles and threats to livelihoods all present major challenges in the region (Wester et al., 2019[6]). Loss of ice mass from glaciers in the Himalayan region as a whole is similar to the global average. But there are strong contrasts across the region from west to east. In the westernmost part, the Hindu Kush, glaciers are retreating slowly. The Ice mass stored in the Karakoram mountains is little changed. But glaciers have been in rapid retreat in the Himalayan mountains which span Nepal and Bhutan (Azam et al., 2018[2]).

Box 1. The Himalayan mountains as the water towers of Asia

The Himalayan mountains are the water towers of Asia (Immerzeel, van Beek and Bierkens, 2010[7]; Immerzeel et al., 2020[8]; Viviroli et al., 2007[9]). No region on Earth will be more affected by the mountain climate change than South, Central and East Asia, as the headwaters of Asia's major rivers, including the Indus, Ganges/Padma, Yarlung Tsangpo/Brahmaputra and Changjiang/Yangtze rivers are located in the Himalayan region. These river basins are very different (Immerzeel, van Beek and Bierkens, 2010[7]). The Ganges, Yangtze, Indus and Brahmaputra basins all support large populations and large-scale irrigation. The Indus, Brahmaputra and Ganges basins have extensive upstream areas above 2 000 m elevation. They have approximately 2 700, 1 300 and 790 km^3 of stored ice reserves, respectively (Bajracharya et al., 2015[1]). The Indus has the driest downstream basin and the highest net difference between the demand for water for irrigation and precipitation in the basin, so is most dependent on the water towers (Viviroli et al., 2007[9]). By contrast, the downstream precipitation contributions to flow in the Ganges and Yangtze basins are over 80%.

In a review of the changes in Himalayan glaciers and their hydrological implications, (Nie et al., 2021[10]) report that glacial meltwater provides 42% of the flow in the arid Tarim Basin; 16% of the flow in the monsoon-controlled Upper Brahmaputra Basin; 12% of the flow in the Upper Ganges Basin; and 9% of the flow in the Yangtze, in the upper basin (Wu et al., 2013[11]). They note that the glacial meltwater contribution decreases substantially with distance from the feeding glaciers and especially for the cases when the monsoon dominates water flows: the meltwater contribution decreases in monsoon-dominated mountain ranges to a few percent towards the mouth of the river. Ice stored in the Himalayan region also plays an important role in protecting downstream populations from the worst effects of droughts particularly for dry river basins (Pritchard, 2019[12]). Glacial ice can act as a buffer against extreme water shortages which may reduce rain and seasonal snow melt, but glaciers in the Himalayan Mountains are in rapid retreat (Bajracharya et al., 2015[1]).

The melt contributions to the flow of the major rivers of Asia from Himalayan glaciers should increase until 2050 and then decrease as the loss of ice begins to affect the amount of meltwater produced (Azam et al., 2018[2]). Modelling shows increases in water flows for 1.5°C and 2°C of global warming of approximately 13% and 17% for the Indus River, 40% and 60% for the Ganges-Brahmaputra and 2% and 8% for the Yangtze River. These are averages for the JULES ecosystem-hydrology in the CMIP5 comparison (Betts et al., 2018[13]). However, the projected increases in river flows were associated principally with increased temperature and precipitation rather than from the meltwater (Mukhopadhyay, Khan and Gautam, 2015[14]). Lutz et al. (2014[15]) agree and stated that despite large differences in runoff composition and differences between the river basins, the projected increases in runoff until 2050, were caused primarily by increases in precipitation for the Upper Ganges and Brahmaputra Basins.

In the short term, increased glacial meltwater resulting from a warming climate will increase available water supplies in some rivers and boost economic development opportunities and support urban expansion, irrigated agriculture, and increased hydropower, amongst others. Hussain et al. (2019[16]) discusses this phenomenon in greater detail. In the long term, this source of economic growth will not be sustainable, and the loss of ice will mean decreasing meltwater contributions after 2050, although the magnitude and timing of the peak and the rate of subsequent decline are uncertain (Nie et al., 2021[10]).

Table 1 shows the warming trend in the Western Himalaya and the Nepal compared with the global average. The warming trend in the Himalayan region is two to five times the global average. You et al. (2017[17]) argued that high altitudes amplify global warming. Melting of Himalayan glaciers has coincided with these increasing average surface air temperatures (See Annex A).

Table 1. Observed Himalayan temperature trends

Region	Time period	Trend (°C per decade)
Western Himalaya	1979-2007	0.26
Nepal	1977-2000	0.60
Global average	1951-2012	0.12

Source: You et al. (2017[17]), "An overview of studies of observed climate change in the Hindu Kush Himalayan (HKH) region", *Advances in Climate Change Research*, Vol. 8/3, pp. 141-147.

It had been speculated that the climate change over the Tibetan Plateau could stop the Indian monsoon, but this has been largely discounted (Box 2). However, the monsoon could be affected by other aspects of climate change affecting flooding in lowland areas in South Asia.

Against this background, this paper focuses on the cases of Nepal and Bhutan, which are two relatively small, land-locked developing countries located in the Himalaya, sandwiched between their two giant neighbours, the People's Republic of China and India and it discusses policy solutions on how governments can manage and reduce disaster risks.

The structure of paper is the following. Section 2 discusses the unique physical and climatic features of the Himalayan region and how climate change alters them. Section 3 discusses the hazards faced by the Himalayan region. Section 4 examines the institutional frameworks for disaster management in Nepal and Bhutan after a brief explanation of their geographic features and how these relate to disasters. Section 5 discusses policy responses to disasters in Nepal and Bhutan, along with disaster resilience challenges faced by each country. Section 6 concludes.

Box 2. Indian monsoon and the Himalayan region

The Himalayan region plays a key role in the Indian summer monsoon rains which supply South Asia with 80% of its annual rainfall. The magnitude and timing of the monsoon rains impact agriculture, surface water flows and replenishment of ground water resources across South Asia. The high mountains of the Himalayan region act as a barrier between the moist warm air over South Asia and the colder, drier air to the north (Boos and Kuang, 2010[18]; Cane, 2010[19]). The global monsoon system can be viewed as the seasonal migration of equatorial trough (termed the Intertropical Convergence Zone or ITCZ) (Gadgil, 2018[20]). Boos and Kuang (2010[18]) proposed that the Himalayan mountains cause the monsoon to be stronger by preventing warm and moist air to the south from being diluted by mixing with cold and dry air to the north (Cane, 2010[19]). These views of the monsoon circulation have largely supplanted older ideas of the monsoon as an onshore sea-breeze driven by high land temperature in which the Tibetan Plateau plays an important role. This new understanding negates the concern that changes in the surface temperature, glacial cover, and vegetation on the plateau in a warming climate might alter monsoon intensity in the coming decades, as had been suggested (Qiu, 2008[21]). However, the plateau may play a role in modifying the wind-driven ocean circulation over the North Atlantic, which in turn affects both the monsoon rainfall and the position of the ITCZ (Fallah et al., 2016[22]). Local heating over the plateau enhances rainfall along its southern edge (Boos and Kuang, 2010[18]).

2 Characteristics of disasters in Himalayan region

The mountainous landscape of the Himalayan region presents unique challenges and risks for its inhabitants. In addition, mountainous areas are at the forefront of climate change (Kato, Rambali and Blanco-Gonzalez, 2021[23]). The Himalayan region, including Nepal and Bhutan, is prone to a variety of natural hazards, including weather extremes (heat waves, cold waves and harsh winter conditions), various types of floods, landslides, wildfires, and earthquakes. This section discusses the characteristics of typical hazards faced by Himalayan region.

2.1. Disasters in the Himalayan mountains

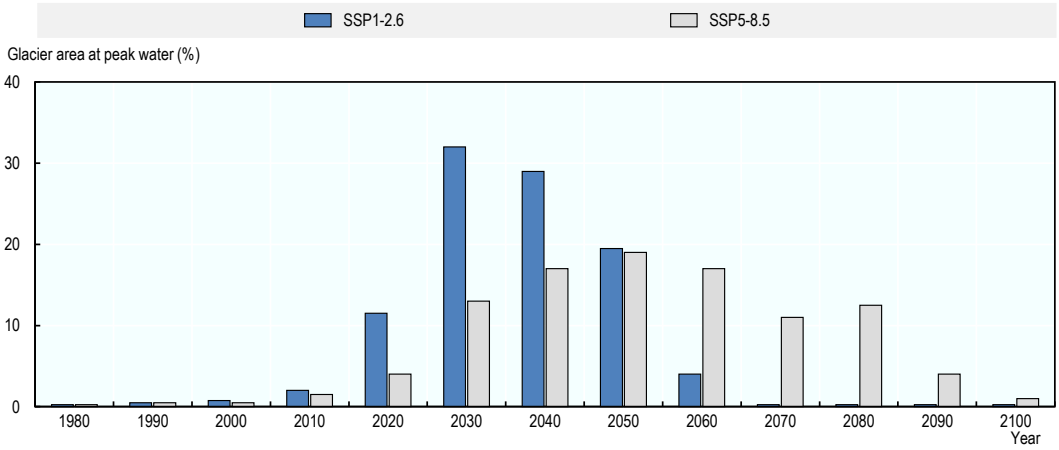
2.1.1. Glacial melting

The IPCC Sixth Assessment Report stated with high confidence that the world's glaciers are presently in imbalance due to the warming of recent decades (IPCC, 2023[24]). The eastern Himalayan glaciers of Nepal and Bhutan are the most vulnerable to climate change due to both decreased precipitation and increased ablation associated with warming (Wiltshire, 2014[25]). High Mountain Asia (HMA) glaciers are already on an irreversible course to lose mass, even without further warming. As discussed in Annex B, the SSP1-2.6 pathway shows a strong reduction in the rate of ice loss by 2050, But total ice loss will continue. For all other higher emission pathways, the rate of ice loss even increases (Zhao et al., 2023[26]). As glaciers lose mass, a time will be reached when the volumes of meltwater produced start to diminish. This is "peak water" (Hock et al., 2019[27]). This is illustrated in Figure 1 for two Shared Socioeconomic Pathways (SSP1-2.6 and SSP5-8.5) pathways for High Mountain Asia (after (Hock et al., 2019[27])). A global glacier model was used to compute the runoff of all individual glaciers in a region until year 2100. There is a tendency for peak water to occur later for larger glaciers.

Glacier melt increases the volume of river discharge, and it causes the melt season to start earlier. That also means less melt later in the season and that the melt contribution to river flow falls later in the year.

Increased glacial melting enhances river flood risk due to greater downstream water flow. Moreover, increased melting adds more water to glacial lakes, elevating the risk of glacial lake outburst floods. More torrential river flows also exacerbate landslide risk by eroding the toes of previous landslides, which promotes further slippage. In addition to landslides, these conditions exacerbate the risk of rockslides and possibly rock avalanches. Retreating glaciers expose bedrock, reducing surface albedo and promoting further melting in a positive feedback loop.

Figure 1. Timing of peak water from glaciers in High Mountain Asia



Note: Timing of peak water from glaciers in High Mountain Asia under two shared socioeconomic pathways: Blue is SSP1-2.6. Grey is SSP5-8.5 (translated from Representative Concentration Pathways). A global glacier model was used to compute the runoff of all individual glaciers in a region until year 2100.
Source: Hock et al. (2019[27]), "High Mountain Areas" in *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*.

Risks also extend beyond the geological sphere. For irrigation, increased glacier melt water will contribute to irrigation in lowlands areas and pastoralism in upland areas, but excess glacier melting can potentially disrupt agriculture by altering the distribution of soil saturation throughout the growing season via oversaturation in the early stages of the growing season followed by drought in the latter stages (Hock et al., 2019[27]). For hydropower generation, changing meltwater volumes with time will need to be modelled over the lifetime of the plant. Furthermore, glacial melting might increase tourism in areas previously covered, leading to the expansion of road networks and settlements. However, tourists unfamiliar with the high mountain region may be more vulnerable to high-mountain hazard risks.

2.1.2. Weather extremes

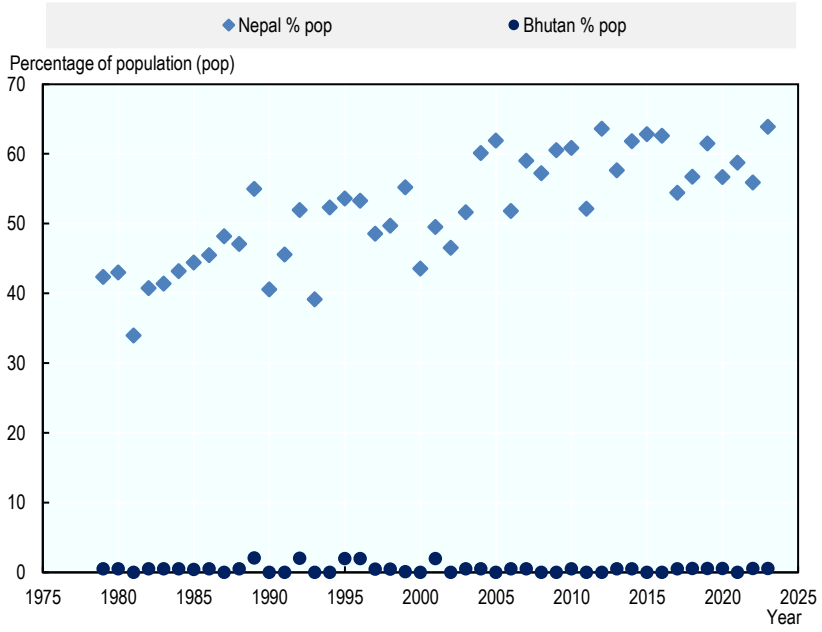
Storms (especially cyclones) produce strikingly high death tolls. Coastal countries such as Bangladesh are particularly vulnerable, but the impacts of storms can penetrate deep into continental interiors. The May 2009 Cyclone Aila originated in the Bay of Bengal and was one of the worst climatic disasters in the history of Bhutan, causing major damage to livelihoods (Tshering, 2019[28]). Cyclones and storms bring heavy precipitation and the threat of flash flooding. There is less recognition of the windstorms which have become more frequent and caused major disasters in the mountains of Bhutan in recent years, including at least one every year from 2011-2015 (Department of Disaster Management, n.d.[29]). Roofs of traditional Bhutanese houses are particularly vulnerable to cyclones and windstorms given the nature of their construction. This issue is most prevalent in rural areas of the country. Simple measures such as pegging the roof can decrease building fragility (EEFIT, 2019[30]).

Heat waves, cold waves and harsh winter conditions represent other significant hazards, particularly at higher elevations. The extreme temperature indices show statistically significant increasing trends with global warming. For instance, Figure 2 shows the percentage of the population in Nepal and Bhutan exposed to heat stress on days where the maximum temperature has exceeded 35°C. The percentage has grown steadily in Nepal, driven by increasing number of hot days as daily maximum temperatures increase. Heat stress that occurred mostly in lowland areas is increasing at higher elevations indicated by the fact that two-thirds of the population are now exposed. In Bhutan which is at high average elevation there has been little change in exposure. The number of days of below average temperatures has halved in both Nepal and Bhutan in the last 30 years from about 25 to 12 days per year (OECD, 2024[31]). However

there has been a small decrease in minimum temperatures in the mountains outside of the monsoon season (Awasthi and Owen, 2020[32]). This is probably due to increased climate variability at high altitudes. In line with rapid warming in High Mountain Asia it is likely that extreme temperatures will increase in frequency and severity with climate change (You et al., 2017[17]).

There have been severe droughts in Nepal in the 21st century in 2006, 2012, 2015 and 2023 (Bagale, Sigdel and Aryal, 2021[33]). These have affected over 500 000 people (CRED/UCLouvain, 2025[34]). More localized drought results in crop failures affecting about 5 000 families each year (Khanal, 2020[35]). Drought events are likely to become more frequent with global warming (Wester et al., 2019[6]). As discussed, reduced or inconsistent meltwater availability after 2050 will impact downstream basins possibly exposing more people to drought risk. Most of Nepal is at risk of drought-like conditions from the end of March until the monsoon arrives. Northwestern Nepal is drought-prone throughout the year. Bhutan has experienced negative soil moisture anomalies each of the last 12 years, with one exception (OECD, 2022). The incidents of droughts are causing concern about the impact on GDP (World Bank, 2023[36]). Drought is already leading to migration from marginal areas (Rauniyar, 2024[37]).

Figure 2. Percentage of the population of Nepal and Bhutan exposed to heat stress



Note: Data are for days where the daily maximum temperature exceeds 35°C.
Source: Data from OECD (2024[31]), *Climate-related hazards: Exposure to river flooding, Environment Statistics* (database).

2.1.3. Wildfires

Wildfires are on the rise across the mountainous regions of South Asia (Wester et al., 2019[6]), which may place livelihoods, infrastructure and biodiversity at risk. Most wildfires occur during the dry season due to human negligence associated with hunting, smoking, intentionally starting fires for livestock and charcoal production, and children playing (Khanal, 2020[35]). Three main factors are involved in the ignition and spread of wildfires, namely fuel availability, temperature and ignition potential (Matin et al., 2017[38]).

Over 70% of Bhutan is covered by forest and wildland fires are seen as one of the biggest threats to forest resources. Forest exposure to wildfire danger is defined as areas with more than three consecutive days of very high or extreme wildfire danger based on prevalent weather conditions. In Bhutan most years the exposure is quite low averaging at 2.2% over the last 20 years, but the data are spikey, with exposure as

high as 14% in some years. In terms of areas burnt by wildfire, the 20-year average is 91 km^2 (or about 0.2% of land), but 210 km^2 were burnt in 2016 (Tshering, 2019[28]; OECD, 2024[31]). Even so, there is minimal population exposure to wildfire.

In Nepal, wildfires are one of the key drivers of forest degradation (Matin et al., 2017[38]). Wildfires occur throughout Nepal and result in the deforestation of approximately 1.7% of the total forest area annually (Khanal, 2020[35]). On average, about 40% of Nepal's forests and about 16% of its population are annually exposed to wildfire danger. There presently is no discernible trend over a 20-year period and there is also considerable variability found in global statistics (OECD, 2023[39]). In countries such as Australia, South Africa, Brazil, India, Colombia, Portugal and Argentina more than 1% of land is burnt annually.

Climate change has increased the frequency and extremity of fire weather globally (Jones et al., 2022[40]). Climate change factors which are impacting the frequency and magnitude of forest fires include: 1) A longer rainy season which causes fuel to accumulate; 2) higher temperatures and longer dry periods which dry the fuel and make fires more intense; 3) in the Himalaya, earlier snowmelt will make the fire season longer (OECD, 2023[39]). These factors are changing the danger from wildfire (Vitolo et al., 2020[41]).

The risk of wildfires can be reduced by reducing the amount of available fuel, that is both living and dead biomass (OECD, 2023[39]). Fuel breaks and buffer zones are important features of wildfire risk management. In agricultural areas introducing non-flammable crops can be beneficial. Given the role that negligence plays in starting wildfires, raising risk awareness and managing recreational use of outdoor fires are important. However, it should be noted that fire is part of the natural cycle of the landscape and its evolution. These natural processes should not be limited by fire risk reduction measures.

Although climate change is exerting a pervasive upwards pressure on fire globally, downscaled global data for the Himalayan region are however sparse. More data and better models of the interactions between climate, climate extremes, humans and fire are needed.

2.1.4. Flooding

Flooding is the most common hazard in the mountain regions of South Asia (ICIMOD, 2023[42]). The principal causes of flooding in the Himalayan region are: 1) Flash floods from cloudbursts, 2) monsoon rains in lower valleys and floodplains to the south 3) glacial melt and glacial lake outburst flooding, (see section below). For instance, Nepal faces high risk for river flooding in terms of the population exposed (Table 2).

Table 2. Percentage of population exposed to river flooding

Annual exceedance probability	Return period (years)	% Population exposed (Bhutan)	% Population exposed (Nepal)
10%	10	1.9	8.8
5%	20	2.0	8.9
2%	50	2.1	9.1
1%	100	2.1	9.5

Source: OECD (2024[31]), *Climate-related hazards: Exposure to river flooding, Environment Statistics* (database).

Cloudbursts, where extreme amounts of precipitation from cyclones or monsoon clouds over a short time causes localised flash flooding, represent a threat particularly for the mountainous regions. These trigger numerous debris flows and significantly widen the lower reaches of the main tributary valleys (Mueller et al., 2019[43]).

Flooding is caused by heavy precipitation during the monsoon season in the mountainous areas. Such flooding causes high loss of life, major property damage and disruption to critical infrastructure such as roads and bridges (Khanal, 2020[35]). The 1993 floods of the Bagmati River and the 2008 floods of the

Koshi River in western Nepal (which affected 70 000 people in Nepal and 1 million in India) after the structural failure of an embankment, were devastating. More recently. the July 2024 floods in Kanchanpur district, Sudurpaschim Province, followed the highest rainfall in the past 78 years and affected over 2 700 people with 24 direct deaths. While the September 2024 floods of the Kathmandu Valley affected over 2.5 million people, causing 268 direct deaths and damage estimated at over USD 1.3 billion (CRED/UCLouvain, 2025[34]).

Climate change will not cause a strong decline in the Indian monsoon as once thought, but there will be more frequent extreme precipitation events during monsoon season in the eastern Himalaya, and a wetter cold season in the western Himalaya (Box 2). Monsoon rainfall is highly variable, but global monsoon rainfall has increased in recent decades. This followed a period of monsoon circulation weakening. These effects have been attributed to cooling induced by local aerosol emissions which increased dramatically as the region industrialised rapidly (Biasutti, Ting and Hill, 2022[44]). This trend is expected to reverse, giving way to a pattern of more intense rainfall interspersed with increased dry periods, which would lead to more severe flooding episodes, particularly downstream.

Land use management is central to reducing flood disaster risks. The Koshi River disaster is an illustration of relying on hard defences, but the development of natural flood management plans is at an early stage. Urban surface water flooding is likely to be an increasing threat. The flash flood disasters in the cities of Zhengzhou (2021) and Barcelona (2024) indicate that adequate drainage must be engineered even in places without a history of flooding, and the community must be made aware of the hazard.

2.1.5. Glacial lake outburst flooding

Glacial lake outburst floods (GLOFs) occur when a moraine dam containing a lake of glacial meltwater on the surface of a glacier is breached. GLOFs affect high mountain regions as well as downstream areas, seriously threatening lives and livelihoods. They can be triggered by ice or rock avalanches, collapse of the moraine dam, earthquakes or heavy rains. The floods are highly mobile mixtures of water and sediment, which can travel large distances, impacting communities down river far from the glacial lake. (Azam et al., 2018[2]) describe a GLOF caused by the collapse of the moraine-dammed Chorabari Glacier Lake triggered by extreme one-day rainfall of 325 mm. The GLOF devastated the Kedarnath Valley (Uttarakhand, India) and downstream areas (Maikhuri et al., 2017[45]).

Glacial lakes have expanded due to increased glacier melt caused by climate change (Chen et al., 2017[46]), increasing the potential frequency and magnitude of GLOFs. Increases in meltwater discharges (which are projected to occur) can result in floods that may further induce rapid erosion, landslides and glacial lake outburst floods, especially if coupled with extreme rainfall. GLOFs also threaten hydropower infrastructure downstream. Nie et al. (2021[10]) noted that minor outburst floods can trigger a hazard chain by causing downstream dam failure.

A number of glacial lakes have been found to be potentially dangerous in the Himalayan region. A study conducted in collaboration with ICIMOD identified 2 674 glacial lakes in Bhutan (Tshering, 2019[28]). In Nepal, ICIMODs 2001 inventory of glaciers, glacial lakes and GLOFs counted 2 323 glacial lakes, 20 of which are very vulnerable to outburst flooding (Khanal, 2020[35]). In Bhutan, the most recent GLOF disaster occurred in 1994, triggered by the outburst of Luggye Tsho in Lunana. The GLOF caused severe damage downstream in the Punakha-Wangdue valley, claiming 21 lives and washing away four bridges.

Early warning systems (EWS) show great promise for reducing disaster risks from GLOFs. GLOF early warning systems monitor water level changes in lakes, movement of end-moraines, ice collapse and downstream runoff (Wang et al., 2022[47]). Precursory activity can be communicated to downstream communities, in order to avoid causalities and to infrastructure manager, to take precautionary measures. An example of such a system is for the Cirenmaco glacial lake close to the Tibet-Nepal border (Wang et al., 2022[47]). Considerable degree of hazard awareness is needed by the community and co-production

of emergency planning can help the response become timely and effective. In Bhutan, an automatic GLOF early warning systems was installed in the Punakha-Wangdue Valley (National Center for Hydrology and Meteorology, 2021[48]).

2.1.6. Landslides and mass movements

The greatest impact of fatal landslides occurs in Asia and especially along the Himalayan arc (Petley, 2012[49]). A number of factors influence the frequency and magnitude of landslides. In general, the density of landslides in an area is correlated with population density (Petley, 2012[49]). In South Asia the occurrence of rainfall-induced fatal landslides is strongly controlled by the monsoon.

In the Himalayan region landslides figure prominently because over 40% of the terrain has slopes steeper than 15° (Wester et al., 2019[6]). The environment in the Himalayan region means that rock masses are weakened by fracturing from cycling of extreme temperatures. There are also many unconsolidated terraces and unstable sediment fans caused by the dynamic environment. Cloudbursts and seismic hazard add to the landslide hazard risk as they both can trigger landslides (Hakhoo et al., 2019[50]). Lakes dammed by landslides can also cause outburst flooding when their dams of poorly consolidated sediments fail.

Petley (2010[51]) showed that although climate change might be expected to increase landslide incidence, the increase in impacts from climate change however are minor compared with those of forecast population changes. Land use planning has a major role to play in reducing landslide vulnerability. This is particularly the case where urban sprawl from towns and surrounding informal settlements may be built on geotechnically unsuitable land.

In Bhutan, landslides have been caused by seasonal monsoons (severely disrupting the Thimphu highway in 2000); by sudden debris flows (2002); heavy rain (a 2005 mudslide damaged the Mongar-Lhuentse highway); and earthquakes (e.g. the 2011 Sikkim earthquake caused landslides) (Tshering, 2019[28]). In 2014, the Sunkoshi River was blocked by landslides, killing 156 people damaged the Katmandu-Lhasa Arniko highway and stoked fears of floods downstream in India's Bihar state. In Nepal, an average 100 people are killed by landslides annually (Khanal, 2020[35]).

2.1.7. Earthquakes

Earthquakes have had a devastating impact along the Himalayan arc, from Kashmir to Bhutan, where the Indian tectonic plate collides with the Eurasian plate. There have been recent calamitous earthquakes in Kashmir in 2005 (magnitude 7.6 with 73 338 dead) and Gorkha (Nepal) in 2015 (magnitude 7.8 with 8 831 dead) (CRED/UCLouvain, 2025[34]). Evidence for high magnitude historic earthquakes have been found such as the 1714 magnitude 8.0 earthquake in Bhutan. These imply that the entire Himalayan arc has a high level of earthquake potential (Hétenyi et al. (2016[52]). More recent earthquakes in Bhutan include the 2009 magnitude 6.1 earthquake in Narang, Mongar where 12 lives were lost, 117 schools and over 800 cultural heritage buildings were damaged; the 2011 magnitude 6.9 earthquake in the Greater Sikkim Area (affecting parts of Bhutan) where 6 977 rural homes were damaged; and the 2016 magnitude 6.7 Manipur earthquake causing widespread damage (Department of Disaster Management, n.d.[29]; Tshering and Sekhsaria, 2019[53]). Major earthquakes need to be considered in compound hazard risk assessments.

The importance of deglaciation for inducing seismicity caused by post-glacial rebound of the Earth’s crust as the mass of ice is removed is well recognised (Muir-Wood, 2000[54]). The retreat of the Fennoscandian ice sheet which covered northwest Europe during the last ice age may have triggered the magnitude 7.5 Lake Vattern earthquake about 11 500 years ago. While recent seismicity in England and Norway, with magnitudes up to 5.5 have been attributed to triggered earthquakes. The ice mass loading in the Himalayas is very much less than from the ice age ice sheets. However, Mishra et al. (2021[55]) have pointed out that deglaciation induced earthquakes will need to be considered.

3 Institutional framework of disaster management in Nepal and Bhutan

This section provides an overview of the institutional frameworks for disaster management in Nepal and Bhutan. It discusses the current frameworks and their development by addressing key legislation, such as strategic plans and delegation of responsibilities. In addition, the section features a brief description of the geographic characteristics of Nepal and Bhutan.

3.1. Geographic characteristics of Nepal and Bhutan

Nepal is divided physically into the Himalayan mountain region in the north and the hilly region (Pahad mountainous belt) to the south, which has peaks between 800 m and 4 000 m and is usually not snow-covered. The climate and vegetation vary from alpine above 3 600 m to subtropical below 1 200 m. The Lower Himalaya form the southern limit of the Pahad, with peaks between 1 500 and 3 000 m and subtropical valleys where the population is concentrated. The Terai southernmost belt, bordering India, is subtropical to tropical lowland plains with some hills, the outmost range of foothills being the Sivalik Hills with peaks up to 1 000 m. (The Sivalik Hills continue as the Shiwalik Hills and the Terai plains as the Duar plains in Bhutan). The capital and largest city of Nepal is Kathmandu. It sits in the Kathmandu Valley in the high plateaus of central Nepal at 1 400 m. Its climate ranges from humid subtropical at lower altitudes to subtropical highland at higher elevations.

Bhutan is mostly mountainous with some fertile valleys and savannah. The land cover of the northern region is snow and ice, rock, and alpine scrub and meadows, and features peaks of the High Himalaya range over 7 000 m in altitude. Alpine valleys provide pasture supporting a small migratory population. The central region of the Black Mountains, with peaks between 1 500 m and 5 000 m, is forested, cut by many fast-flowing rivers, and supports most of the population. In the south, the Shiwalik Hills, a mountain range of the Outer Himalaya, has peaks up to 1 500 m and foothills covered in subtropical forest which descend to the subtropical Duar Plains, a narrow strip of Bhutan bordering India. The climate of Bhutan is alpine to temperate to subtropical with a monsoon season from June to September. The capital and largest city of Bhutan is Thimphu. It sits in the thinly forested valley of the Thimphu River at 2 248 to 2 648 m altitude and is surrounded by mountainous landscape between 2 000 and 3 800 m, which ranges in climate from warm temperate to cold temperate.

Table 3 provides a summary of disaster impacts in Nepal and Bhutan in 1950-2025. Large numbers of people are affected by disasters in high mountain regions. With climate change, not only are hazard risks increasing, but so is exposure to hazards, while too little is being done to address vulnerability.

Table 3. Disaster impacts in Nepal and Bhutan 1950-2025

Nepal			
	Number of events	Total deaths	Total affected
Flood	59	8 426	8 318 171
Earthquake	11	10 026	6 738 830
Storm	7	229	15 757
Drought	6	0	4 903 000
Bhutan			
	Number of events	Total deaths	Total affected
Flood	4	232	1 600
Earthquake	3	12	20 530
Storm	2	29	65 000

Source: CRED/UCLouvain (2025[34]), *EM-DAT, The International Disaster Database*.

3.2. Nepal framework for disaster management

The *National Disaster Response Framework* (NDRF) was issued in 2013 (Ministry of Home Affairs, 2013[56]). According to the Framework, "The main purpose of this framework is to develop a clear, concise and comprehensive national disaster response framework for Nepal that can guide a more effective and co-ordinated national response in case of a large-scale disaster" that considers all phases of the disaster cycle (Ministry of Home Affairs, 2013[56]). The Framework built upon the *Natural Calamity Relief Act 1982* and the *Local Self Governance Act 1999*. The 1982 legislation mandated the formation of the Central Natural Disaster Response Committee (CNDRC), Regional Disaster Relief Committees (RDRC), District Disaster Relief Committees (DDRC), and Local Disaster Relief Committees (LDRC), while the 1999 legislation gave subnational authorities responsibility for disaster preparedness and response.

The *Disaster Risk Reduction and Management Act, 2074 (2017)* established the National Council for Disaster Risk Reduction and Management (NCDRRM) as the highest policy-making body for disaster risk reduction in Nepal (Ministry of Home Affairs, 2019[57]). The Prime Minister serves as the chair of the council and is joined on the council by other government ministers, the leader of the opposition party in the House of Representatives, the Chief Ministers of each province, the Commander-in-Chief of the Nepal Army, some other officials, three subject matter experts, and some administrators. The Minister for Home Affairs chairs the Executive Committee responsible for the implementation of decisions taken by the NCDRRM. The Minister for Home Affairs is joined on the committee by several other designated government ministers, leadership representatives of the Armed Forces and police, the director of Nepal Rastra Bank (NRB, the central bank of Nepal), leaders of other designated policy councils and some administrators (Ministry of Home Affairs, 2019[57]).

The Act also established the National Disaster Risk Reduction and Management Authority (NDRRMA) to conduct and manage disaster risk management activities under the direction of the NCDRRM Executive Committee. The NDRRMA is responsible for ensuring the decisions of the NCDRRM and Executive Committee are implemented, functioning as the central DRRM resource agency, ensuring subject matter research is conducted, providing financial and technical assistance to sub-national bodies, collecting and analysing disaster data, advising other government agencies as appropriate, developing and maintaining physical and digital disaster risk management and response infrastructure, engaging NGOs and the private sector on DRRM, and co-ordinating or conducting a variety of disaster response activities (Ministry of Home Affairs, 2019[57]).

The Act also prescribed the establishment of provincial disaster management councils and executive committees. These bodies were made responsible for developing and executing disaster management policies and plans aligned with the national strategy, providing guidance to officials at the district and local

levels, and performing many of the same response functions prescribed to the national-level bodies. The provincial Disaster Management Executive Committees are also prescribed as a nexus of co-ordination among federal, provincial and local officials to enhance the effectiveness of search-and-rescue operations. District and local level Disaster Management Committees are subordinate to the national and provincial Disaster Management Councils and Executive Committees. The Disaster Management Committees at these levels are responsible for implementation planning, the maintenance of preparedness, and some response activities, but play little to no role in plan development (Ministry of Home Affairs, 2019[57]).

The DDRM Act provides a robust legal framework, defining roles and responsibilities of various government agencies, including the establishment of NCDRRM. However, for an effective implementation and to avoid delayed disaster responses due to administrative and bureaucratic hurdles, it is crucial to ensure adequate resources and good coordination at all levels of government and provide capacity building at the local level.

The *Disaster Risk Reduction National Strategic Plan of Action (2018-2030)* (Ministry of Home Affairs, 2018[58]) follows the Sendai Framework in adopting a holistic approach for disaster risk reduction within the development process in order to meet the UN Sustainable Development Goals. Four priority areas have been identified: 1) Understanding Disaster Risk; 2) Strengthening Disaster Risk Governance at Federal, Provincial and Local Level; 3) Promoting Comprehensive Risk-Informed Private and Public Investments in Disaster Risk Reduction for Resilience; 4) Enhancing Disaster Preparedness for Effective Response and to "Build Back Better" in Recovery, Rehabilitation and Reconstruction. The plan aims to reduce the disaster mortality rate, reduce the number of affected people, reduce economic losses and damage to critical infrastructure, increase availability of multi-hazard early warning systems, and reduce the economic, physical, social, cultural and environmental impacts on persons, businesses and communities (Khanal, 2020[35]; Ministry of Home Affairs, 2018[59]).

The key objective in the first priority area is developing an information system that allows policy makers to foresee disaster risk and track threats, damages and other vital information in real-time (or as closely as possible) using a centralised Disaster Information Management System (DIMS) (Ministry of Home Affairs, 2018[59]). The DIMS was developed and released in the years following the release of the *Disaster Risk Reduction National Strategic Plan of Action (2018-2030)*, though parts are still undergoing enhancement. The key objective in the second priority area is to establish the bodies described in the preceding paragraphs as well as Emergency Operation Centers (EOC). The *Disaster Risk Reduction National Strategic Plan of Action (2018-2030)* identified 271 priority activities for reducing disaster risk (Khanal, 2020[35]; Ministry of Home Affairs, 2018[59]), but there is still room for improvement in the level of progress and implementation on those activities. The key objectives of the third priority area are to create an enabling environment for disaster preparedness and response and to facilitate both public and private investments in disaster risk reduction. The recovery efforts following the 2015 earthquake, and 2017 floods show progress is already underway, but there is significant room for improvement in depth and breadth of partnerships and the inclusion of more groups of stakeholders. Private sector response has been strongest in the areas of disaster response and recovery, but more progress is needed in disaster risk reduction (Khanal, 2020[35]; Ministry of Home Affairs, 2018[59]). The key objective of the final priority area is to use "Build Back Better" principles to guide reconstruction. However, translating these principles into actionable policies, covering rural and marginalised areas, is crucial. As of January 2020, the Government of Nepal had initiated its six priority actions under this objective and was bringing together relevant agencies to collaborate as required (Khanal, 2020[35]; Ministry of Home Affairs, 2018[59]). A successful implementation, however, requires a strong inter-agency coordination and an effective resource mobilisation.

Nepal is practicing a cluster approach for disaster response and recovery, built around 11 clusters: logistics, health, WASH, nutrition, shelter, camp management, food security, education, protection, communication, and early recovery. This approach has been informed by the response to the 2015 Gorkha Earthquake. Ensuring involvement of all stakeholders, including not only government agencies but also

private sector and non-governmental stakeholders could help to achieve effective implementation of response and recovery efforts.

3.3. Bhutan framework for disaster management

Disaster management and disaster risk reduction in Bhutan are governed under the *Disaster Management Act of Bhutan 2013* (Parliament of Bhutan, 2013[60]), which established the National Disaster Management Authority (NDMA) as the highest decision-making body on disaster management in the country, chaired by the Prime Minister. The NDMA is responsible for 1) approving national strategies and policies; 2) preparing contingency plans; 3) undertaking national vulnerability and hazard zoning; 4) producing disaster management guidelines. It is also responsible for resource allocation for disaster management and disaster risk reduction. It has the power to direct any government agency or private sector organisation on disaster management. Answering to the NDMA, the Department for Disaster Management (DDM) oversees the divisions for Preparedness and Mitigation, Response and Early Warning, and Recovery and Reconstruction. It also constitutes the Inter-Ministerial Task Force comprising technical experts from relevant agencies, which is chaired by the head of the DDM (Parliament of Bhutan, 2013[60]; Tshering, 2019[28]).

Bhutan has 20 administrative districts, the dzongkhag, each with their own elected local government and wide-ranging responsibilities. Each constitutes a Dzongkhag Disaster Management Committee (DDMC), chaired by the Dzongdag. A DDMC is responsible for preparing and implementing a local disaster management and contingency plan; monitoring and evaluating; mitigation and preparedness, including DRR in planning and compliance; response and capacity building; establishment and functioning of a critical disaster management facility; communications during disasters; promotion of DRR education; awareness and mock drills; report on the progress of implementation of the Disaster Management and Contingency Plan (Parliament of Bhutan, 2013[60]). The DDMCs are tasked with important responsibilities, however, successful and consistent implementation across districts would require strengthened local capacity including human resources, infrastructure and technology.

In Bhutan, both the national and local (dzongkhag) governments have roles to play in disaster response governance, according to the Disaster Response and Coordination Process (DRCP) (Department of Disaster Management, 2023[61]). The DRCP functions via an Incident Command System (ICS). A National Emergency Operations Centre (NEOC) is at the pinnacle of the co-ordination framework and the NEOC is responsible for developing a multi-agency, multi-sectoral response to disasters. The NEOC identifies how each contributing agency can best help in the response. An NEOC is a temporary structure established in response to a disaster and transcends other existing jurisdictions (Department of Disaster Management, 2023[61]). This helps reduce the likelihood and severity of jurisdictional disputes or confusion within the disaster response. The modular structure of ICS allows the structure to be expanded to included higher levels of government as disasters become more widespread or severe, while allowing local authorities to retain as much autonomy as possible and avoiding tasking higher authorities with minor issues. A key feature of the ICS is that local authorities remain the co-ordinators even when higher authorities or agencies must get involved in the response. The ICS allows for a disaster response structure that is well delineated, outlining clear roles and responsibilities for all actors and minimising unnecessary duplication or the development of unintended gaps in response due to confusion, which can arise when national stakeholders reach out to multiple dzongkhags independently of one another without their knowledge. At the same time, the ICS is structured in such a way that all agencies are familiar with it and therefore representatives from various agencies can integrate into disaster response in a seamless manner, as necessary.

While the governance structure for Type III (national) disasters is well-formulated through the ICS framework, structures for Types I and II (subnational-level disasters) require some improvement and have

yet to be implemented formally. Authorities propose a similar structure to the ICS for Type III disasters, but without national government involvement and an Incident Management Team, rather than a national Incident Commander leading the operations (Department of Disaster Management, 2023[61]). This is a crucial area for development in the disaster governance of Bhutan because most disasters occur at those levels. This will also reduce resource waste, as multiple police and army units currently operate in response structures within each dzongkhag, leading to confusion of the roles and activities of each actor.

According to the 2023 report on which this examination of Bhutan's disaster management governance is based (Department of Disaster Management, 2023[61]), there are plans for further capacity development at subnational levels. The finalisation of plans for establishing Emergency Operations Centres (EOC) at the national, dzongkhag, and thromde levels is underway. Parameters of roles and responsibilities for agencies operating within this framework will also need to be established. At the same time, clear methods of integration with national leadership in the event of a Type III disaster will also be necessary, so national leadership will need to play a part in the development of these subnational plans. A National Disaster Response Coordination Committee (NDRCC) led by the prime minister will be established and operate out of the national EOC located at DDM. The NDRCC will guide dzongkhag IMTs remotely, preventing unnecessary direction of human and physical resources to the incident site. Support actions will include making executive-level policy decisions, co-ordination among agencies, playing a supportive role for the IMT, and managing and distributing information such as disaster warnings (Department of Disaster Management, 2023[61]).

The report also outlines roles and responsibilities for every actor in the disaster response system and provides several organograms explaining how the different bodies are to be constructed and relate to one another. The document also outlines the roles of different agencies in response to different disasters, as applicable. For instance, the agencies responsible for watch and warning services differ by disaster type. Streamlining these responsibilities into a central agency might be helpful, especially since disasters may not occur in isolation, but rather spawn secondary disasters (e.g. earthquakes may lead to landslides).

The *Disaster Management Act of Bhutan 2013* provides for: 1) Response and Relief Expenditure; 2) Budget for National Disaster Management Activities; 3) Budget for Department of Disaster Management; 4) Recovery and Re-construction (Parliament of Bhutan, 2013[60]). The annual budget for the Department for Disaster Management has grown from BTN 34 million (USD 0.4 million) in 2012-13 to BTN 225 million (USD 2.7 million) in 2019-20 (Tshering, 2019[28]).

The budget for the recovery and reconstruction in the aftermath of disaster is assessed after the DDMC submits its assessment of costs to public assets and infrastructure within its area of responsibility. The NDMA makes a recommendation to government for the release of funds. The total budget estimate for the National Recovery and Reconstruction Plan 2011 (NRRP 2011) for the 2009 magnitude-6.1 Narang Earthquake in eastern Bhutan was BTN 699 million (USD 11.7 million), funded in roughly equal parts cash and indicative contributions. Direct and indirect contributions from foreign governments made up more than half the total (Tshering, 2019[28]). The Government of India was by far the biggest contributor with this contribution being in cash. Significant funds were re-directed by the Royal Government of Bhutan. International agencies, and particularly the Asian Development Bank and Global Faculty for Disaster Reconstruction and Recovery made substantial indicative contributions. Strengthening collaboration with international organisations, while enhancing national capacities could create a balanced and sustainable disaster management ecosystem. The largest budgetary outlays in the NRRP 2011 were for the restoration of educational facilities and cultural sites as part of the recovery from the earthquake that caused an estimated USD 42 million in losses, an amount several times larger than the 2011 NRRP budget (Tshering, 2019[28]). For a more sustainable disaster management financing model, the country still has room for improvement by diversifying and exploring various financing mechanisms including market-based financing tools.

Following the 2011 Sikkim Earthquake (magnitude 6.9) the NRPP 2012 target was set at BTN 1 479 million. This was to be met through budget re-appropriation of BTN 515.06 million and the remainder in international contributions. However, few funds were forthcoming from international agencies and other donors (Tshering, 2019[28]). The 2009 and 2011 earthquakes spurred the passing of the 2013 Disaster Management Act and the establishment in 2014 of the Disaster Management Strategic Policy Framework.

Bhutan has shown efforts in improving its disaster management framework. However, to further strengthen disaster resilience, addressing the challenges would be needed, including, among others, ensuring effective resource mobilisation, improving local capacity, and enhancing private sector engagement.

More recently, in 2022, Bhutan implemented a civil service restructuring and reorganisation, through the Civil Service Reform Act of Bhutan 2022 (Parliament of Bhutan, 2022[62]), reducing the number of ministries from ten to nine. Following the enactment of this Act, several ministries have been reorganised, including those related to disaster management. For instance, under the Ministry of Home Affairs, the Department of Local Governance and the Department of Disaster Management has been merged into the new Department of Local Governance and Disaster Management. The Department serves as the secretariat and executive arm of the National Disaster Management Authority, and functions as the national co-ordinating agency for disaster management.

4 Challenges and policy responses in Nepal and Bhutan

This section examines challenges Nepal and Bhutan face in disaster management, including strengths and weaknesses of their respective frameworks and their implementation, by addressing several key issues, such as governance structures, co-ordination, education, infrastructure, the use of technology, budgeting and finance, and health. By implementing holistic approaches (Box 3), Nepal and Bhutan can make significant advances toward disaster-resilient development.

Box 3. Holistic approach to disaster-resilient development

The approach OECD (2024[63]) offers will provide a framework for assessing the current policy landscapes in Nepal and Bhutan to identify challenges the countries face and provide suggestions for future policy directions. OECD (2024[63]) explores the importance of developing a holistic approach to disaster-resilient development and provides several essential elements, including:

- improving governance and institutional capacity
- strengthening disaster risk reduction education
- investing in disaster-resilient infrastructure
- developing disaster-related technology
- ensuring an adequate budget for coping with disasters
- broadening disaster risk financing options
- establishing comprehensive land-use planning
- improving health responses to disasters
- facilitating the role of the private sector.

Improving governance and institutional capacity involves developing clear plans for disaster risk management. Plans must outline the responsibilities of each and indicate how they are to co-ordinate efforts if appropriate. Investing in disaster-resilient infrastructure involves developing infrastructure that can not only endure but also mitigate the impacts of disasters. Improved ICT infrastructure will facilitate adoption and effective use of technology to enhance both disaster preparedness and response. Ensuring adequate budgets for disasters and broadening financial options will be critical. Comprehensive land-use planning can be used to direct development away from vulnerable areas. Furthermore, a robust health response will mobilise resources to treat affected people while maintaining continuity of care for existing patients with physical or mental health needs. Private sector firms also have roles to play in facilitating disaster risk reduction.

4.1. The case of Nepal

4.1.1. Governance structure and co-ordination

The disaster response framework in Nepal is cluster-based, as discussed in Section 3. Each cluster is led by a government agency and has a United Nations agency as a subordinate co-lead. In response to disasters, National Emergency Operations Centers (NEOC) or Local Emergency Management Agencies (LEMA) should be formed to be the pinnacle of co-ordination with assistance from the CNDRC. Separate but integrated co-ordination centres should be established for foreign militaries (Multi-National Military Coordination Center or MNMCC), international agencies, and other civil or private actors (On Site Operations Coordination Center or OSOCC). The Framework delineates co-ordination responsibilities and delegates various agencies with leading a variety of time-sensitive response tasks. The Framework also delineates tasks for agencies in mustering personnel and supplies. Nepal's National Disaster Risk Reduction and Management Authority (NDRRMA) hosts Building Information Platform Against Disaster (BIPAD), a disaster management information system to improve coordination (Box 4).

Box 4. Building an information platform against disaster in Nepal

NDRRMA hosts BIPAD, a disaster management information platform to improve co-ordination. BIPAD features maps showing hazard locations, recent incidents, their effects (e.g. people killed or injured, livestock destroyed, infrastructure damaged), the state of nearby physical and human resources, and estimates of economic losses due to the events. Disaster incidence, damage and losses are available for custom periods at the provincial, district and municipal levels (BIPAD Portal, n.d.[64]). BIPAD is also linked to Nepal's DRR Portal, which provides strategic action plans and other documents, press releases, records of relief distributed, lists of contact persons, disaster alerts and information (especially for laypeople), as well as information on how people can volunteer to help respond to disasters (BIPAD Portal, n.d.[64]). The database also contains regional demographic information, risk information, and two additional tools in earlier stages of development. One of the tools in development is VisRisk, which allows for visual representation of disaster risk, a useful aid for officials and media in storytelling to laypeople. The VisRisk system is currently operational in 11 municipalities and 2 provinces of Nepal with the intention to continue expanding it. The other tool in development is the Introduction to Impact-based Forecasting (IBF) Dashboard for Early Action, a forecast combining weather or climate hazards with exposure and vulnerability information for floods, which allows authorities to take early action against floods and make their responses more effective. The IBF Dashboard is still a prototype, but it will eventually include household-level data (BIPAD Portal, n.d.[64]).

Vij et al. (2020[65]) explore how disaster resilience in Nepal has undergone many paradigm changes, most recently to a federalised disaster risk reduction approach with an emphasis on co-ordination between levels of government. This paradigm only truly began to emerge in the aftermath of the 2015 Nepal earthquake and a coherent *National Policy for Disaster Risk Reduction* (NPDRR) is a recent development for Nepal, being released in 2018 (Ministry of Home Affairs, 2018[58]). Vij et al. (2020[65]) note that prior to this time, co-ordination challenges and competition for resources hampered disaster response effectiveness and the development of resilience.

Effective implementation is critical but could be hampered by numerous policy challenges. Complex bureaucracies and fragmentated implementation of national policies can impede disaster response and foil even the plans already exist. Differing levels of capacity among officials at different levels of government is a common issue. While highly decentralised disaster management systems could permit the necessary flexibility to respond to local needs in general, the practical results could be different, in case local officials may lack the knowledge or resources to do their part effectively (OECD, 2024[66]).

4.1.2. Disaster risk reduction education

Nepal's *National Policy for Disaster Risk Reduction* (NPDRR) states that the subject of disaster risk reduction will be incorporated into curricula at the levels of both schools and higher education (Ministry of Home Affairs, 2018[58]). Disaster risk reduction education will also be provided to people outside the formal education system through awareness campaigns that are structured in an accessible way and make use of communication systems (Ministry of Home Affairs, 2018[58]). Therefore, policy makers will not only need to design campaigns that are relevant to different localities, but also ensure that ICT infrastructure is sufficient to deliver them.

Based on data from a UNICEF survey series, students in Nepal are slightly less likely to hear about climate change in school often or very often than those in Bhutan (82% in Nepal vs. 86% for Bhutan), but the proportion that report never hearing about it is the same at 5% (UNICEF, 2021[67]; UNICEF, 2021[68]). Disaster risk reduction education should be mandatory, and the curriculum must be rich, balanced, locally relevant, and current. A robust curriculum will feature a balance of instruction on preventative action and appropriate responses. Different regions within a given country might face different risks and the curriculum presented to students should reflect the risks they face where they live. Co-ordinating between ministries may be required to develop this properly. For instance, school districts in areas at higher risk for GLOFs should feature more instruction on GLOFs in their curricula than those districts where the risk of GLOFs is low or non-existent. It is also vital that curriculum and resources reflect the current situation of disaster risk. This could become more challenging as climate change continues to progress quickly, increasing the pace at which the information in textbooks becomes outdated. Specialised training for teachers is also crucial via training of trainers (ToT) professional development methods to ensure they are able to deliver current information accurately (OECD, 2024[66]).

Disaster risk reduction education must also reach those who are no longer students, including both those who have completed their education and are now in the workforce or retired, or those who chose to abandon their education before its completion. Disaster risk must be explained clearly to people looking to purchase land or build upon it (residential or commercial) and advice should be given on how to mitigate risk. For instance, policies should be updated to include mandatory disclosure if a parcel of land lies within a floodplain and the recommended actions a buyer should take (e.g. building an elevated home) (OECD, 2024[66]).

4.1.3. Disaster-resilient infrastructure

Disaster resilience is becoming a greater consideration for Nepalese authorities as the country continues its infrastructure development. The NPDRR indicates that reducing losses to physical infrastructure is one of its objectives before outlining some policies for both new and existing infrastructure in becoming more resilient (Ministry of Home Affairs, 2018[58]). Disaster resilience measures will be incorporated in design and construction of new infrastructure and this also applies to infrastructure under construction at the time the NPDRR was released. The construction of infrastructure suitable for climate change adaptation will be promoted as well (Ministry of Home Affairs, 2018[58]). In addition, the NPDRR notes that disaster insurance on buildings, educational and health infrastructure, water supply infrastructure and some other types of physical infrastructure would become mandatory (Ministry of Home Affairs, 2018[58]).

The NPDRR also calls for monitoring the effects of disaster risk reduction efforts. In doing so, the assets and services preserved by infrastructure built specifically for disaster risk reduction would receive special attention (Ministry of Home Affairs, 2018[58]). Nature-based solutions (NbS) are gaining recognition in Nepal as beneficial, but adoption has been slow. At the same time, integration of grey infrastructure with NbS and finding the right balance between the elements is essential to maximise benefits of both (Molnar-Tanaka and Surminski, 2024[69]).

A lack of national policies or frameworks dedicated to infrastructure investment and most adjacent guidelines ignoring disaster risk reduction represent significant challenges to disaster-resilient infrastructure development in Nepal (Mukherjee et al., 2023[70]). Nepal also faces numerous financing challenges, including weak frameworks for public-private partnerships (PPP), a precarious fiscal balance, and immature capital markets that limit both domestic and foreign investment (Dixit, 2017[71]).

4.1.4. Disaster-related technology

Despite mobile phone penetration of over 100%, less than half the population in Nepal (49.6%) uses the internet and less than 90% of the population has access to electricity (89.9%) (Kemp, 2024[72]). As a result, few of the weather stations are automatic, relying on human intervention significantly. This arrangement can lead to more system failure via human error and also make the implementation of early warning systems and dissemination of information challenging. Electrification rates vary sharply among provinces (Bishwokarma et al., 2020[73]), so collaboration between central authorities and local leaders is essential for designing disaster responses suited to current conditions in each region. At the same time, electrification and the development of ICT infrastructure for the purposes of disaster risk reduction and disaster management are important priorities. The NPDRR calls for the adoption of remote-sensing technologies in disaster management (Ministry of Home Affairs, 2018[58]), a development that appears to be underway. However, there is still room for improvement in this area, and use of these tools may not yet be feasible in all areas of Nepal.

Smart technologies such as satellite remote sensing, real-time monitoring, artificial intelligence and the Internet of Things need to be encouraged further and continual investment in impact-oriented research is needed. Smart boulders technology provides protection of lives and infrastructure against landslide and flood risk, offering an example of a smart technology already being employed successfully in Nepal (Dini et al., 2021[74]). In addition, other challenges of technical capacity need to be addressed. These could include infrastructure challenges or a lack of technical expertise within disaster management teams. Furthermore, early warning systems should be developed for more types of disasters and existing systems should be see their coverage expanded. Resident-engaged risk mapping should be pursued at the community level, bringing awareness to risk (OECD, 2024[66]). Cell phone and social media data can also be useful if analysed correctly. Nepal already has a history with this. Relief groups used imagery comparison, analysis of crowd-sourced data, and machine learning to identify the hardest-hit areas after the 2015 Gorkha earthquake (OECD, 2024[66]).

4.1.5. Adequate disaster budgets

Nepal adopted new strategies for disaster budgeting under a federal system in 2019 (Flood Resilience Alliance and Mercy Corps, 2019[75]). The new system hopes to encourage local government investment in DRR, which is essential for addressing local-level needs. Under the system, local governments craft Local Disaster and Climate Resilience Plans (LDCRP), but often lack the capacity to do so most effectively (Flood Resilience Alliance and Mercy Corps, 2019[75]). The challenges with performing this function optimally, hamper efforts to define adequate disaster budgets. According to Flood Resilience Alliance and Mercy Corps (2019[75]), “Environment and Disaster Management” accounted for 0.7% to 3.4% of municipal budgets in 2019. Despite adopting a governance approach that considers the stages of the disaster cycle, this approach has yet to be applied to disaster budgeting. While pursuit of Climate Change Adaption (CCA) is laudable, disaster budgets should be treated as separate and must be scaled up sharply. This separation should be clarified through the development of new legal frameworks, such as “Disaster Management Laws” that would be in alignment with the *National Policy for Disaster Risk Reduction 2018*.

4.1.6. Disaster risk financing

Nepal is highly exposed to disasters, but only 11% of Nepali adults reported having any kind of formal insurance (CENFRI, FinMark Trust and UNCDF, 2014[76]). Of those with formal insurance policies, 41% reported having life insurance, making it the preferred product among insurance users. The intangible and long-term nature of insurance often discourages uptake, particularly in target markets where disposable incomes are low and awareness of the value of insurance is limited. Furthermore, affordability and accessibility remain key issues in Nepal. While most adult consumers may not be able to understand, afford, or access insurance, they are nevertheless faced with a multitude of risks and need to be covered for unforeseen events. For most, this will likely be in the form of savings, although there is also the potential for the use of credit products, in which case repayment can occur over time (CENFRI, FinMark Trust and UNCDF, 2014[76]).

Insurance appears to be more popular among low-income individuals in Nepal linked to microfinance than among the general population. As many as 44% of surveyed low-income persons who are microfinance (MFI) users have purchased some type of insurance policy, compared to only 24% among low-income survey respondents who are not microfinance users. This discrepancy could be due to the microfinance distribution channel making the purchase of insurance easier. Of those who had not purchased an insurance policy, 60% of respondents cited lack of awareness as a reason, higher than the 51% who cited a lack of capacity to pay premiums. Lack of awareness was lower among MFI respondents (48%) compared to those not involved with MFIs (72%). In addition, 29% of respondents without insurance said lack of trust was another reason for not purchasing, followed by lack of need for insurance, and lack of availability of insurance services (UKaid, 2018[77]).

Under these circumstances, the Government of Nepal announced in the FY 2016/17 budget that at least 5% of every insurance company's premium revenue should come from microinsurance (UKaid, 2018[77]). The government also issued a Microinsurance Directive in 2014, which defines the products that can be classified as microinsurance for both the life and non-life segments. Furthermore, Sakchyam is an initiative funded by UKaid as part of an agreement between the governments of Nepal and the United Kingdom to expand financial access and develop the country's finance sector by working with the public and private sectors in Nepal (UKaid, 2018[77]). Sakchyam has been instrumental in encouraging partnerships within Nepal's private sector to develop microinsurance products. The Nepal Insurers' Association and the Nepal Microfinance Banker's Association signed a memorandum of understanding to distribute microinsurance products to MFI clients. This was the first time a partnership between these associations has occurred. It is expected to help expand the outreach of formal microinsurance products to low-income households across Nepal (UKaid, 2018[77]).

In addition, a crop and livestock insurance programme was introduced in Nepal after the Insurance Board formally issued the *Crops and Livestock Directives, 2013* in January of that year. Approximately six months later, the Council of Ministers decided to approve the Crops and Livestock Insurance Subsidy Directive, 2013. Under this directive, the Government of Nepal granted a 50% subsidy on original insurance premiums paid by farmers for a wide variety of perils. The subsidy was eventually increased to 75% a VAT exemption on the policy was granted. In a further effort to enhance take-up and penetration, the government removed the NPR 10 million limit as of 17 July 2014 (World Bank, 2020[78]).

However, the offerings in the market are not necessarily reflecting the need of consumers in Nepal. Insurance providers should be encouraged to develop a variety of offerings that are customisable to suit the needs of clients. Decision makers in the insurance industry should work with professionals to enhance their skills in policy design, and industry representatives should work with the government and regulatory agencies to gain approval for a wider array of offerings.

In addition, the lack of awareness on knowledge of financial instruments further hinders the take-up of disaster insurance. The *Nepal Financial Inclusion Action Plan* (Nepal Rastra Bank, 2018[79]) is an

implementation plan for the *National Financial Inclusion Roadmap (2017-2030)*. The plan identifies bolstering risk-mitigation capability as a priority, focussing essentially on developing and expanding insurance take-up.

Moreover, low levels of insurance awareness and financial literacy are significant barriers and that shifting to an institutional model for insurance delivery would improve access (Box 5).

Box 5. Institutionalisation of disaster risk insurance in Nepal

Most insurance customers in Nepal deal with insurance agents, especially in rural areas (Nepal Rastra Bank, 2018[79]). Unfortunately, these agents may have inadequate training to answer all the questions of a potential customer and effectively sell the product. In addition, for those that do take up insurance, their avenue of access to insurance is through a particular person, rather than an institution. If the agent leaves the area or the industry, customers may simply let their policies lapse because they are unsure of how to renew them or modify them to meet new needs (Nepal Rastra Bank, 2018[79]). Facilitating insurance sales through banks and financial institutions will help establish more permanent points of contact for customers with people who may be better trained in a formal way to offer them assistance. While the agent model might have some trust benefits, the institutional model should become preferred. Challenges include a lack of diversity in offerings, which focus mostly on urban populations, and eligibility barriers for people with irregular incomes. Mandates to expand the diversity of offerings so that irregular income earners could be included and a prioritisation of research and development in products (in a manner that those making the expenditure are able to benefit) and for the use of technology to deliver insurance (e.g. partnering with e-payment and e-money systems) could help with these challenges (Nepal Rastra Bank, 2018[79]).

The UNDP recently launched an Insurance and Risk Finance Initiative to help Nepal to enhance access to disaster insurance market (UNDP, 2024[80]). The initiative will work with the Ministry of Finance, Nepal Insurance Authority, and the National Disaster Risk Reduction and Management Authority to construct a Risk Management Framework, a project already underway before the commencement of this initiative. Initiatives targeted to the groups most underinsured, including women, farmers and businesses will help increase access to insurance, leading to greater inclusion. The *Nepal Financial Inclusion Report 2023* provides some insight into how the implementation is progressing. Insurance remains the least used financial tool as of 2022, with only 29% of survey respondents using it, though this figure represents a marked increase over the 11% take-up rate in 2014. The enabling of banks to cross-sell insurance products as of 2014 has helped increase formal take-up as well as decrease take-up via informal channels from 9% to 0.4% (IFC and UNCDF, 2023[81]), though most of these gains are in the area of life insurance. The usage of agricultural insurance by farmers has increased from 8% to 22% between 2014 and 2022 (IFC and UNCDF, 2023[81]), mostly due to the *Agricultural and Cattle Insurance Directive 2020*, that mandates all on-life insurance companies to allocate 5% of their portfolios to agricultural and cattle insurance as well as to the increase in the agricultural insurance subsidy from 50% in 2014 to 75% in 2019. The *Financial Literacy Framework* developed by Nepal Rastra Bank (2022[82]), identifies risk management as a key component, and offers a number of ways to conduct financial literacy training on this and other issues. However, any plans remain in the proposal or development stage.

In addition to insurance, market-based risk transfer mechanisms such as bond markets are also developing in Nepal, though such markets are in their initial stages of development (IMF Statistics Department and IMF Monetary and Capital Markets Department, 2023[83]). The PwC analysis (2020[84]) indicates the tax treatment of bond income in Nepal relative to fixed deposits reduces demand for bonds. In addition, improved regulatory support related to financial disclosure should help boost investor confidence. The creation or enhancement of digital financial infrastructure, such as an electronic trading platform, central

depository, and settlement system is essential to the flourishing of the bond market in Nepal (PwC, 2020[84]).

Further development will be needed in security markets in Nepal. Fostering institutional investors is critical. As of now, foreign institutional investors are not permitted to invest in the secondary market and their participation in the primary market is low. Furthermore, there are no secondary market trades in debt securities (Bikash Rinpatra) issued by the Government of Nepal, even though most of these are listed on the Nepal Stock Exchange (NEPSE). Insurance-linked securities (ILS) are not available in Nepal as of the time of publication. While the development of CAT bonds may become a long-term goal for Nepal, policy makers can focus on a number of capital market improvements in general in the interim (OECD, 2024[63]).

4.1.7. External financial support

Funding for disaster risk management in Nepal relies heavily upon external support. India and Nepal have had strong ties for decades through which India provides significant support in a variety of areas, including disaster risk financing. Nepal also has productive relationships with international and intergovernmental organisations. The World Bank announced the launch of a "Nepal Disaster Resilience Development Policy Credit with Cat DDO (NDRC)" on 8 October 2024 (World Bank, 2024[85]). Supported by the World Bank (IBRD), the global Facility for Disaster Risk Reduction and Recovery (GFDRR), and multiple national development agencies, the facility supports the development of climate and disaster risk reduction (World Bank, 2024[85]). The CAT DDO portion of the instrument provides emergency contingent credit following a qualifying disaster, and these types of instruments typically feature contingencies related to development and policy goals that bring the policies of developing countries further into alignment with best practices and the SDGs. In the case of the instrument for Nepal, funding will be used to strengthen institutional capacity and enhance early warning systems.

4.1.8. Health responses to disasters

Planning and strong co-ordination are essential for delivering health supplies and personnel to disaster areas quickly (OECD, 2024[66]). In this area, Nepal should strengthening such a plan (Bhandari et al., 2020[86]). The Ministry of Health and Population (MoHP) leads the health cluster at the national level, but capacity for similar efforts as sub-national levels is absent or nearly absent, though even national level capacity is weak (Bhandari et al., 2020[86]). Local health professionals are often first responders to a disaster, and their roles become even more crucial if support from major centres is delayed by weather or infrastructure damage (OECD, 2024[66]). Disaster medicine presents a challenging environment as infrastructure damage can impede the function of health facilities. Therefore, specific training in disaster medicine should be added to curricula for doctors, nurses, and community health workers (CHW) (OECD, 2024[66]). In the case of the 2015 Gorkha earthquake, many of the first responders were female community health volunteers (FCHV). They were trained in health support for mothers and young children during normal times, but many interviewed by Fredricks et al. (2017[87]) believed they needed more disaster-specific training on concepts such as building safe shelter, first aid, hygiene, water purification techniques, and how to maintain the health of children and pregnant women and meet their nutritional needs with limited food supplies.

Mental health support is another essential component of a robust health response to a disaster. In the aftermath of the 2015 Gorkha earthquake, many adults were fearful of aftershocks for weeks or months, as were children old enough to understand what happened in the earthquake. One FCHV, a type of CHW in Nepal, noted she was still fearful of aftershocks ten months after the earthquake and fear decreased her interest in working, while another reported continued anxiety regarding loud noises while living in a temporary shelter (Fredricks et al., 2017[87]). Fredricks et al. (2017[87]) also recount that some children wanted to be held by their parents at the slightest amount of ground movement. Mental health services in

responses to disasters must be scaled up throughout the country, and the mental health needs of responders (including mental health responders) must be fulfilled (OECD, 2024[66]).

4.2. The case of Bhutan

4.2.1. Governance structure and co-ordination

Bhutan achieves co-ordination through its Disaster Management Information System (DMIS) (Ministry of Home and Cultural Affairs, 2019[88]). The DMIS facilitates co-ordination of both pre-disaster planning and post-disaster response for multiple agencies. The *Disaster Management Act of Bhutan 2013* designates the Department of Disaster Management (DDM) as the leading agency for disaster response co-ordination in the country and the DDM is tasked with developing and maintaining the DMIS in this role in conjunction with relevant agencies. The DMIS has five modules:

1. Pre-Crisis Data Module (contains population details, database of available emergency relief items, search and rescue equipment, volunteers and personnel with disaster management training, critical infrastructure and vital contact details).
2. Damage and Needs Assessment Module (contains forms to be filled out relating to damage and assessment needs for immediate response and longer-term reconstruction). The documents in this module are to be filled out within certain time limits after a disaster (24 hours, 72 hours, or 2-3 weeks) and the process for filling out the forms pertaining to immediate assessment and response is supported by a mobile application that allows for data input even in the absence of mobile data connectivity.
3. Report Module (allows viewing of records of past disaster events and their consequences). The data is presented in a variety of ways including spreadsheets, tables, graphs and maps so it can be accessed in a manner most suited to user needs.
4. Risk Mapping Module (hazard, vulnerability and risk mapping information developed by relevant agencies).
5. Disaster Risk Reduction Activities Module (provides information on disaster risk reduction projects, progress and achievements related to those projects, capacity building activities, and DRR costs and budgets).

Disaster management officials at various levels of government are expected to update the DMIS regularly.

As sub-national agencies begin to take larger roles in disaster response, it is important to maintain a level of stability within them so the decision makers can learn from experience and use that experience to guide those in their charge. Furthermore, since there is some variability in responsible agencies by disaster type, it is essential to ensure the agencies can co-ordinate effectively in the event of a multi-faceted disaster. The *Disaster Management Act of Bhutan 2013* mandated “all agencies to prepare, implement, review, and update Disaster Management and Contingency Plan[s] (DM&CP)” (Ministry of Works and Human Settlement, 2021[89]). In response, many agencies have developed DM&CP, some of which have been revised to reflect changing needs and priorities. For instance, the Ministry of Works and Human Settlement most recently updated its DM&CP in May 2021. The first section of the document places the Ministry within the context of Bhutan’s overarching disaster management and response framework as outline in the aforementioned *Act*. The second section of the document discusses risk assessments, roles and responsibilities of the Ministry, standard operating procedures for how to fulfil many of them and identifies capacity gaps. The third section of the report focuses on how the Ministry itself can sustain critical operations during and after a disaster and proposes steps to improve in this area. Annexures of the report list United Nations standards for emergency shelters (emergency shelter provision is a responsibility of the Ministry), and the locations and required minimum sizes of critical stockpiles (Ministry of Works and Human

Settlement, 2021[89]). The document drew upon the *Contingency Planning Guideline for Bhutan*, issued in 2014 to help guide ministries in the formation of their DM&CP in compliance with the *Disaster Management Act of Bhutan 2013*. Disaster Management and Contingency Plans have also reached the dzongkhag and gewog levels. At the dzongkhag level, plans are updated annually and reviewed quinquennially in compliance with Section 79 of the *Disaster Management Act of Bhutan 2013* (Haa Dzongkhag Administration, 2023[90]). The plans provide overviews of their respective dzongkhags, an outline of the disaster management system within the dzongkhags, a risk profile and action plan, contingency plans with standard operating procedures for various disaster types, a description of the implementation mechanism that deals mainly with budgetary responsibilities and flows, as well as an annexure featuring contact lists for key personnel (Haa Dzongkhag Administration, 2023[90]). Gewogs (villages or subdivisions of dzongkhags) are required to formulate their own plans as well.

4.2.2. Disaster risk reduction education

Disaster risk reduction education (DRRE) does not receive significant attention in Bhutan and there is little indication it is targeting those out of school, such as adults who have completed their education. DRRE appears to be focused heavily on safe responses to disasters, with comparatively little emphasis on prevention. Climate change education is offered as part of environmental science at the secondary level, which is an elective subject of study. Disaster risk reduction does not appear to receive any significant attention in the curriculum, and neither climate change nor DRRE are integrated into other aspects of education in a holistic way, though the Ministry of Education intends to develop a climate change curriculum (National Education Commission, 2020[91]; Thapa, Gough and Cooper, 2024[92]). A 2021 UNICEF survey indicates that 86% of surveyed students hear about climate change in school often or very often and primarily through geography classes (78%) rather than science (10%). The survey also reveals that students aged 20-24 are more concerned about climate change than those aged 15-19 and females are more concerned than males, suggesting that targeted messaging may be required to close cohort and gender gaps. However, these results should be interpreted with some degree of caution as the survey offers no insight into disaster risk reduction specifically (UNICEF, 2021[67]).

Disaster risk reduction should be mainstreamed into the curriculum as an additional component beyond climate change. The same policy suggestions with regard to disaster risk reduction education in Nepal are also relevant to Bhutan. At higher levels of education, especially in subjects leading to government posts, disaster risk reduction education should be added to the curriculum. Such a change would allow for new policy makers to consider disaster risk reduction from the beginning of their tenures rather than relying on later professional development training. Professional development training may be necessary regardless, but this would be more focused on responding to the changing situation and the adoption of new best practices.

Recommendations on disaster risk reduction include, for instance, having an emergency plan and supply kit, keeping homes in good condition to minimise secondary hazards such as fires caused by earthquakes and floods, and having a grasp of risks where appropriate (e.g. whether a home or business is in an area prone to earthquakes or floods). Notably, landslide risk is the only disaster type where relocation is mentioned as a potential option, while other disaster types are essentially treated as something to live with. Mandatory risk disclosure and the bundling support for household disaster risk reduction (e.g. foundation repair, electrical repair) with insurance could be beneficial policies to promote disaster risk reduction.

4.2.3. Disaster-resilient infrastructure

The *National Human Settlement Policy of Bhutan 2019* (NHSP) (Ministry of Works and Human Settlement, 2019[93]) is the key document on disaster-resilient infrastructure development for the country. Limited land area suitable for human settlement and increasing development combine to create an environment where demand for land and infrastructure is highly competitive. Bhutan's exposure to the risks of disasters and

climate change makes infrastructure highly vulnerable. Therefore, the use of design and construction practices suitable for the difficult environment are essential to prevent damage. With this in mind, Bhutan has a large incentive to mitigate local effects of climate change. Infrastructure development will promote low-emission, energy-efficient designs, according to the policy objective described in the NHSP 2019 (Ministry of Works and Human Settlement, 2019[93]). According to two policy statements associated with the objective of reducing vulnerability and increasing resilience to disaster, the NHSP 2019 calls for the MoWHS to "carry out geo-technical studies for settlement sites, prepare geo-hazard maps, and demarcate no-construction zones" and to "develop building codes, design standards and guidelines for disaster resilient designs and development of human settlements" (Ministry of Works and Human Settlement, 2019[93]). Nature-based solutions to reduce flood risk are planned in Phuentsholing Township through the Amochhu Land Development and Township Project (ALDTP) that would implement these solutions on land bordering the Amochhu River (Mukherjee et al., 2022[94]). One advantage of NbS is their potential to offer multiple benefits (OECD, 2024[66]).The NbS planned for Phuentsholing Township could also offer potential positive spillovers, such as enhanced safety and reduced erosion risk (Mukherjee et al., 2022[94]).

The uneven terrain and scattered nature of human settlements in Bhutan create major challenges for infrastructure development, as these factors can lead to significant disparities in infrastructure quality within the country. Other challenges include the absence of a centralised agency for plan and policy review, and conflicts in legislation that must be rectified to prevent confusion (Ministry of Works and Human Settlement, 2019[93]).

4.2.4. Disaster-related technology

Disasters in what authorities in Bhutan refer to as the renewable natural resources (RNR) sector will be dealt with according to the *Renewable Natural Resources (RNR) Strategy 2040* (Ministry of Agriculture and Forests, 2021[95]). This Strategy accounts for some of the unique characteristics associated with RNR disaster such as forest fires, human and animal disease, and crop destruction. The particular needs of the RNR seem to suggest a sector-specific plan is necessary. Indeed, the Strategy calls for the development of a holistic RNR contingency plan for such unforeseen events based on prior experience of managing such situations (Ministry of Agriculture and Forests, 2021).

Bhutan has weather stations across the country, many of which are automatic (National Center for Hydrology and Meteorology, 2021[96]). However, several sites still have stations that require manual operation. Upgrading these stations should be a short-term goal. Despite the wide coverage of weather stations, the stations are not consistently networked to a central agency or amongst themselves. Increasing automation and building a network of the stations under the auspices of a central agency would allow the value they add to be maximised. Early warning systems were uncommon in Bhutan, though developing a network of them seems to have become a particular priority since at least 2018 with multiple calls for projects to establish such systems (Ministry of Health, 2020[97]; National Center for Hydrology and Meteorology, 2018[98]). For instance, a GLOF early warning system for the Punakha-Wangdue Valley has been in place since at least 2021 (National Center for Hydrology and Meteorology, 2021[48]). An automated early warning system has also been installed along the Punatsangchhu River basin (Tshering, 2019[28]). This was done in collaboration with local partners and an education programme for affected communities on hazard risks and risk reduction strategies. Regular drills are conducted throughout the river basin.

To be effective, early warning systems need to be developed and used, based on the understanding of how people use IT (APMCDRR, 2022[99]). The development of early warning infrastructure will also need to be accompanied by awareness campaigns and the limitations on electricity and internet access mean that the methods of delivering early warnings may need to vary by region to suit local needs. Nevertheless, Bhutan could benefit from integrating satellite or other remote-sensing data into its early warning systems, an avenue being explored by Bhutanese authorities for agricultural purposes since at least 2023 (Ellingson, 2023[100]).

Doing so would require significant upgrades to ICT infrastructure, and an increase in available personnel skilled in that area. Achieving country-wide internet coverage would be a reasonable short-term policy goal that would also improve networking of weather stations and early warning systems. Existing early warning systems should be expanded and automated as much as possible to reduce the likelihood of failure via human error. As of July 2024, the Royal Government of Bhutan Government Technology Agency (GovTech) was exploring the possibility of introducing satellite-based internet service in the country to close coverage gaps (Sharma, 2024[101]).

4.2.5. Adequate disaster budgets

As per the *Disaster Management Act of 2013*, four budget allocation methods were introduced: Response and Relief Expenditure, Disaster Relief Budget, Budget for the Department of Disaster Management, and Recovery and Reconstruction per the Financial Guides for Disaster Management. Beyond the methods introduced in the Act, some other funds were also set up to respond to the increasing threat of disasters from natural hazard events that Bhutan faces. The *Druk Gyalpo's Relief Fund Act of 2012* was enacted to grant relief, recovery, and reconstruction support to affected families. The Relief Fund with the Department of National Budget was to reserve BTN 250 million annually for use in disaster relief (Department of Disaster Management, n.d.[29]). The Bhutan Disaster Risk Management Strategy was published in 2017, articulating all policies and principles required to efficiently allocate available resources to achieve the priorities outlined in the Disaster Management Act of 2013. It aligns with the Sendai Framework and highlights the importance of climate change adaptation (ADPC and UNDRR, 2021[102]). In recent years, specific budget allocations for disaster preparedness and response have been provided to certain agencies through Bhutan's Five-Year Plans (Kuensel, 2024[103]; Royal Government of Bhutan, 2023[104])

Response and Relief Expenditure requires each dzongkhag (district) and other relevant agencies to meet the expenses for response and relief operations from their respective annual budgets. The grant provides affected families with relief, recovery and reconstruction support. These emergency expenses are to be reimbursed by the Ministry of Finance. However, reliance on emergency reimbursements at the dzongkhag level may lead to delays. Enhancing the financial autonomy of subnational units could improve efficiency.

The Disaster Relief Budget is used for restoring essential public infrastructure and public service centres. This is a separate budget allocation for national disaster management operations undertaken by the Department of National Budget, Ministry of Finance. Most of the procurement is expected to follow the normal Royal Government of Bhutan (RGoB) Procurement Rules and Regulations. However, in case of emergency, if there is an urgent need for immediate relief and response, this procurement may be exempt from the standard procedures. In 2017, Finance Minister Namgay Dorji said it is not possible to allocate a certain amount of budget for natural disaster relief activities in the dzongkhags. Thus, expenses are incurred only on an emergency basis and agencies of each dzongkhag must claim later for reimbursement from the Ministry of Finance through the Department of Disaster Management. At the moment, by the *Disaster Management Act of 2013* (Parliament of Bhutan, 2013[60]), budget allocation and funding solely aim to cover recovery and reconstruction as disasters are generally unpredictable and occasional, and it would be difficult to estimate appropriate budgets for recurrent disasters on an annual basis.

The Budget for Department of Disaster Management (DDM) is a budget allocated to the specific department that is responsible for overall disaster management and response. This separate budget is used for capacity building, such as establishing and maintaining critical disaster management facilities, including the purchase of equipment and other activities required to strengthen disaster preparedness in the country. The rapid increase in budget in FY 2011/12 originated from an increase in awareness of the importance of disaster risk reduction activities in the aftermath of the 2011 earthquake.

Recovery and Reconstruction funding is granted to each Dzongkhag Disaster Management Committee (DDMC) via several processes. As the DDMC is responsible for undertaking damage assessments of public assets and infrastructure, it should submit the assessment report along with the work programme

and cost estimate to the DDM for review and onward submission to the National Disaster Management Authority (NDMA). The NDMA then recommends that the government release funds to the concerned sectors.

Despite these positive developments, further reallocation is still being requested by many sectors, such as education, transportation, and disaster alerting. The education sector is concerned mainly with preparedness for and resilience to earthquakes, given the state of school buildings and the vulnerability of children. The Ministry of Works and Human Settlement is calling for the allocation of funds to support the development of road networks more resilient to disasters (Ministry of Works and Human Settlement, 2017[105]), while Bhutan's *Thirteenth Five-Year Plan 2024-2029* allocates BTN 2.56 billion for disaster preparedness across additional agencies. The National Center for Hydrology and Meteorology will receive BTN 1.7 billion of those funds in part to develop critical infrastructure, including a weather and flood warning centre in Yusipang (Kuensel, 2024[103]; Royal Government of Bhutan, 2023[104]).

Disaster budgets should be integrated into the government budgets at each level. In the event that the entirety of a disaster budget is not used, there should be policies allowing for low-risk reinvestment to grow the fund, or the reallocation of an annual response budget to disaster risk reduction activities. Even so, budgets for response and disaster risk reductions should be kept separate and both items should appear in government budgets. There should also be clear policies for how budget shortfalls are to be handled. The disaster budgeting framework of the Philippines provides an example of both vertical and horizontal options in this regard (OECD, 2024[66]). Budgets should be reviewed regularly, in addition to after a shortfall, to examine the possibility of increasing them as demanded by changes in exposure brought on by evolving disaster risks and internal migration of people and assets.

4.2.6. Disaster risk financing

In Bhutan, since 2013, the country has shown a high commitment to strengthen disaster risk financing at the national level via several plans and policies. The first policy, called the *Disaster Management Act of 2013* (Parliament of Bhutan, 2013[60]), aims to establish and strengthen institutional capacity, co-ordination and communication for disaster management and to ensure arrangement of finances for disaster management projects. The funding has increased over the years in recognition of the fact that disaster risk reduction is inseparable from sustainable and resilient development. Nonetheless, disaster risk financing in Bhutan is currently limited, relying on a few measures.

Using insurance as a method of managing disaster risk has yet to gain widespread acceptance in Bhutan. Bhutan's Ministry of Agriculture and Livestock (MoAL) has attempted to introduce national crop insurance at least twice (in 2016 and 2021), but these endeavours were unsuccessful (UNDP, 2024[106]). Farmers have judged the premiums to be too expensive, even if they have taken up insurance policies for structures (Dolkar, 2022[107]). Nevertheless, the MoAL appears ready to make another attempt in late 2024 or sometime in 2025. Indeed, a motion to establish a Crop and Livestock Compensation Trust Fund was brought forth in Bhutan's National Assembly (lower house) in 2024. The motion passed, and an implementation plan should be presented shortly (National Assembly of Bhutan, 2024[108]). The Royal Insurance Corporation of Bhutan Limited (RICB), a public-private insurance and reinsurance company offers insurance for a variety of animals (e.g. cattle, pigs, poultry, fisheries, etc.) being used for both household and commercial purposes. Deaths caused by disasters are covered in at least some of these policies (RICB, n.d.[109]). In contrast, crop insurance excludes several natural hazard perils (RICB, n.d.[109]). Fire insurance is available for residential and commercial properties, and the perils covered can be extended to include earthquakes, floods, landslides, storms and other hazards, all for additional fees (RICB, n.d.[110]). Three insurance companies are currently operating in the market: Royal Insurance Corporation of Bhutan Limited (RICB), Bhutan Insurance Limited (BIL) and GIC-Bhutan Reinsurance Company Limited (GIC-BRCL) (Box 6).

Box 6. Insurance companies in Bhutan

Royal Insurance Corporation of Bhutan Limited (RICB) is one of the main insurance companies in Bhutan. RICB was established in 1975 under the royal charter of the fourth Druk Gyalpo to cater to the insurance needs of the people and promote the socio-economic development of the country; it is the oldest insurance company in Bhutan (RICB, n.d.[111]). Article 251 (b) of the Financial Services Act (FSA) of 2011 states that insurers are restricted to either life or non-life business. On the other hand, composite insurers existing before FSA came into force were allowed to continue their businesses according to Article 251 (c) providing they maintain separate books and accounting for life and non-life insurance business (World Bank; First Inititative; Royal Monetary Authority of Bhutan, 2018[112]). According to these articles of the FSA, life and non-life insurance businesses should be pursued by separate companies, but when considering the size of Bhutan's insurance market, it is unlikely that separate sources of capital would establish these separate companies (World Bank; First Inititative; Royal Monetary Authority of Bhutan, 2018[112]). In addition to the RICB, BIL and GIC-BRCL were also established and licensed, helping people improve their financial well-being and build financial resilience.

RICB has reinsurance arrangements with various companies in the world. The corporation not only provides life and non-life insurance programmes, but also private provident funds, and a group insurance cum savings scheme (RICB, n.d.[113]). Non-life insurance products encompass group personal accident insurance, householder's insurance, or overseas travel insurance. These non-life insurances are needed in preparation for unforeseen and unpredictable events such as disability, accidents, and loss of income and assets.

Amongst the non-life insurance plans provided by RICB, both fire insurance and rural house insurance are most closely related to natural disaster risk transfer mechanisms. Fire insurance is available in various forms to suit the needs of different types of clients, such as householders, shopkeepers and industries. The most common and general fire insurance for property is Standard Fire Insurance which protects homes and property against the risk of fire and lightning with an option to extend the risk coverage against other disasters including flood, inundation, landslide, earthquake, strike, riot and malicious damages (RICB, n.d.[114]). While it covers a wide range of disasters, it also clarifies that the insurance does not cover events as follows: subterranean fire, natural fermentation, theft during and after fire, demolition by civil authority, war and nuclear radioactivity damages, and losses from the overrunning, short circuiting and electricity leakage of appliances (RICB, n.d.[114]). Potential clients can access this detailed information via the website of RICB and download the proposal and claim forms for onward processing. Rural House Insurance covers damages caused by fire, earthquake, flood, landslides, storms or lightning. Only rural houses are eligible, and coverage is limited to one house per individual, the so-called One-House-One-Insurance policy (RICB, n.d.[115]). Through this arrangement, the government subsidised BTN 42.785 billion in rural house insurance in the period between 2013 and 2015, while the benefit to the rural household was BTN 81.906 billion (Royal Audit Authority, 2016[116]). The scheme not only helps rural households to benefit from insurance to reconstruct new houses of higher quality, but it also eases the burden on the government by compensating the claims through premium subsidies rather than directly (Royal Audit Authority, 2016[116]). In addition, Householder's Insurance protects the contents of houses, but not the structures. It provides coverage against fire, natural disasters and burglary, the burglary coverage setting it apart from Standard Fire Insurance (RICB, n.d.[117]). It also provides insurance for cash-in-transit, cash-in-safe and BTN 50 000 of coverage for personal accidents (RICB, n.d.[117]).

Shopkeeper's Insurance is specifically designed to provide comprehensive coverage against fire and many other natural disasters for small and medium-sized businesses. Properties with a maximum value of BTN 1 500 000 are eligible for coverage under the policy (RICB, n.d.[118]). While it does not cover money and valuables within shops, it covers damage due to fire, lightning, earthquakes, subsidence, landslides

and rockslides, floods, storms, cyclones, tempests, gas explosion in domestic appliances, bursting and overflowing of water tanks, falling aircraft, which means it covers almost every natural disaster according to the policy. It offers premium savings of up to 10% if more than two covers are purchased. The extent of the coverage of the Industrial Insurance Policy is similar to that of Shopkeeper's Insurance, but it is designed to cover the widest range of accidental loss or damages typically faced by large, single and multi-location businesses (RICB, n.d.[119]). This policy is recommended for any company with high-value physical assets such as property or industrial sites, large universities and councils.

The financial sector of Bhutan is still in its development stage, facing significant resource constraints to finance the socio-economic development of the country. Bhutan's bond market is developing, nonetheless. Bhutan issued its first sovereign bond to meet financial needs related to the COVID-19 pandemic response. As of 2020, 16 bonds were issued totalling BTN 10.9 billion in value (with the aforementioned sovereign bond the single largest issuance (ADB, 2021[120]). The market remains marginal with an issued debt-to-GDP ratio of a mere 5.8%, a figure that drops to 4.2% if the sovereign bond issue is excluded (ADB, 2021[120]). Key challenges include an underdeveloped sovereign securities market, the absence of a credit rating agency, and regulatory framework issues. Resolving these issues would broaden the possibilities of the Royal Government of Bhutan to use bonds as a tool for financing disaster preparedness and response (see Annex B for further discussion).

4.2.7. External financial support

Bhutan showed high reliance on external financial aid and support from development partners and international organisations. The Royal Government of Bhutan's budget has primarily been dependent on external grants. The share of total government revenues represented by external grants rose to 30% during the COVID-19 pandemic though it began slowly decreasing afterwards (Table 4). The Government of India is Bhutan's largest source of external grants. The peg of the ngultrum to the Indian rupee has created challenges for the Bhutanese monetary authorities in dealing with the imbalance generated by loose macroeconomic policies and currency flows related to a series of hydroelectric power projects also mostly funded by India through grants and loans.

Table 4. Bhutan government revenues and grants (% of total revenues), 2018-23

Revenue & grants	Fiscal year				
	2018/19	2019/20	2020/21	2021/22	2022/23
Domestic revenue	82.6	66.3	60.1	71.8	74.2
Other receipts	-7.6	3.6	15.0	3.2	2.0
External grants	25.0	30.1	24.9	25.0	23.8
GOI	15.4	21.0	17.3	17.7	18.1
Others	9.6	9.1	7.6	7.2	5.6

Source: Royal Monetary Authority of Bhutan (2023[121]), *Annual Report 2023*.

High dependence on external resources have led to a lack of internally financed disaster risk reduction and management projects. The Japan Policy and Human Resources Development Fund (PHRD) supported the Technical Assistance Program 2013-2017 in Bhutan to make this change, and the programme was jointly implemented by the Department of Engineering Services, the Department of Geology & Mines, and the Department of Disaster Management. It included a project on Improving Resilience to Seismic Risk worth USD 1.29 million. The project focused on risk assessment of critical facilities, seismic-resilient design and retrofitting, and capacity building related to the development of resilient infrastructure, under project-based funding (Tshering and Sekhsaria, 2019[53]).

Some projects to improve the climate resiliency of urban areas have started in collaboration with development agencies, including the Strategic Environmental Assessment (SEA) of the Thimphu Structure Plan 2002-2027. It assesses the interconnectedness of urban systems, functions and facilities vis-à-vis different challenges, including disaster risk, to inform revision, implementation and monitoring of the plan in the changing context. The SEA of the Thimphu Structure Plan was conducted by a multi-sectoral Core Team comprising representatives from local and national government agencies with technical and capacity-building support from external contributors (Ministry of Works and Human Settlement, 2018[122]).

Several external stakeholders also provided financial support. Support from the Asian Development Bank was strong as it offered the Asian Develop Fund, worth USD 34.2 million, to a project on flood protection and early warning to safeguard Phuentsholing Township (one of the key commercial and trading hubs located along the India-Bhutan border) and its residences from flood and enhance climate-resilient urban development (ADB, 2019[123]). The Green Climate Fund (GCF), a climate fund formed in the Paris Agreement), has provided Bhutan USD 61.9 million to date in support of three projects and seven "readiness activities". Most recently, a proposal for the GCF to support the enhancement of climate resilience and adaptation at the local government level was approved on 14 August 2024. Building the capacity of local governments to access climate resilience, adaptation, and transition financing is a desired outcome of this project (GCF, 2024[124]). The Global Environment Facility has also provided support to Bhutan from its Least Developed Countries Fund (LDCF). In January 2025, Bhutan secured USD 20 million from the GEF LDCF for the *Enhancing Climate Resilience of Urban Landscapes and Communities in Thimphu-Paro Region (ECRUL)* project. Over a six-year term, the ECRUL project will implement nature-based solutions (NBS) to counteract worsening climate risk in the urban areas of the capital Thimphu and the neighbouring district of Paro. The grant of USD 20 million will supplement USD 62 million of financing from the Royal Government of Bhutan and be used to "[restore] 800 hectares of watershed and springshed land" to the direct benefit of more than 146 000 residents (UNDP, 2025[125]). The Ministry of Infrastructure and Transport (MOIT) will lead the implementation in partnership with the UNDP. Since Bhutan graduated from LDC status on 13 December 2023 (UNDESA, 2023[126]), it will lose access to the LDCF in the near future, but remain eligible for general GEF funding (Razzaque, 2019[127]).

4.2.8. Health responses to disasters

The Ministry of Health released its first *Health Emergency and Disaster Contingency Plan* in 2016, calling it a "plan for health sector disaster preparedness and response in Bhutan" (Ministry of Health, 2016[128]). The plan outlines the legal frameworks for health responses to disasters, as well as definitions of several key terms within the plan (Ministry of Health, 2016[128]). The type of disaster, which is based on its geographic coverage, and coping capacities of involved levels of government dictate the people or agencies responsible for co-ordination of health responses (Ministry of Health, 2016[128]). The plan calls for the establishment of Health Emergency Operations Centres (HEOC) in response to disasters. These command-and-control facilities will operate according to Standard Operating Procedures (SOPs) given elsewhere in the plan (Ministry of Health, 2016[128]). The plan delineates roles and responsibilities involved bodies and agencies clearly as well as mechanisms of co-ordination for both domestic resources and international assistance and also provides template documentation so actions and outcomes can be tracked consistently, allowing opportunities for monitoring and evaluation both during and after responses (Ministry of Health, 2016[128]). While the *Health Emergency and Disaster Contingency Plan* (Ministry of Health, 2016[128]) recognises the importance of mental health support in disasters, the country faces severe resource constraints. Only one hospital is capable of providing advanced mental health care and the department suffers from low staffing (only four psychiatrists and no psychologists of 2023) (Dorji, 2023[129]; Gyeltshen, Chhetri and Gyeltshen, 2024[130]). Access is also a major issue that disasters only serve to exacerbate. Even in normal times, some patients report travelling as much as 500 kilometres by car to reach the facility, located in the main public hospital of Thimphu (Gyeltshen, Chhetri and Gyeltshen, 2024[130]).

5 Conclusion

This paper discusses the disaster challenges that threaten the development of the Himalayan region, with a focus on the countries of Nepal and Bhutan. Both climate change and the region's landscape leave it exposed to a variety of hazards. The Himalayan region is prone to a variety of natural hazards, including weather extremes (heat waves, cold waves and harsh winter conditions), various types of floods, landslides, wildfires, and earthquakes. Therefore, pursuing disaster-resilient development must be an urgent priority for policy makers.

Against this background, Nepal and Bhutan have both started to build institutional frameworks. However, implementing them in a manner that permits their full effectiveness remains a work in progress. Doing so will require the fulfilment of several key objectives and institutional capacity must improve, including at sub-national levels. Moreover, disaster risk reduction education must not only be integrated into the curriculum of compulsory schooling but must also be offered to those outside of their schooling years through alternative means. Further technological upgrades of early warning systems, including those that derive predictive power from AI processing of big data should also be pursued as part of a transition from reactive to proactive approaches to disaster risk reduction and management. Electrical and ICT infrastructure should be upgraded forthwith. All of these efforts must be underpinned by the availability of financing. Further development in both insurance and financial markets is essential to achieving all of the aforementioned financial goals, especially given its low level of development in Nepal and Bhutan.

Coping with disaster risk will require a holistic policy approach. While Nepal and Bhutan are highly exposed to disaster risk, policy makers in these countries can take comfort in the clear paths that are available to reduce vulnerability and bolster resilience.

References

ADB (2024), *ADB Key Indicator Database*, https://kidb.adb.org/. [134]

ADB (2021), *Kingdom of Bhutan: Financial Market Development Program (Subprogram 2), Report on Bhutan's Capital Markets and Alternative Investment Markets Regulations - Technical Assistance Consultant's Report*, Asian Development Bank, https://www.adb.org/sites/default/files/project-documents/51252/51252-004-tacr-en_0.pdf (accessed on 3 November 2024). [120]

ADB (2019), *Bhutan: Phuentsholing Township Development Project*, Asian Development Bank, https://www.adb.org/node/189337/printable/pdf (accessed on 3 November 2024). [123]

ADPC and UNDRR (2021), *Disaster Risk Reduction in Bhutan: Status Report 2020*, Asian Disaster Preparedness Center and United Nations Office for Disaster Risk Reduction, https://www.adpc.net/igo/category/ID1664/doc/2021-dhx3BO-ADPC-Disaster_Risk_Reduction_in_Bhutan_Status_Report_2020.pdf. [102]

APMCDRR (2022), *APMCDRR Co-chairs' Statement*, Asia-Pacific Ministerial Conference on Disaster Risk Reduction, Brisbane, https://apmcdrr.undrr.org/sites/default/files/inline-files/Co-chairs%E2%80%99%20Statement_APMCDRR%202022_1.pdf?startDownload=true. [99]

Awasthi, R. and J. Owen (2020), "Observed Climate Extreme in Nepal", *The Geographic Base*, Vol. 7, pp. 1-14, https://doi.org/10.3126/tgb.v7i0.34262. [32]

Azam, M. et al. (2018), "Review of the status and mass changes of Himalayan-Karakoram glaciers", *Journal of Glaciology*, Vol. 64/243, pp. 61-74, https://doi.org/10.1017/jog.2017.86. [2]

Bagale, D., M. Sigdel and D. Aryal (2021), "Drought Monitoring over Nepal for the Last Four Decades and Its Connection with Southern Oscillation Index", *Water*, Vol. 13/23, p. 3411, https://doi.org/10.3390/w13233411. [33]

Bajracharya, S. et al. (2015), "The glaciers of the Hindu Kush Himalayas: current status and observed changes from the 1980s to 2010", *International Journal of Water Resources Development*, Vol. 31/2, pp. 161-173, https://doi.org/10.1080/07900627.2015.1005731. [1]

Betts, R. et al. (2018), "Changes in climate extremes, fresh water availability and vulnerability to food insecurity projected at 1.5°C and 2°C global warming with a higher-resolution global climate model", *Philosophical Transactions of the Royal Society A: Mathematical, Physical and Engineering Sciences*, Vol. 376/2119, https://doi.org/10.1098/rsta.2016.0452. [13]

Bhandari, D. et al. (2020), *Disaster risk reduction and management in Nepal: Delineation of roles and responsibilities*, Oxford Policy Management Limited, https://www.opml.co.uk/files/Publications/a1594-strengthening-the-disaster-risk-response-in-nepal/delineation-of-responsibility-for-disaster-management-full-report-english.pdf. [86]

Biasutti, M., M. Ting and S. Hill (2022), *Guest post: How the south Asian monsoon is changing in a warming climate*, Carbon Brief. [44]

BIPAD Portal (n.d.), *BIPAD Portal*, Government of Nepal, https://bipadportal.gov.np/ (accessed on 12 September 2024). [64]

Bishwokarma, R. et al. (2020), *Deep Neural Network based Automatic System for Electricity Meter Reading in Nepal*, https://doi.org/10.6084/m9.figshare.13515128.v1. [73]

Boos, W. and Z. Kuang (2010), "Dominant control of the South Asian monsoon by orographic insulation versus plateau heating", *Nature*, Vol. 463/7278, pp. 218-222, https://doi.org/10.1038/nature08707. [18]

Cane, M. (2010), "A moist model monsoon", *Nature*, Vol. 463/7278, pp. 163-164, https://doi.org/10.1038/463163a. [19]

CENFRI, FinMark Trust and UNCDF (2014), *Nepal Financial Inclusion Country Report 2014*, The Centre for Financial Regulation and Inclusion/FinMarkTrust/ United Nations Capital Development Fund, https://www.uncdf.org/article/2931/nepal-financial-inclusion-country-report (accessed on 4 November 2024). [76]

Chen, X. et al. (2017), "Improved modeling of snow and glacier melting by a progressive two-stage calibration strategy with <scp>GRACE</scp> and multisource data: How snow and glacier meltwater contributes to the runoff of the Upper Brahmaputra River basin?", *Water Resources Research*, Vol. 53/3, pp. 2431-2466, https://doi.org/10.1002/2016WR019656. [46]

CRED/UCLouvain (2025), *EM-DAT, The International Disaster Database*, CRED/UCLouvain, Brussels, Belgium, http://www.emdat.be. [34]

Department of Disaster Management (2023), *Disaster Response and Coordination Process at the National and Dzongkhag level*, Ministry of Home and Cultural Affairs, Royal Government of Bhutan, https://www.dlgdm.gov.bt/storage/upload-documents/2023/7/26/hz3IIT3OB5.pdf. [61]

Department of Disaster Management (n.d.), *Bhutan: Disaster Risk Management Status Review*, Ministry of Home and Cultural Affairs, Royal Government of Bhutan, https://www.ddm.gov.bt/wp-content/uploads/downloads/acts&rules/Bhutan_DRM_Status_Review.pdf. [29]

Dini, B. et al. (2021), "Development of smart boulders to monitor mass movements via the Internet of Things: a pilot study in Nepal", *Earth Surface Dynamics*, Vol. 9/2, pp. 295-315, https://doi.org/10.5194/esurf-9-295-2021. [74]

Dixit, A. (2017), , UN ESCAP, https://www.unescap.org/sites/default/d8files/knowledge-products/National%20Study%20-%20Final%20-%2020170303.pdf. [71]

Dolkar, S. (2022), "Crop and livestock insurance in Bhutan yet to take off", *Royal Insurance Corporation of Bhutan Limited*, https://www.ricb.bt/crop-and-livestock-insurance-in-bhutan-yet-to-take-off/ (accessed on 3 November 2024). [107]

Dorji, C. (2023), "Addressing Mental Health in Bhutan", *The Druk Journal*, Vol. 9/1, pp. 4-14, http://drukjournal.bt/wp-content/uploads/2023/04/Dr-Chencho-Dorji.pdf. [129]

EEFIT (2019), *Mw 7.8 Gorkha, Nepal, Earthquake, 25th April 2015*, Earthquake Engineering Field Investigation Team. Institution of Structural Engineers, London. [30]

Ellingson, S. (2023), *Remote-Sensing for Climate-Resilient Agriculture in Bhutan*, The School for Field Studies, https://fieldstudies.org/blog/remote-sensing-for-climate-resilient-agriculture-in-bhutan/ (accessed on 3 November 2024). [100]

Fallah, B. et al. (2016), "A numerical model study on the behaviour of Asian summer monsoon and AMOC due to orographic forcing of Tibetan Plateau", *Climate Dynamics*, Vol. 47/5-6, pp. 1485-1495, https://doi.org/10.1007/s00382-015-2914-5. [22]

Flood Resilience Alliance and Mercy Corps (2019), *Budget Governance for Disaster Risk Reduction and Climate Change Adaptation Under Nepal's New Federal System*, https://www.dpnet.org.np/uploads/files/Policy%20Brief_Nepal%20Budget%20Governance%20Zurich%202021-09-12%2010-12-46.pdf. [75]

Fredricks, K. et al. (2017), "Community Health Workers and Disasters: Lessons Learned from the 2015 Earthquake in Nepal", *Prehospital and Disaster Medicine*, Vol. 32/6, pp. 604-609, https://doi.org/10.1017/S1049023X1700680X. [87]

Gadgil, S. (2018), "The monsoon system: Land–sea breeze or the ITCZ?", *Journal of Earth System Science*, Vol. 127/1, p. 1, https://doi.org/10.1007/s12040-017-0916-x. [20]

GCF (2024), *SAP038: Climate Adaptation, Resilience and Engagement in Local Governments (CARE-LG)*, Green Climate Fund, https://www.greenclimate.fund/sites/default/files/document/approved-funding-proposal-sap038.pdf. [124]

Govin, G. et al. (2020), "Early onset and late acceleration of rapid exhumation in the Namche Barwa syntaxis, eastern Himalaya", *Geology*, Vol. 48/12, pp. 1139-1143, https://doi.org/10.1130/G47720.1. [5]

Gyeltshen, K., B. Chhetri and D. Gyeltshen (2024), "Delivery of Mental Health Services in Bhutan: Challenges and Way Forward", *Public Health Challenges*, Vol. 3/3, https://doi.org/10.1002/puh2.211. [130]

Haa Dzongkhag Administration (2023), *Dzongkhag Disaster Management and Contingency Plan*, Haa Dzongkhag Administration, Department of Local Governnance and Disaster Management, Royal Government of Bhutan, https://www.dlgdm.gov.bt/storage/upload-documents/2023/7/26/1eVKl58yC9.pdf. [90]

Hakhoo, N. et al. (2019), "Natural hazards - their drivers, mechanisms and impacts in the Shyok-Nubra Valley, NW Himalaya, India", *International Journal of Disaster Risk Reduction*, Vol. 35, https://doi.org/10.1016/j.ijdrr.2019.101094. [50]

Hetényi, G. et al. (2016), "Joint approach combining damage and paleoseismology observations constrains the 1714 A.D. Bhutan earthquake at magnitude 8 ± 0.5", *Geophysical Research Letters*, Vol. 43/20, pp. 10695-10702, https://doi.org/10.1002/2016GL071033. [52]

Hock, R. et al. (2019), "High Mountain Areas", in Pörtner, H. et al. (eds.), *IPCC Special Report on the Ocean and Cryosphere in a Changing Climate*, Intergovernmental Panel on Climate Change, https://www.ipcc.ch/site/assets/uploads/sites/3/2019/11/06_SROCC_Ch02_FINAL.pdf. [27]

Hussain, A. et al. (2019), "Hydropower development in the Hindu Kush Himalayan region: Issues, policies and opportunities", *Renewable and Sustainable Energy Reviews*, Vol. 107, pp. 446-461, https://doi.org/10.1016/j.rser.2019.03.010. [16]

Hu, S., T. Zhou and B. Wu (2025), "Accelerated warming of High Mountain Asia predicted at multiple years ahead", *Science Bulletin*, Vol. 70/3, pp. 419-428, https://doi.org/10.1016/j.scib.2024.09.023. [132]

ICIMOD (2023), *Water, ice, society, and ecosystems in the Hindu Kush Himalaya: An outlook*, https://doi.org/10.53055/ICIMOD.1028. [42]

IFC and UNCDF (2023), *Nepal Financial Inclusion Report 2023*, International Financial Corporation/United Nations Capital Development Fund, https://www.ifc.org/content/dam/ifc/doc/2023-delta/2023-nepal-financial-inclusion-report.pdf. [81]

IMF Statistics Department and IMF Monetary and Capital Markets Department (2023), *Nepal: Technical Assistance Report—Financial Sector Stability Review*, International Monetary Fund, https://doi.org/10.5089/9798400255793.002. [83]

Immerzeel, W. et al. (2020), "Importance and vulnerability of the world's water towers", *Nature*, Vol. 577/7790, pp. 364-369, https://doi.org/10.1038/s41586-019-1822-y. [8]

Immerzeel, W., L. van Beek and M. Bierkens (2010), "Climate Change Will Affect the Asian Water Towers", *Science*, Vol. 328/5984, pp. 1382-1385, https://doi.org/10.1126/science.1183188. [7]

IPCC (2023), *Climate Change 2021 – The Physical Science Basis*, Intergovernmental Panel on Climate Change, Cambridge University Press, https://doi.org/10.1017/9781009157896. [131]

IPCC (2023), "Ocean, Cryosphere and Sea Level Change", in *Climate Change 2021 – The Physical Science Basis*, Intergovernmental Panel on Climate Change, Cambridge University Press, https://doi.org/10.1017/9781009157896.011. [24]

Jones, M. et al. (2022), "Global and Regional Trends and Drivers of Fire Under Climate Change", *Reviews of Geophysics*, Vol. 60/3, https://doi.org/10.1029/2020rg000726. [40]

Kato, T., M. Rambali and V. Blanco-Gonzalez (2021), "Strengthening climate resilience in mountainous areas", *OECD Development Co-operation Working Papers*, No. 104, OECD Publishing, Paris, https://doi.org/10.1787/1af319f0-en. [23]

Kaukab, I., S. Raza and S. Mahmood (2018), "Appraisal of surface deformation along Nanga Parbat Haramosh Massif through Remote Sensing and GIS Techniques", *Journal of Pakistan Vision*, Vol. 19/2, pp. 1-11, https://www.thefreelibrary.com/Appraisal+of+surface+deformation+along+Nanga+Parbat+Haramosh+Massif...-a0561461101. [3]

Kemp, S. (2024), *Digital 2024: Nepal*, Datareportal, https://datareportal.com/reports/digital-2024-nepal (accessed on 3 November 2024). [72]

Khanal, B. (2020), *Nepal: Brief Country Profile on Disaster Risk Reduction and Management*, Asian Disaster Reduction Center, https://www.adrc.asia/countryreport/NPL/2019/Nepal_CR2019B.pdf. [35]

Kuensel (2024), *Government allocates Nu 2.56 billion for disaster preparedness*, Kuensel, 31 August, https://kuenselonline.com/government-allocates-nu-2-56-billion-for-disaster-preparedness/. [103]

Lutz, A. et al. (2014), "Consistent increase in High Asia's runoff due to increasing glacier melt and precipitation", *Nature Climate Change*, Vol. 4/7, pp. 587-592, https://doi.org/10.1038/nclimate2237. [15]

Maikhuri, R. et al. (2017), "Socio-ecological vulnerability: Assessment and coping strategy to environmental disaster in Kedarnath valley, Uttarakhand, Indian Himalayan Region", *International Journal of Disaster Risk Reduction*, Vol. 25, pp. 111-124, https://doi.org/10.1016/j.ijdrr.2017.09.002. [45]

Matin, M. et al. (2017), "Understanding forest fire patterns and risk in Nepal using remote sensing, geographic information system and historical fire data", *International Journal of Wildland Fire*, Vol. 26/4, p. 276, https://doi.org/10.1071/WF16056. [38]

Ministry of Agriculture and Forests (2021), *RNR Strategy 2040*, Royal Government of Bhutan, Thimphu, https://faolex.fao.org/docs/pdf/bhu207784.pdf. [95]

Ministry of Health (2020), *Early Warning System for the Environmental Health Program*, https://www.moh.gov.bt/early-warning-system-for-the-environmental-health-program/. [97]

Ministry of Health (2016), *Health Emergency and Disaster Contingency Plan*, Royal Government of Bhutan, https://www.dlgdm.gov.bt/storage/upload-documents/2023/7/26/B4R6FC0zIS.pdf. [128]

Ministry of Home Affairs (2019), *Disaster Risk Reduction and Management Act, 2074 And Disaster Risk Reduction and Management Rules, 2076 (2019)*, Government of Nepal, https://bipad.gov.np/uploads/publication_pdf/DRRM_Act_and_Regulation_english.pdf (accessed on 3 November 2024). [57]

Ministry of Home Affairs (2018), *Disaster Risk Reduction National Strategic Plan of Action 2018-2030*, Government of Nepal, http://drrportal.gov.np/uploads/document/1475.pdf (accessed on 4 November 2024). [59]

Ministry of Home Affairs (2018), *National Policy for Disaster Risk Reduction*, Government of Nepal, http://drrportal.gov.np/uploads/document/1476.pdf (accessed on 5 November 2024). [58]

Ministry of Home Affairs (2013), *National Disaster Response Framework (NDRF)*, Government of Nepal, http://drrportal.gov.np/uploads/document/113.pdf. [56]

Ministry of Home and Cultural Affairs (2019), *DMIS-Introductory-movie-2019 v 08*, Royal Government of Bhutan, https://www.youtube.com/watch?v=YbmJaht3Z3k. [88]

Ministry of Works and Human Settlement (2021), *Disaster Management and Contingency Plan*, https://www.moit.gov.bt/wp-content/uploads/2021/07/DMCP-compressed.pdf. [89]

Ministry of Works and Human Settlement (2019), *National Human Settlement Policy of Bhutan 2019*, Royal Government of Bhutan, https://policy.thinkbluedata.com/sites/default/files/National%20Human%20Settlement%20Policy%20of%20Bhutan%202019.pdf#page=6.31. [93]

Ministry of Works and Human Settlement (2018), *Strategic Environmental Assessment of the Thimphu Structure Plan*, Ministry of Works and Human Settlement, Royal Government of Bhutan, https://www.moit.gov.bt/wp-content/uploads/2019/08/Strategic-Environment-Assessment-for-Thimphu-Structure-Plan-2018.pdf (accessed on 4 November 2024). [122]

Ministry of Works and Human Settlement (2017), *Review of Road Sector Master Plan (2007-2027)*, https://www.mowhs.gov.bt/wp-content/uploads/2017/04/Review-of-RSMP-2007-2027-FINAL.pdf. [105]

Mishra, O. et al. (2021), "Glacial mass change–induced earthquakes in the Himalayan region of South Asia and its bearing to understand Arctic glaciers dynamics: proxy of climate change", in *Understanding Present and Past Arctic Environments*, Elsevier, https://doi.org/10.1016/b978-0-12-822869-2.00025-6. [55]

Molnar-Tanaka, K. and S. Surminski (2024), "Nature-based solutions for flood management in Asia and the Pacific"*, OECD Development Centre Working Papers*, No. 351, OECD Publishing, Paris, https://doi.org/10.1787/f4c7bcbe-en. [69]

Mueller, S. et al. (2019), "Disaster scenario simulation of the 2010 cloudburst in Leh, Ladakh, India", *International Journal of Disaster Risk Reduction*, Vol. 33, pp. 485-494, https://doi.org/10.1016/j.ijdrr.2018.09.004. [43]

Muir-Wood, R. (2000), "Deglaciation Seismotectonics: a principal influence on intraplate seismogenesis at high latitudes", *Quaternary Sci. Rev. 19*, pp. 1399-1411. [54]

Mukherjee, M. et al. (2023), "Extent and evaluation of critical infrastructure, the status of resilience and its future dimensions in South Asia", *Progress in Disaster Science*, Vol. 17, https://doi.org/10.1016/j.pdisas.2023.100275. [70]

Mukherjee, M. et al. (2022), "Nature-Based Resilience: Experiences of Five Cities from South Asia", *International Journal of Environmental Research and Public Health*, Vol. 19/19, https://doi.org/10.3390/ijerph191911846. [94]

Mukhopadhyay, B., A. Khan and R. Gautam (2015), "Rising and falling river flows: contrasting signals of climate change and glacier mass balance from the eastern and western Karakoram", *Hydrological Sciences Journal*, Vol. 60/12, pp. 2062-2085, https://doi.org/10.1080/02626667.2014.947291. [14]

National Assembly of Bhutan (2024), *Motion (4P1S/M2): Establishment of Crop and Livestock Compensation Trust Fund*, https://nab.gov.bt/post/motion-4p1sm2-establishment-of-crop-and-livestock-compensation-trust-fund. [108]

National Center for Hydrology and Meteorology (2021), *Meteorological Stations in Bhutan*, Royal Government of Bhutan, https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/MET%202021.pdf. [96]

National Center for Hydrology and Meteorology (2021), *Standard Operating Procedure (SOP) for GLOF Early Warning System in Punakha-Wangdue Valley: Version 3.00*, Royal Government of Bhutan, https://www.nchm.gov.bt/attachment/ckfinder/userfiles/files/Final%20SOP.pdf. [48]

National Center for Hydrology and Meteorology (2018), *Establishment of Comprehensive Flood Forecasting and Early Warning System for Amochhu Basin under Phuentsholing Township Development Project*, https://www.nchm.gov.bt/home/pageMenu/892. [98]

National Education Commission (2020), *Climate Change Policy of the Kingdom of Bhutan 2020*, Royal Government of Bhutan, https://faolex.fao.org/docs/pdf/bhu207787.pdf. [91]

Nepal Rastra Bank (2022), *Financial Literacy Framework*, Nepal Rastra Bank, https://www.nrb.org.np/contents/uploads/2022/11/Financial-Literacy-Framework-2022.pdf. [82]

Nepal Rastra Bank (2018), *Nepal Financial Inclusion Action Plan*, UNNATI-Access to Finance (A2F) Project, Microfinance Promotion and Supervision Department, Nepal Rastra Bank. [79]

Nie, Y. et al. (2021), "Glacial change and hydrological implications in the Himalaya and Karakoram", *Nature Reviews Earth & Environment*, Vol. 2/2, pp. 91-106, https://doi.org/10.1038/s43017-020-00124-w. [10]

OECD (2024), *Climate-related hazards: Exposure to river flooding, Environment Statistics (database)*, http://oe.cd/dx/4TK. [31]

OECD (2024), *Economic Outlook for Southeast Asia, China and India 2024: Developing amid Disaster Risks*, OECD Publishing, Paris, https://doi.org/10.1787/3bbe7dfe-en. [66]

OECD (2024), *Fostering Catastrophe Bond Markets in Asia and the Pacific*, The Development Dimension, OECD Publishing, Paris, https://doi.org/10.1787/ab1e49ef-en. [63]

OECD (2023), *Taming Wildfires in the Context of Climate Change*, OECD Publishing, Paris, https://doi.org/10.1787/dd00c367-en. [39]

Parliament of Bhutan (2022), *Civil Service Reform Act of Bhutan 2022*, https://rcsc.gov.bt/wp-content/uploads/2025/02/Civil-Service-Reform-Act-of-Bhutan-2022.pdf. [62]

Parliament of Bhutan (2013), *Disaster Management Act of Bhutan 2013*, https://www.ddm.gov.bt/wp-content/uploads/downloads/acts&rules/dm_act_2013.pdf (accessed on 4 November 2024). [60]

Petley, D. (2012), "Global patterns of loss of life from landslides", *Geology*, Vol. 40/10, pp. 927-930, https://doi.org/10.1130/G33217.1. [49]

Petley, D. (2010), "On the impact of climate change and population growth on the occurrence of fatal landslides in South, East and SE Asia", *Quarterly Journal of Engineering Geology and Hydrogeology*, Vol. 43/4, pp. 487-496, https://doi.org/10.1144/1470-9236/09-001. [51]

Pritchard, H. (2019), "Asia's shrinking glaciers protect large populations from drought stress", *Nature*, Vol. 569/7758, pp. 649-654, https://doi.org/10.1038/s41586-019-1240-1. [12]

PwC (2020), *A roadmap for strengthening Nepal's bond market*, https://www.pwc.in/assets/pdfs/consulting/financial-services/a-roadmap-for-strengthening-nepals-bond-market.pdf (accessed on 3 November 2024). [84]

Qiu, J. (2008), “China: The third pole”, *Nature*, Vol. 454/7203, pp. 393-396, https://doi.org/10.1038/454393a. [21]

Rauniyar, T. (ed.) (2024), *The drought that forced a Himalayan village in Nepal to relocate*, BBC, http://www.bbc.com. [37]

Razzaque, M. (2019), *LDC graduation: Potential implications and policy imperatives for Bhutan [presentation]*, UNESCAP, 1 October 2019, https://www.unescap.org/sites/default/files/Session%201.2_M%20A%20Razzaque.pdf. [127]

RICB (n.d.), *Householder’s Insurance*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/products/general-insurance/property/fire-insurance/householders-insurance/. [117]

RICB (n.d.), *Industrial Insurance Policy*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/products/general-insurance/property/fire-insurance/industrial-insurance-policy/. [119]

RICB (n.d.), *Operational Guidelines: Priority Sector Lending (PSL) Crop and Livestock Insurance Schemes*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/wp-content/uploads/2021/12/PSL-GUIDELINE-AND-SOP-final.pdf. [109]

RICB (n.d.), *Products*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/products/. [113]

RICB (n.d.), *Property*, https://www.ricb.bt/products/general-insurance/property/ (accessed on 3 November 2024). [110]

RICB (n.d.), *Rural House Insurance*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/products/general-insurance/property/rural-house-insurance/. [115]

RICB (n.d.), *Shopkeeper’s Insurance*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/products/general-insurance/property/fire-insurance/shopkeepers-insurance/. [118]

RICB (n.d.), *Standard Fire Insurance*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/products/general-insurance/property/fire-insurance/standard-fire-insurance/. [114]

RICB (n.d.), *Years Of Experience*, Royal Insurance Corporation of Bhutan Limited, https://www.ricb.bt/about-us/company/years-of-experience/. [111]

Royal Audit Authority (2016), *Performance Audit of Disaster Management: May 2016*, https://www.bhutanaudit.gov.bt/wp-content/uploads/2020/08/Performance_Audit_Report_on_Disaster_Management.pdf. [116]

Royal Government of Bhutan (2023), *Thirteenth Five-Year Plan 2024-2029*, Royal Government of Bhutan, 17 December 2023, https://www.pmo.gov.bt/wp-content/uploads/2019/09/13-FYP.pdf. [104]

Royal Monetary Authority of Bhutan (2024), *RGoB Bond*, https://www.rma.org.bt/rgobBond/ (accessed on 3 November 2024). [136]

Royal Monetary Authority of Bhutan (2023), *Annual Report 2023*. [121]

Royal Monetary Authority of Bhutan (2014), *Regulation on Credit Rating Agencies*, https://www.rma.org.bt/media/Laws_By_Laws/Credit%20Rating%20Agency%20Regualtion,%202014.pdf (accessed on 3 November 2024). [137]

Royal Securities Exchange of Bhutan (n.d.), *Royal Securities Exchange of Bhutan Annual Report 2019*, https://rsebl.org.bt/online/uploadfiles/RSEB/annual_report_2019.pdf (accessed on 28 October 2024). [133]

Sharma, K. (2024), "GovTech studying possibility of introducing Starlink in Bhutan", *Kuensel*, https://kuenselonline.com/govtech-studying-possibility-of-introducing-starlink-in-bhutan/. [101]

Thapa, R., A. Gough and G. Cooper (2024), "Understanding the impact of climate change on Bhutanese school communities: Challenges and responses", *Interdisciplinary Journal of Environmental and Science Education*, Vol. 20/3, https://doi.org/10.29333/ijese/14692. [92]

Tshering, D. and P. Sekhsaria (2019), *How can Bhutan better prepare for earthquakes?*, https://www.preventionweb.net/news/how-can-bhutan-better-prepare-earthquakes. [53]

Tshering, N. (2019), *Country Report: Bhutan*, Asian Disaster Reduction Center, https://www.adrc.asia/countryreport/BTN/2019/Bhutan_CR2019B.pdf. [28]

UKaid (2018), *Study on the Microinsurance Industry in Nepal*, https://www.a2ii.org/sites/default/files/2020-09/study-on-the-microinsurance-industry-in-nepal_final.pdf (accessed on 5 November 2024). [77]

UN ESCAP (2020), "Bhutan's First Sovereign Bond: Financing Lessons During the Pandemic". [135]

UNDESA (2023), *Bhutan graduates from LDC status*, United Nations Department of Economic and Social Affairs, 13 December 2023, https://www.un.org/development/desa/dpad/2023/bhutan-graduates-from-ldc-status/. [126]

UNDP (2025), *Bhutan secures US$20M from GEF Least Developed Countries Fund for a new urban resilience project*, United Nations Development Programme, https://www.undp.org/bhutan/press-releases/bhutan-secures-us20m-gef-least-developed-countries-fund-new-urban-resilience-project. [125]

UNDP (2024), *Bhutan's push for national crop and livestock insurance*, https://www.undp.org/bhutan/stories/bhutans-push-national-crop-and-livestock-insurance. [106]

UNDP (2024), *Inclusive insurance and risk financing in Nepal: Snapshot and way forward 2024*, United Nations Development Programme/UNDP Insurance and Risk Finance Facility, https://irff.undp.org/sites/default/files/2024-04/nepal.diagnostic.pdf (accessed on 3 November 2024). [80]

UNICEF (2021), *Rising to the Challenge: Youth Perspectives on Climate Change and Education in Bhutan*, https://www.unicef.org/rosa/media/16906/file/Rising%20to%20the%20Challenge%20-%20Youth%20Perspectives%20on%20Climate%20Change%20and%20Education%20in%20Bhutan.pdf. [67]

UNICEF (2021), *Rising to the Challenge: Youth Perspectives on Climate Change and Education in Nepal*, https://www.unicef.org/rosa/media/16961/file/Rising%20to%20the%20Challenge%20-%20Nepal.pdf. [68]

Vij, S. et al. (2020), "Evolving disaster governance paradigms in Nepal", *International Journal of Disaster Risk Reduction*, Vol. 50, https://doi.org/10.1016/j.ijdrr.2020.101911. [65]

Vitolo, C. et al. (2020), "ERA5-based global meteorological wildfire danger maps", *Scientific Data*, Vol. 7/1, https://doi.org/10.1038/s41597-020-0554-z. [41]

Viviroli, D. et al. (2007), "Mountains of the world, water towers for humanity: Typology, mapping, and global significance", *Water Resources Research*, Vol. 43/7, pp. 1-13, https://doi.org/10.1029/2006WR005653. [9]

Wang, W. et al. (2022), "Monitoring and early warning system of Cirenmaco glacial lake in the central Himalayas", *International Journal of Disaster Risk Reduction*, Vol. 73, p. 102914, https://doi.org/10.1016/j.ijdrr.2022.102914. [47]

Wester, P. et al. (eds.) (2019), *The Hindu Kush Himalaya Assessment*, Springer Cham, Cham, https://doi.org/10.1007/978-3-319-92288-1. [6]

Wiltshire, A. (2014), *Climate change implications for the glaciers of the Hindu-Kush, Karakoram and Himalayan region.*, Cryosphere 8 (3), 941e958. [25]

World Bank (2024), *World Bank Approves $150 Million to Strengthen Nepal's Disaster Response and Resilience*, https://www.worldbank.org/en/news/press-release/2024/10/07/world-bank-approves-150-million-to-strengthen-nepal-s-disaster-response-and-resilience. [85]

World Bank (2023), *Droughts and Deficits*, World Bank: Washington, http://www.worldbank.org. [36]

World Bank (2020), *Nepal: National Disaster Risk Financing Strategy, 2020*, World Bank, Washington DC. [78]

World Bank; First Inititative; Royal Monetary Authority of Bhutan (2018), *Gap Analysis and Assessment of the Current Insurance*, World Bank Group, Washington DC, https://documents.worldbank.org/en/publication/documents-reports/documentdetail/587561593609078465/bhutan-gap-analysis-and-assessment-of-the-current-insurance-legislation. [112]

Wu, S. et al. (2013), "Glacier retreat and its effect on stream flow in the source region of the Yangtze River", *Journal of Geographical Sciences*, Vol. 23/5, pp. 849-859, https://doi.org/10.1007/s11442-013-1048-0. [11]

You, Q. et al. (2017), "An overview of studies of observed climate change in the Hindu Kush Himalayan (HKH) region", *Advances in Climate Change Research*, Vol. 8/3, pp. 141-147, https://doi.org/10.1016/j.accre.2017.04.001. [17]

Zeitler, P. et al. (1982), "Fission-track evidence for Quaternary uplift of the Nanga Parbat region, Pakistan", *Nature*, Vol. 298/5871, pp. 255-257, https://doi.org/10.1038/298255a0. [4]

Zhao, H. et al. (2023), "A new projection for glacier mass and runoff changes over High Mountain Asia", *Science Bulletin*, Vol. 68/1, pp. 43-47, https://doi.org/10.1016/j.scib.2022.12.004. [26]

Annex A. Mountain climate change

The warming trend in the Himalayan region is two to five times the global average. You et al. (2017[17]) argued that high altitudes amplify global warming. Melting of Himalayan glaciers has coincided with increasing average surface air temperatures.

Global climate models often consider the Himalayan region as part of a larger area, termed High Mountain Asia (HMA). This includes not only the Himalayan mountains, the Karakoram and Hindu Kush, but also the Tibetan Plateau and Tien Shan. This term is used in this report when the models, particularly from the IPCC, refer to this larger area.

Projected changes in annual global mean surface air temperatures relative to 1850 to 1900 are shown in (Table A A.1). These projections are from the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2023[131]). The table shows five IPCC Shared Socioeconomic Pathways (SSP). These are for "storylines" linked to climate change, population growth, urbanisation and technologic advancement. They relate to the Representative Concentration Pathways (RCPs) labelled by the expected changes in radiative forcing, used in previous assessments as shown. So, SSP1-1.9 is the scenario which aligns to the Paris Agreement preference to the limit the average global temperature increase to 1.5 °C.

Table A A.1. Shared Socioeconomic Pathways (SSPs) and long-term global and HMA temperature increases

Shared Socioeconomic Pathway	SSP1	SSP1	SSP2	SSP3	SSP5
Storyline	Sustainability	Sustainability	Middle of the Road	Inequality (Rocky Road)	Fossil-fuelled Development
RCP 2100 Radiative Forcing (Wm^{-2})	1.9	2.6	4.5	7.0	8.5
SSP-RCP combined	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5
Global best long-term estimate temp. (2081-2100)	+1.4°C	+1.8°C	+2.7°C	+3.6°C	+4.4°C
HMA long-term estimate temp. (2090)	-	+2.5°C	+3.8°C	+5.3°C	+6.4°C

Source: Data from IPCC (2023[131]), *Climate Change 2021 – The Physical Science Basis* and derived from Hu et al. (2025[132]), "Accelerated warming of High Mountain Asia predicted at multiple years ahead", *Science Bulletin* 70/3, pp. 419-428.

Table A A.1 also shows projected changes in mean surface air temperatures for the HMA, which includes the Himalayan region. These data are from recent projections by Hu et al. (2025[132]). As an example, for the SSP1-2.6 pathway of sustainability, the best-estimate of the long term (2081-2100) global mean surface temperature rise is +1.8°C. This would correspond to a HMA temperature rise of +2.5°C. For the fossil-fuelled development pathway SSP5-8.5 the best long-term estimate of global temperature rise is +4.4°C. This would correspond to +6.4°C for HMA.

Projected changes in glacier mass balance for HMA have been modelled by Hock et al. (2019[27]) and Zhao et al. (2023[26]). Prior to 2010 ice mass loss was about 22 gigatons per annum but then the rate of ice loss increases dramatically. For the sustainability pathway, SSP1-2.6, the modelled rate of ice loss showed a strong reduction by 2050, but the total ice loss continues. For the fossil-fuelled development pathway, SSP5.85, the rate of ice loss implies that by the end of the century only about a third of glacier mass remains in HMA.

Projected temperature increases will increase river flows as snow changes to rain, adding to the discharge. As glaciers retreat and expose more bedrock, the surface albedo will be reduced so that less solar radiation will be reflected back and more absorbed. This will have the effect of lengthening the summer melt season. It had been speculated that climate change over the Tibetan Plateau could stop the Indian Monsoon, but this has been largely discounted.

Annex B. Bhutanese capital market

The financial sector of Bhutan is still in its development stage, facing significant resource constraints to finance the socio-economic development of the country. Bhutan's capital market, insurance and pension fund are regulated by the Royal Monetary Authority of Bhutan (RMA). There are five banks in the country: Bank of Bhutan (BoB), Bhutan National Bank (BNB), Druk PNB Bank, TBank and Bhutan Development Bank (BDB). Among the five, BoB is the oldest and largest bank, established in 1968. Out of the five banks, three are relative newcomers, being licensed in 2010. These banks play a crucial role in Bhutan's banking and financial landscape, serving the needs of both individual customers and corporations.

The Royal Securities Exchange of Bhutan (RSEB) is the sole stock exchange in Bhutan, established in 1993 as a non-profit quasi-public organisation controlled by the RMA. It aims to encourage a wider spread of share ownership in the enterprises, mobilise savings, provide a platform to raise equity capital for new ventures and provide liquidity to the existing shareholders. Under the technical assistance of ADB, RSEB was incorporated under the *Companies Act of the Kingdom of Bhutan, 2000* and is regulated by the FSA. RSEB operates as a membership organisation comprised of four member firms including four subsidiary companies of four financial institutions, BNB, BOB, RICB, and BDB. As of 2024, 19 companies are listed with RSEB, and the total market capitalisation amounts to BTN 64.9 billion (USD 777 million). According to the Annual Report of RSEB 2019 (Royal Securities Exchange of Bhutan, n.d.[133]) 17 bonds worth a combined BTN 8.65 billion (USD 103 million) have also been issued on the RSEB, and their redemption dates each fall in the period from 2021 to 2026. Banks and non-bank financial institutions hold more than 80% of the total bonds by face value. As of 2018, only 3.9% of the bonds were held by individuals.

While most of the regional stock exchanges have grown over the last decade, they remain relatively small compared to those elsewhere. The ratios of stock market capitalisation-to-GDP in Bhutan, Bangladesh and Sri Lanka remain lower than 30%, while that of neighbouring India reached almost 100% in 2020 (ADB, 2024[134]). While Bhutan's ratio has improved from 15.2% in 2017 to 26.1% in 2020, it still remains modest in comparison (ADB, 2024[134]). Bhutan's stock market is characterised by low levels of liquidity which can be parameterised with the turnover-to-GDP ratio. It is attributed to the small number of investors, insufficient availability of shares, insufficient information about listed companies available to investors, inadequate information dissemination systems, and high dividend yields. Furthermore, the number of listings on the main board has decreased in recent years. This sluggish growth of the capital market results from inadequate institutional regulation, cumbersome listing requirements, lack of understanding of the advantages of listing and of adequate listing incentives, the inability of issuers to fulfil listing requirements, low market awareness and knowledge of investors, and underwriting being prohibited by regulations (ADB, 2021[120]). The institutional regulatory framework of Bhutan's stock market may not be ideal as the primary and secondary markets are regulated by two distinct institutions. Moreover, research conducted in 2018 showed that the majority of people surveyed possessed insufficient knowledge about the market and its technicalities (ADB, 2021[120]).

Bhutan's bond market is developing, nonetheless. Bhutan issued its first sovereign bond to meet financial needs related to the COVID-19 pandemic response. The bond issue was met enthusiastically with oversubscription of more than 300% (UN ESCAP, 2020[135]). The 3-year domestic bond had a value of BTN 3 billion, approximately USD 41 million. The issuance was hailed as a transformative step in the development of the Bhutanese bond market that would allow other types of bonds to be issued in the future. ADB (2021[120]) identified several positive developments in Bhutan's bond market as well as

challenges the market still faces. As of 2020, 16 bonds were issued totalling BTN 10.9 billion in value (with the aforementioned sovereign bond the single largest issuance. The market remains marginal with an issued debt-to-GDP ratio of a mere 5.8%, a figure that drops to 4.2% if the sovereign bond issue is excluded. Key challenges include an underdeveloped sovereign securities market, the absence of a credit rating agency, and regulatory framework issues. The underdeveloped sovereign securities market makes the construction of a sovereign securities yield curve difficult. In turn, pricing corporate bonds is challenging in the absence of such a benchmark. The government will need to issue bonds in a wider range of maturities so that a continuous risk-free yield curve can be developed. The Royal Government of Bhutan has issued ten other bond series since the initial issuance (most recently on 25 November 2023) with maturities of 2-12 years (Royal Monetary Authority of Bhutan, 2024[136]).

In addition, the absence of a credit rating agency in Bhutan is another challenge. This may constrain interest in bonds as investors (mainly institutional) are missing a key signal of the risk they are taking. A legal basis for the establishment of a credit agency was created in the 2014 RMA's Regulation on Credit Rating Agencies (Royal Monetary Authority of Bhutan, 2014[137]). Furthermore, the capital markets in Bhutan are closed to foreign investors. Once a proper institutional framework is in place, opening up capital markets to foreign investors while possibly maintaining some levels of restrictions would help the markets flourish while preserving the interests of Bhutan in their operations.