HIMAP

CHAPTER 7 BRIEF

STATUS AND CHANGE OF THE HINDU KUSH HIMALAYAN CRYOSPHERE

The cryosphere encompasses frozen water in its many forms — glaciers, ice caps, ice sheets, snow, permafrost, and river and lake ice — and is a key freshwater resource. Industry, agriculture, and hydroelectric power generation rely on timely and sufficient delivery of water in major river systems. Changes in the cryospheric system may thus pose challenges for these sectors and for disaster risk reduction in the extended Hindu Kush Himalaya.

This chapter summarizes the current status of cryospheric components in the extended HKH, examines patterns and impacts of change, and synthesizes cryospheric change projections in response to representative concentration pathway (RCP) scenarios.

KEY FINDINGS

- The cryosphere is an important part of the water supply of the extended Hindu Kush Himalaya (HKH). Observed and projected changes in the cryosphere will affect the timing and magnitude of streamflows across the region, with proportionally greater impacts upstream.
- Snow-covered areas and snow volumes will decrease in most regions over the coming decades due to increased temperatures and snowline elevations will rise.
- Glaciers have thinned, retreated, and lost mass across the HKH since the 1970s, except for parts of the Karakoram, eastern Pamir, and western Kunlun. These trends are projected to continue, with possibly large consequences for the timing and magnitude of glacier melt runoff and glacier lake expansion.
- Permafrost will continue to thaw and the depth of the active layer (seasonally thawed upper soil layer) will increase.

POLICY MESSAGES

- To reduce and slow cryospheric change, international agreements must mitigate climate change through emission reductions.
- To better monitor and model cryospheric change and to assess spatial patterns and trends, researchers urgently need expanded observation networks and data-sharing agreements across the extended HKH region.
- Improved understanding of cryospheric change and its drivers will help reduce the risk of high-mountain hazards.

LINKS TO SUSTAINABLE DEVELOPMENT GOALS

6 CLEAN WATER AND SANITATION

7 AFFORDABLE AND CLEAN ENERGY

13 CLIMATE ACTION

OBSERVATIONS AND TRENDS

GLACIERS IN MOST REGIONS ARE SHRINKING AND LOSING MASS

Glacier meltwater provides a regular and reliable source of streamflow in glacierized river basins. According to a compilation of glacier mass and area change studies, glaciers in most regions are shrinking and losing mass. Average rates of mass loss are slower than observed in other mountain regions, but have accelerated from -0.26 mwe/yr (1970–2000) to -0.37 mwe/yr.

GLACIER MASS LOSS HAS INCREASED SINCE 2000, AND WILL ACCELERATE IN THE FUTURE

It is projected that glacier mass loss will accelerate through the 21st century, and higher-emission scenarios will result in even faster mass loss. The rise of regional equilibrium line altitudes will result in the complete disappearance of debris-free lower elevation glaciers, and will increase volume losses from glaciers with high-elevation accumulation areas.

AS GLACIERS CONTINUE TO RETREAT, THERE IS INCREASED RISK OF DANGEROUS GLACIAL LAKE OUTBURST FLOODS

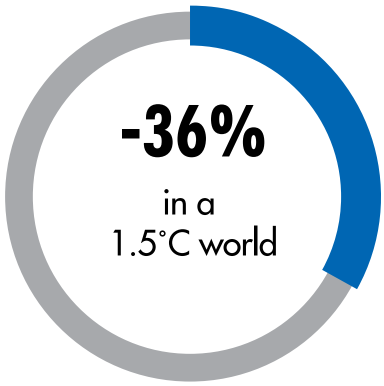
Glacial lakes occur frequently in the extended HKH, and numerous new lakes will form in response to cryospheric change. Since the 1990s, glacial lakes show a clear increase both in number and in area. Several glacial lakes in the extended HKH are potentially hazardous — and as glaciers continue to retreat, the risk of dangerous glacial lake outburst floods (GLOFs) may increase further.

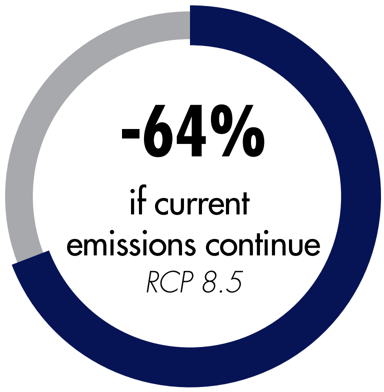
HYDROLOGICAL TRENDS RELATED TO CRYOSPHERIC CHANGE ARE DIFFICULT TO IDENTIFY

Hydrological trends related to cryospheric change are difficult to identify for three reasons: confounding influences on discharge, scarcity of long-term data sets, and high interannual variability in discharge that masks any temporal trends. Nevertheless, large volumes of snow and ice in the extended HKH are important for regional water supplies — more so as one looks further upstream. An increase in air temperature will reduce snowpack accumulations and result in earlier and lower snowmelt runoff volumes. Medium- and long-term changes in glaciers and permafrost will reduce summer melt contributions.

The HKH cryosphere is a key water resource for the region. Changes may pose challenges for industry, agriculture, hydropower, and disaster risk reduction beyond the extent of the HKH.

HKH GLACIER VOLUMES WILL DECLINE SUBSTANTIALLY BY 2100





FUTURE PROJECTIONS POINT TOWARDS REDUCED SNOW COVER AND LOWER BASIN-WIDE SNOW WATER EQUIVALENT

Snow is an important seasonal water storage component in the extended HKH and, in many areas, a critical source of streamflow for irrigation. Yet snowfall totals at high elevations are not well documented. Long-term measurements of snow water equivalent and solid precipitation are needed to validate gridded data sets or remote sensing-derived precipitation data sets. As snow cover in the extended HKH is highly variable and satellite-derived records are short, observed trends in snow cover are generally weak and inconsistent between studies and regions. Future projections point towards reduced snow cover and lower basin-wide snow water equivalent.

CAPACITY FOR ADAPTATION AND RISK REDUCTION DILUTED DUE TO LACK OF ATTENTION ON IMPACT OF PERMAFROST CHANGE

Permafrost exists beneath large parts of the extended HKH — yet its occurrence and importance is not widely known in the region. As permafrost cannot easily be seen, it is easy to ignore. Yet permafrost can shape many climate impacts in cold regions. Existing measurement sites indicate permafrost warming, with an increase in the depth of the active layer. Thawing permafrost can reduce ground stability and cause a range of problems, from undermining engineered structures, to increased occurrence of rockfall, and increased outburst potential of glacier lakes. In addition, thawing permafrost affects the hydrological cycle: water stored in ground ice may be released or near-surface soil water availability may decline as the active layer thickens.

Strong future warming will lead to partial permafrost thaw throughout the entire HKH region. Continued neglect of permafrost in large parts of the extended HKH could limit future capacity for adaptation and risk reduction programmes.

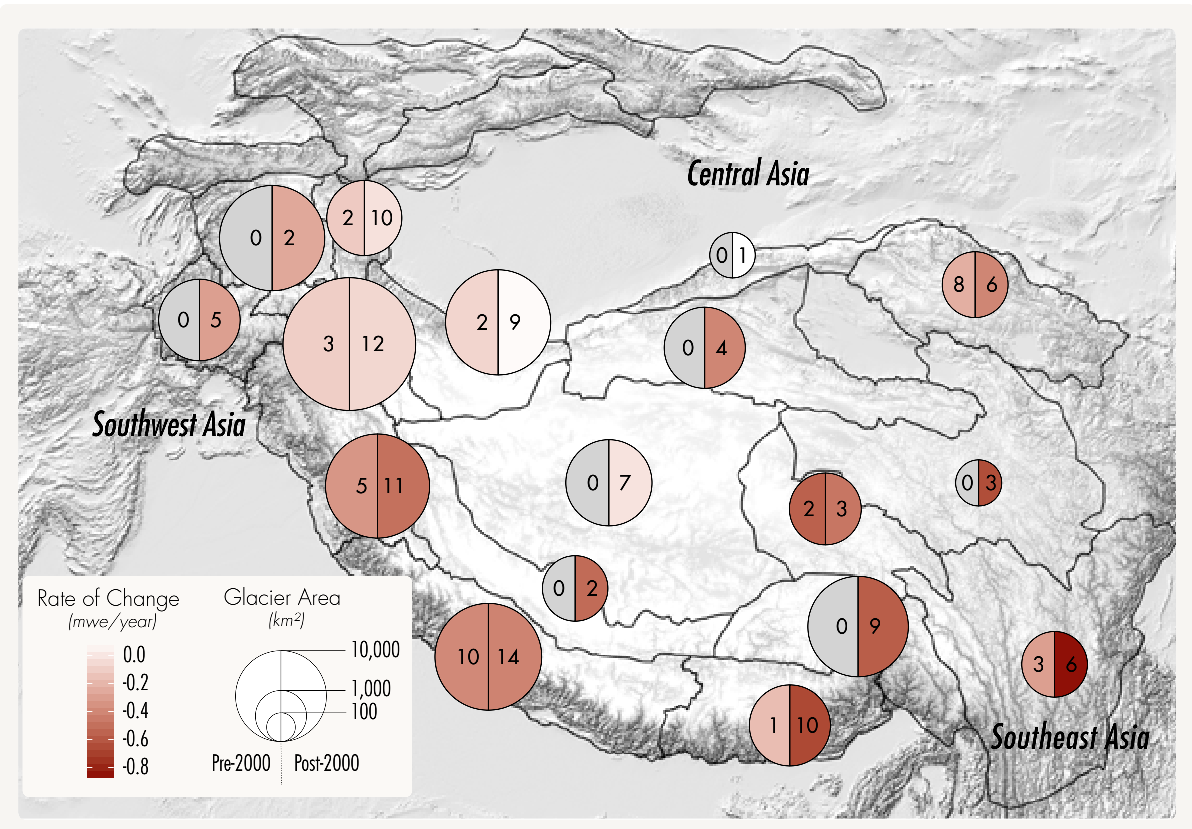
ICE COVERAGE DECLINING IN LARGER LAKES

Information about lake and river ice has been identified as a suitable proxy for mean air temperatures and their variability. Remote sensing-based studies show ice coverage declining in larger lakes since 1980, but no clear trend emerges for the period 2000–2012. While no future projections exist, it is likely that with a continuous increase in air temperature, ice coverage will decrease further.

Even if warming is limited to the ambitious target of +1.5°C, volume losses of more than one-third are projected for extended HKH glaciers, with more than half of glacier ice lost in the eastern Himalaya by 2100.

GLACIER CHANGE VARIES ACROSS THE HKH, WITH GREATER LOSSES IN THE EASTERN HIMALAYA

This figure summarizes 164 estimates of glacier mass change by glacier region. The average rate of change from all studies is shown by the shading in half circles (pre-2000 left, post-2000 right). The numbers in each circle indicate the number of studies available for each period.



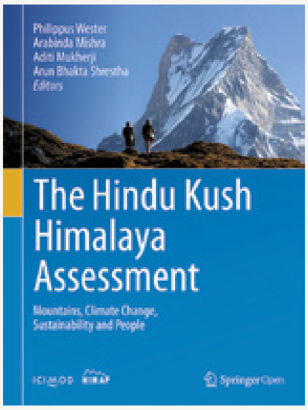
ACTION POINTS

- More resources are needed for cryospheric change impact studies — both regional- and sector-specific. High-level international agreements should promote systematic data collection, data sharing, training of local and regional scientists and technicians, and the development of cryosphere-related hazard warning systems.
- Stronger global commitments are needed to reduce greenhouse gas emissions, as all projections indicate that lower emission futures result in reduced cryospheric change.
- Reductions in carbon emissions today will reduce future climate change impacts.

RESEARCH GAPS

The following critical research gaps were identified for which urgent action is needed:

- Better snow water equivalent observations and estimates are needed for high mountain areas; long-term snow course monitoring sites and strategies should be developed.
- Glacier volume change estimates prior to 2000 are currently unavailable for several regions — a gap that researchers can now fill using declassified satellite imagery.
- Detailed studies of high-elevation snow accumulation and snowmelt processes and scenarios concerning future snowpack properties are needed.
- Well-documented, reliable, and long-term hydrological observations are needed across different climate zones and elevations to assess uncertainty and variability in discharge observations, and to improve and develop models of hydrological change
- Although many studies quantify glacier area and volume change, few try to diagnose the reasons for these changes. Better models of future glacier change will require a closer focus on regional glacier sensitivity and the causes of regional glacier change.



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