

## Briefing Paper

Committee: CEP

Topic: The Question of Dealing with Increased Glacier Melt and Decreased Snowfall due to Global Warming

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### Summary

The accelerating degradation of the cryosphere, critically the reduction in mountain glaciers and the decline in snowfall, is one of the world's most immediate consequences of climate change that faces the international community in 2026. As delegates convene, the International Year of Glaciers' Preservation, in 2025, will have concluded - a diplomatic initiative by the UN (United Nations) to sufficiently address and draw attention to the pressing threat posed by increased glacier melting. The scientific consensus is unequivocal; the cryosphere is declining - terminally. There will be, and already are, irreversible consequences for sea-level rise, hydrology, and geopolitical stability.

This crisis is defined by a distinct temporal paradox known as "peak water." As global temperatures rise, glacier melt rates initially accelerate, causing a temporary surge in river discharge. This "meltwater dividend" often masks the looming crisis, creating a false sense of water security. However, once glaciers cross a critical threshold of mass loss, runoff sharply declines, plunging dependent regions into permanent hydrological scarcity. Current data indicates that many river basins in the Andes, Central Asia, and the Caucasus have already passed this tipping point, threatening the water security of approximately 1.9 billion people who rely on these sources for irrigation, sanitation, and hydroelectric power.

Concurrently, the phenomenon of "snow drought"-characterized by decreased precipitation falling as snow and earlier spring melt-is dismantling the natural storage capacity of mountain ranges. Historically, snowpack has functioned as a natural reservoir, storing water during the winter and releasing it gradually during the dry summer months. The shift from solid precipitation (snow) to liquid precipitation (rain) forces water through river systems immediately, exacerbating winter flood risks while leaving riverbeds dry during critical agricultural seasons.

The geopolitical ramifications of this hydrological shift are profound and escalating. Transboundary river systems fed by glacial melt-most notably the Indus, Brahmaputra, Mekong, and Amu Darya-are becoming theatres of tension. Upstream nations, seeking to secure their own diminishing water supplies, are investing heavily in dam infrastructure, often to the detriment of downstream neighbours. This dynamic creates a high risk of "hydro-hegemony," where water

becomes a weapon of statecraft, challenging existing treaties like the Indus Waters Treaty which were drafted in an era of climatic stability.

Furthermore, the physical hazards associated with cryospheric decay are intensifying. The formation of unstable glacial lakes behind fragile moraine dams has put millions at risk of Glacial Lake Outburst Floods (GLOFs). Recent catastrophes in the Himalayas and the Andes underscore the urgent need for robust disaster risk reduction frameworks and international liability mechanisms.

## Definition of Key Terms

**Cryosphere** – This term refers to the portions of the Earth's surface where water exists in solid form, including sea ice, lake ice, river ice, snow cover, glaciers, ice caps, ice sheets, and frozen ground (permafrost).

**Glacier Mass Balance** – The single most critical indicator of a glacier's health, mass balance represents the difference between accumulation (mass gain) and ablation (mass loss) over a specific period, typically a hydrological year.

**Ablation** – The combined processes that remove snow and ice from a glacier or snowpack. This includes:

- **Surface Melting:** The phase change from solid to liquid due to thermal energy.
- **Sublimation:** The transition from solid ice directly to water vapor, driven by dry air and solar radiation.
- **Calving:** The mechanical breaking off of ice chunks from the glacier terminus, typically into the ocean or a glacial lake (forming icebergs).
- **Wind Erosion:** The removal of snow by strong winds.

**Accumulation** – The processes by which mass is added to a glacier.

**Glacial Lake Outburst Flood (GLOF)** – A sudden, high-energy release of water from a lake dammed by a glacier or a terminal moraine.

**Peak Water** – A hydrological concept describing the point in time when meltwater runoff from a retreating glacier reaches its maximum volume. As a glacier recedes, it initially generates more water (the "dividend"). However, once the glacier shrinks below a critical mass threshold, the volume of runoff begins an irreversible decline.

**Permafrost** – Ground (soil, sediment, or rock) that remains at or below 0°C for at least two consecutive years.

**Snow Water Equivalent (SWE)** – A metric used to quantify the amount of water contained within a snowpack. It represents the depth of water that would result if the snow cover melted entirely. Because the density of snow varies widely (from light powder to dense, wet sludge), SWE is a more accurate measure of available water resources than snow depth alone.

Third Pole – A geographic term referring to the region encompassing the Hindu Kush Himalaya (HKH) mountain range and the Tibetan Plateau. Containing the largest reserve of freshwater outside the North and South Poles (over 100,000 square kilometres of glaciers), it serves as the source for ten major Asian river systems that support roughly 2 billion people.

## Background Information

### The Physics of Cryospheric Decay

The degradation of the world's glaciers and snowpacks is driven by the fundamental thermodynamics of a warming atmosphere. The Intergovernmental Panel on Climate Change (IPCC) and the World Meteorological Organization (WMO) have documented that the cryosphere is responding to anthropogenic forcing with unprecedented speed. The years 2022 to 2024 marked the largest three-year loss of glacier mass in recorded history, with glaciers losing approximately 5% of their total volume between 2000 and 2023 alone.

This accelerated loss is not uniform but is amplified in high-altitude regions due to Elevation-Dependent Warming (EDW). Mechanisms such as the snow-albedo feedback and increasing atmospheric water vapor mean that mountain ranges like the Alps, Andes, and Himalayas are warming faster than the global average. For example, the Tibetan Plateau has warmed by approximately 1.8°C over the past 50 years, outpacing the Northern Hemisphere average.

A critical driver of this acceleration is the deposition of Light-Absorbing Particles (LAPs), primarily black carbon (soot) from biomass burning and industrial emissions. When these particles settle on pristine snow and ice, they darken the surface, reducing albedo and increasing the absorption of solar radiation. This process is particularly acute in the Himalayas, where pollution from the Indo-Gangetic Plain is transported up-valley, settling on glaciers and accelerating melt even during sub-zero ambient temperatures.

### The Hydrological Shift

Glaciers and seasonal snowpacks perform a critical ecosystem service: they function as natural water towers. In a stable climate regime, these systems accumulate moisture during the winter months and release it gradually during the spring and summer. This meltwater provides the "base flow" for rivers during dry seasons when rainfall is minimal.

Global warming is fundamentally disrupting this cycle through two primary mechanisms:

1. **Phase Change of Precipitation:** As the freezing level (0°C isotherm) rises to higher altitudes, precipitation that historically fell as snow is increasingly falling as rain. Rain moves through the watershed immediately, rather than being stored for later release. This results in a "flashy" hydrological regime characterized by winter floods and severe summer droughts. The "snow drought" phenomenon—where snowpack accumulation is significantly below average—is becoming the new normal in regions like the Western United States and the Hindu Kush Himalaya.

2. **The Peak Water Trajectory:** The relationship between glacier retreat and water availability is non-linear. As glaciers begin to melt rapidly, river basins experience a temporary increase in discharge—the "meltwater dividend." This surplus can misleadingly suggest water abundance. However, once the glacier shrinks below a critical volume, discharge collapses. Many regions, including the tropical Andes (Peru/Bolivia) and parts of Central Asia, have already passed peak water, entering a phase of irreversible decline in water availability.

### **Socio-Economic Implications**

The collapse of the cryosphere poses a threat to the fundamental pillars of human security for approximately 1.9 billion people.

#### **1. Agricultural Insecurity:**

Irrigation systems in major breadbaskets—such as the Indus Basin in Pakistan and the arid valleys of Peru—are designed based on historical meltwater timing. The Indus River, which supports 90% of Pakistan's food production, is highly vulnerable. Changes in the timing of flows (earlier peaks) and reduction in volume during the late summer growing season threaten to destabilize regional food security and agricultural economies. In the Andes, indigenous agricultural practices that have adapted to glacial cycles for millennia are facing obsolescence as wetlands dry up and water sources vanish.

#### **2. Energy Vulnerability:**

Hydropower generation is intricately linked to glacial runoff. In nations like Switzerland, Norway, and Bhutan, hydropower constitutes a significant portion of the energy mix. Changing flow regimes threaten the reliability of these plants. The Alto Maipo hydroelectric project in Chile serves as a cautionary tale; the project faced financial ruin (filing for Chapter 11 bankruptcy) partly because the actual water flows from the retreating glaciers were significantly lower than the historical data used in the project's design phase.

### **Major Countries and Organizations Involved**

**Tajikistan** – Tajikistan has emerged as the undisputed diplomatic leader on this issue.

Recognizing that its 10,000+ glaciers are vital not only for its own economy (hydropower and agriculture) but for the entire Central Asian region, Tajikistan initiated the UN General Assembly resolution declaring 2025 the International Year of Glaciers' Preservation.

**Switzerland** – As an Alpine nation witnessing the rapid disappearance of its glaciers (losing 10% of volume in just two years, 2022-2023), Switzerland acts as a hub for cryospheric science and "Blue Diplomacy."

China – China occupies a strategic position as the "hydro-hegemon" of Asia. Controlling the Tibetan Plateau, it is the upstream riparian state for major rivers including the Mekong, Brahmaputra, and Indus. China's domestic water security policies—specifically the construction of mega-dams (e.g., on the Yarlung Tsangpo) and water diversion projects—are sources of intense geopolitical friction.

India – India finds itself in a dangerous double-bind. As a downstream nation vis-à-vis China, it advocates for transparency and data sharing regarding the Brahmaputra. However, as an upstream nation vis-à-vis Pakistan, it engages in its own dam construction on the Indus tributaries, leading to accusations of water weaponization. India is highly vulnerable to both GLOFs in the Himalayas (e.g., Uttarakhand, Sikkim).

Pakistan – Pakistan is arguably the most vulnerable nation to the glacio-hydrological crisis. With over 7,000 glaciers—more than any region outside the poles—it faces the dual threat of catastrophic flooding (GLOFs) and water scarcity.

UNESCO & WMO – These two UN agencies are the co-leads for the International Year of Glaciers' Preservation (2025). They provide the scientific backbone for global policy, managing the Global Cryosphere Watch and coordinating the Decade of Action for Cryospheric Sciences (2025-2034).

UN Environment Programme (UNEP) – UNEP focuses on the implementation of ecosystem-based adaptation (EbA) strategies. Through initiatives like "Mountains ADAPT," it provides funding and technical support for community-led adaptation in mountain regions.

### **Timeline of Events (Relevant UN Treaties)**

1959 – The Antarctic Treaty: Signed in Washington, this treaty demilitarized Antarctica and established it as a scientific preserve.

1960 – Indus Waters Treaty (IWT): Brokered by the World Bank between India and Pakistan. It remains one of the most successful transboundary water treaties but is currently under severe strain because it allocates water based on fixed rivers rather than volumetric flows, failing to account for the variability introduced by climate change.

1991 – Protocol on Environmental Protection to the Antarctic Treaty (Madrid Protocol): Established the Committee for Environmental Protection (CEP) for Antarctica and designated the continent as a "natural reserve, devoted to peace and science," prohibiting mining.

2015 – The Paris Agreement: A foundational moment establishing the goal to limit global warming to well below 2°C, preferably to 1.5°C.

2019 – IPCC Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC): The first IPCC report dedicated specifically to the cryosphere. It provided the definitive scientific evidence that glacier retreat is accelerating and that adaptation limits are being reached in high-mountain regions.

2022 – UNGA Resolution A/RES/77/158: Adopted on December 14, 2022, this resolution declared 2025 as the International Year of Glaciers' Preservation and proclaimed March 21 of each year as World Day for Glaciers. It was a diplomatic victory for Tajikistan and set the stage for current global actions.

2025 (March 21) – First World Day for Glaciers: The inaugural observance was marked by the launch of the UN World Water Development Report titled "*Mountains and Glaciers: Water Towers,*" which highlighted the dependency of 2 billion people on these resources.

2025 (May) – Dushanbe Conference on Glaciers' Preservation: A high-level international conference held in Tajikistan. It resulted in the Dushanbe Glaciers Declaration, which called for a global inventory of perennial ice, increased climate finance for mountain nations, and the integration of glacier preservation into the global climate agenda.

## Previous Attempts to Solve the Issue

### Technological Interventions

- Geotextiles (Glacier Blankets):
  - *Mechanism:* Covering glaciers with white, UV-reflective fleece blankets during the summer ablation season to insulate the ice and increase albedo.
  - *Successes:* Extensively used in Switzerland (e.g., Rhone Glacier, Gurschenfirn) and studies show these covers can reduce local snow/ice melt by up to 60%.
  - *Limitations:* They are prohibitively expensive (approx. \$4,500 - \$8,500 per hectare). Covering all Swiss glaciers would cost an estimated \$1 billion annually. Furthermore, the synthetic fibres release microplastics into the pristine glacial environment, creating a secondary pollution crisis.
- Artificial Glaciers and Ice Stupas:
  - *Mechanism:* A form of "water grafting" pioneered in Ladakh, India. Water is piped from high-altitude streams during winter (when it is not needed for farming) and sprayed into the air. The freezing temperatures turn the spray into ice, creating conical towers ("stupas") or horizontal ice fields. These structures melt in late spring, providing water for irrigation before the natural glacial melt begins.
  - *Successes:* The project has successfully provided millions of litres of water to villages like Igoo and Phyang.
  - *Limitations:* They require specific climatic conditions (sub-zero winters) and manual labour or automated systems to prevent pipe freezing.

## Legal and Diplomatic Efforts

- Rights of Nature Litigation:
  - *Case:* In 2017, the High Court of Uttarakhand (India) granted legal personhood to the Gangotri and Yamunotri glaciers, effectively giving them the same rights as human beings.
  - *Outcome:* The ruling was stayed by the Indian Supreme Court. The practical challenges were immense: if a glacier floods a village (GLOF), can the glacier be sued for damages? Who represents the glacier in court (*loco parentis*)? While symbolically powerful, the legal framework was deemed unworkable for liability.
- Transnational Climate Litigation (Lliuya v. RWE):
  - *Case:* Saúl Luciano Lliuya, a Peruvian farmer, sued German utility RWE. He argued that RWE, having contributed 0.47% of historic global emissions, should be liable for 0.47% of the cost of flood defences needed to protect his home from a potential GLOF from Lake Palcacocha.
  - *Outcome:* The German court set a historic precedent by accepting the legal admissibility of the claim (acknowledging that emitters *can* be liable for remote damages). However, the case faced significant evidentiary hurdles in proving the specific causality between RWE's emissions and the specific local flood risk. The case was ultimately dismissed on evidentiary grounds in 2025, but the legal principle stands as a warning to polluters.

## Possible Solutions

1. Establishment of a Transboundary Open Data Protocol. The "weaponization of data" is a major barrier to safety. Downstream nations cannot prepare for floods if upstream nations withhold real-time discharge data.

- Proposal: The CEP should draft a resolution mandating the depoliticization of hydrological data.
- Incentive: Access to the hub's advanced satellite analytics and AI forecasting models would be conditional on data sharing participation.

### 2. Modernization of Water Treaties

Existing treaties like the Indus Waters Treaty (1960) are rigid, allocating water based on fixed volumes or specific tributaries. They fracture under the variability of climate change.

- Proposal: The committee should recommend the inclusion of "Climate Variability Clauses" in all transboundary water agreements. These clauses would trigger emergency allocation protocols during years of extreme snow drought or GLOF events, shifting from fixed allocations to percentage-based sharing of available flow.

- Mechanism: Joint scientific commissions would determine the "available water status" annually using the SWE metrics.

### 3. Operationalizing a "Cryosphere Loss and Damage Window"

The financial gap for adaptation in mountain regions is massive (12-14 times less than needed).

- Proposal: Within the UNFCCC Loss and Damage Fund, a specific "Cryosphere Window" should be operationalized. This fund would be dedicated solely to:
  - GLOF Risk Reduction: Lowering glacial lakes (pumping/siphoning)
  - Relocation Costs: Financing the managed retreat of communities (like Newtok, Alaska, or Thame, Nepal) that are becoming uninhabitable

### Useful Links

1. International Year of Glaciers' Preservation (IYGP 2025): <https://www.un-glaciers.org/en>
2. World Glacier Monitoring Service (WGMS): <https://wgms.ch/>
3. GlAMBIE Project (Data on Mass Loss): <https://glambie.org/>
4. Ambition on Melting Ice (AMI) Group: <https://ambitionmeltingice.org/>
5. ICIMOD (Hindu Kush Himalaya): <https://www.icimod.org/>

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