# Governing the cryosphere beyond political timeframes

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## Abstract

Cryospheric systems are nearing irreversible thresholds, yet political processes remain misaligned with the long timescales of ice loss. Using COP30 as context, we argue that cryosphere science must inform governance capable of linking near-term decisions with long-term stability in a rapidly changing world.

With increasing greenhouse gas emissions, the cryosphere – Earth's coupled system of glaciers, ice sheets, sea ice, snow, and permafrost – continues to destabilise rapidly. The past year has seen the global annual mean temperature reach an increase of ~1.5 °C since pre-industrial times (1). Prolonged warming at this level may trigger several cryospheric tipping points (2). Even small overshoots could commit future generations to centuries of sea-level rise and permafrost-carbon release (3,4). Although often perceived as geographically distant, cryospheric systems are tightly linked to the security, infrastructure, and economic stability of societies worldwide (5). Decisions and actions taken this decade will influence the fate of the cryosphere for centuries and beyond, determining the long-term impact of the cryosphere on coastal settlements, predictable water availability, and manageable climate feedbacks – or whether it shifts toward long-term trajectories of ice loss and amplified warming (3). This places the cryosphere squarely within the domain of long-horizon climate governance, where the stakes span centuries to millennia (5). Yet the policy mechanisms shaping outcomes remain tied to five-year pledges and mid-century targets that are misaligned with the centuries-long implications of ice loss.

COP30 – the 30th Conference of the Parties to the UN Framework Convention on Climate Change (UNFCCC) –, convened in Belém, Brazil, on 10-21 November 2025, under the banner of *implementation and justice*, once again highlighted the gap between political ambition, international consensus, and the physical laws of the climate system. Belém's verdict is therefore one of insufficiency: progress measured in political cycles cannot match the physics of irreversible loss. Here, we examine how COP30 reflects this mismatch and why aligning governance with cryosphere dynamics is now essential for managing cryospheric landscapes in a rapidly warming world. The cryosphere is fundamentally linked to our daily lives, and changes occurring there translate into increasingly severe consequences for societies everywhere.

## Evidence known, but still ignored

Observations indicate accelerating mass loss from the Greenland and West Antarctic ice sheets (6) and continued retreat of mountain glaciers worldwide (7), as well as a drastic decrease in snow meltwater (8). The Arctic Ocean is projected to experience its first nearly ice-free summer before 2030 (9), while Antarctic sea ice has undergone an abrupt and persistent decline since 2016, suggesting a potential regime shift (10).

Despite these warnings, COP30 discussions only partially acknowledged cryospheric thresholds. References to polar and high-mountain regions appeared mainly in adaptation and loss-and-damage contexts, without mechanisms that link these physical feedbacks to global carbon budgets, or the Global Stocktake under the United Nations Framework Convention on Climate Change (UNFCCC). Recognition of cryospheric impacts has yet to become integrated.

This disconnection has implications far beyond the polar regions. Unmanaged cryospheric change threatens water security for billions of people living in, or directly downstream of, mountain areas. It also exposes coastal infrastructures to accelerating sea-level rise and affects Indigenous Peoples' livelihoods, as well as regional economies and security. Together, these impacts undermine long-term global climate stability.

These concerns have also been raised outside the COP process. Ahead of COP30, dozens of scientific organizations and institutes issued an Open Letter to world leaders (11), urging that cryospheric thresholds and long-term sea-level commitments be formally integrated into global climate governance. Its widespread engagement underscored both scientific consensus and persistent gaps in the policy response.

## What has been achieved – and what remains missing

Some progress occurred at COP30: increased attention to mountain and polar adaptation, modestly higher funding commitments, and new cooperation on environmental monitoring should all be seen as positive steps. However, these remain insufficient to address the pace of cryospheric change and several challenges remain.

**Cryospheric feedbacks are not represented in carbon accounting frameworks**. Permafrost-carbon emissions and committed sea-level rise remain outside global carbon budgets (12), undermining their utility for long-term planning.

**Long-term observations are insecure**. Polar and alpine measurement networks depend on short-term project funding, hindering continuity, early-warning capability, and responsible landscape management.

**Finance is poorly aligned with systemic risk**. A small proportion of adaptation resources reach cryosphere-affected regions, even though their changes influence global sea level, water security, infrastructure resilience, and climate stability worldwide.

**Cryospheric risks are amplified by global inequities in exposure and vulnerability.** Just as emissions anywhere have global ramifications, declining cryospheric stability has global consequences, but these are not evenly distributed. The most severe impacts fall on climate-vulnerable regions and communities, including many in the Global South, Small Island Developing States, Least Developed Countries, and Indigenous and low-income communities in polar, mountain, and coastal areas. COP30 again showed how imbalances in political power and economic capacity shape who bears the earliest and hardest outfall from cryospheric change. While major economies may not intentionally overlook cryosphere-related instabilities, their policy priorities ultimately determine which risks receive political attention and resources.

Until these challenges are addressed, mitigation targets will continue to underestimate irreversible risks, and policies will fail to reflect the long-term trajectories of cryospheric landscapes.

## Aligning governance with cryospheric timescales

The physical evidence indicates that current policy mechanisms remain profoundly mismatched with cryospheric timescales (13, 5). Addressing this temporal gap requires not only more ambitious mitigation, but also political will and governance architectures capable of incorporating the long-term commitments inherent in cryospheric change**.** Based on this evidence, several directions could help align climate policy with long-term cryospheric processes.

**Commit dedicated resources for sustained cryospheric science**. Stable, multilateral, multilateral and national funding for polar and high-mountain monitoring and modelling is essential to secure the baseline data underpinning both adaptation and mitigation.

**Sustain cryosphere knowledge within global environmental and climate frameworks**. Structures such as the Global Cryosphere Watch (GCW) of the World Meteorological Organization (WMO) could evolve into permanent science-policy interfaces that deliver continuous assessments to the UNFCCC and inform the management of cryospheric landscapes from mountain catchments to polar seas. Regional governance regimes, including the Antarctic Treaty System, the Arctic Council, and high-mountain partnerships such as the Third Pole Process, already demonstrate elements of long-term environmental stewardship. Incorporating cryosphere-commitment metrics into these regimes would further align regional decisions with global stability.

**Quantify irreversible cryospheric risk in future Global Stocktakes**. Future Global Stocktakes should incorporate cryosphere-commitment indicators such as committed sea-level rise and projected permafrost-carbon release (3) to capture the long-term consequences of near-term emissions. Complementary tools, such as a Cryosphere Stability Index integrating observations of ice, permafrost, and snow, could provide continuous signals of emerging risk and guide both mitigation and adaptation priorities.

**Embed long-term scenarios into national and regional decision-makin**g. Long-term scenarios should inform land use planning, marine spatial planning, conservation and restoration of terrestrial, freshwater and marine ecosystems, and the design of urban, rural and Arctic infrastructure. Assessments must extend to the century-long timescales at which cryospheric change becomes most consequential. This includes long-term coastal hazard mapping, permafrost-related infrastructure liability assessments, and water-resource planning for snow- and glacier-fed basins. Indigenous Peoples' governance systems, grounded in multigenerational stewardship in both Arctic and high-mountain regions, offer additional models for long-horizon decision-making.

**Recognise the implications of cryospheric instability for human rights law.** Long-term cryosphere governance intersects with emerging developments in human rights law. As courts increasingly recognise the right to a clean, healthy, and sustainable environment – and its links to the rights to life, health, food, and water – cryosphere instability is becoming a basis for rights-based climate claims. These legal frameworks emphasise duties to protect both present and future generations, reinforcing the need for decision-making horizons that extend beyond electoral cycles and reflect the multi-century consequences of cryospheric change.

**Improve transparency and accountability of cryosphere-focused investments**. Transparent tracking of investments that influence cryospheric stability, such as glacier-dependent water systems, Arctic infrastructure, and polar observation networks, and the integration of cryosphere-informed risk disclosures into development bank and climate funds would help align investments with long-term physical commitments rather than short-term political interests.

Together, these directions indicate where governance must evolve to close the gap between political cycles and cryosphere system dynamics, and to build governance architectures

commensurate with the irreversible trajectories now unfolding across the planet's frozen regions.

## Creating incentives and momentum

Protecting the cryosphere will require incentives that accelerate climate action. Because early emission reductions slow ice loss far more effectively than later cuts, policies that reward early mitigation, long-term risk planning, sustained observations, early adaptation, and transparent reporting could deliver disproportionate benefits for cryosphere stability. Under Article 6 of the Paris Agreement, cooperative carbon market mechanisms are structured around countries' nationally determined contributions (NDCs). Postponing NDC milestones reduces the strength of the incentives these mechanisms are intended to create for early and rapid decarbonisation.

National risk assessments should incorporate cryosphere-driven hazards such as committed sea-level rise, coastal flooding, declining snow and glacier water resources, and permafrost-related infrastructure loss, internalising long-term liabilities. Strengthening partnerships with Arctic, alpine, and coastal communities can also align mitigation and adaptation by coupling local resilience with global stability.

## The cryosphere as the barometer of political will

The accelerating decline of the cryosphere is a measurable indicator of whether global climate action is aligned with the timescales that matter. COP30 shows that acknowledgement alone is insufficient: without sustained observations, stable financing, and integration of cryospheric processes into policy frameworks, we risk continuing to govern for a climate that effectively no longer exists.

Safeguarding the cryosphere is therefore not a specialised concern but a foundation of long-term climate and societal stability. Ultimately, governing the cryosphere requires governance systems that can incorporate the long-term time horizons inherent in cryospheric change, and act before irreversible changes become inevitable. Looking ahead, integrating cryosphere-informed metrics into climate governance will be essential for ensuring that decisions made today remain effective across the multi-century trajectories now unfolding in the frozen regions of our planet.

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## Author contributions

L.T., J.R., and P.H. conceived the Comment and prepared the first draft. S.A., J.C., K.L., J.S., and A.L.-U contributed to manuscript review and editing.

## Competing interests

The authors declare no competing interests.