Barriers to Glaciers-Related Financing:

Financing mitigation to preserve glaciers while adapting to their loss

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01. Executive Summary

Glaciers around the world, along with snowpack and mountain permafrost, are melting and disintegrating due to the rapidly warming climate. This is destabilizing regional and global hydrological cycles, altering terrain stability and ecosystems. From flash floods and the loss of agriculture to civil unrest, the loss of the mountain cryosphere contributes to catastrophes with significant human toll.

The only way to preserve glaciers, the mountain cryosphere, and their essential ecosystem services is through swift and impactful emissions reductions aimed at or below the lower 1.5°C Paris Agreement limit. Even with such urgent action, some level of adaptation to deteriorating mountain and downstream conditions is essential. Many communities already face extensive loss and damage from glacier loss and are already moving beyond the limits of adaptation. At each fraction of a degree above today's level, impacts on ecosystems and communities will increase, as will the need for financing.

Eighty-five percent of UN member states are either glaciated or impacted by glaciers making this a topic that touches a majority of the world's population.[1] As much as US$4 trillion in GDP from glacier-fed freshwater sources is currently at risk.[2] Despite this, with few exceptions, the global community is underprepared for this reality and is in urgent need for targeted finance to adapt to current and future glacier-related disasters.

Unlocking such financing for glacier issues, however, requires overcoming some barriers beyond those normally associated with climate and adaptation finance, e.g., opaque accounting and regulatory risk. Some of these include the episodic nature of catastrophes associated with glacier-related extreme events; lack of connection with, or knowledge of glacier dynamics and downstream changes by central governments and international financial institutions (IFIs); the transboundary nature of glaciers and their impacts; and the slow onset yet essentially irreversible changes entailed by glacier loss, such as river flow changes that are out of sync with the harvests. Notably, many of the glaciers that impact the most vulnerable regions do not have long observational records. This makes projections about their future and needed adaptation measures more difficult.

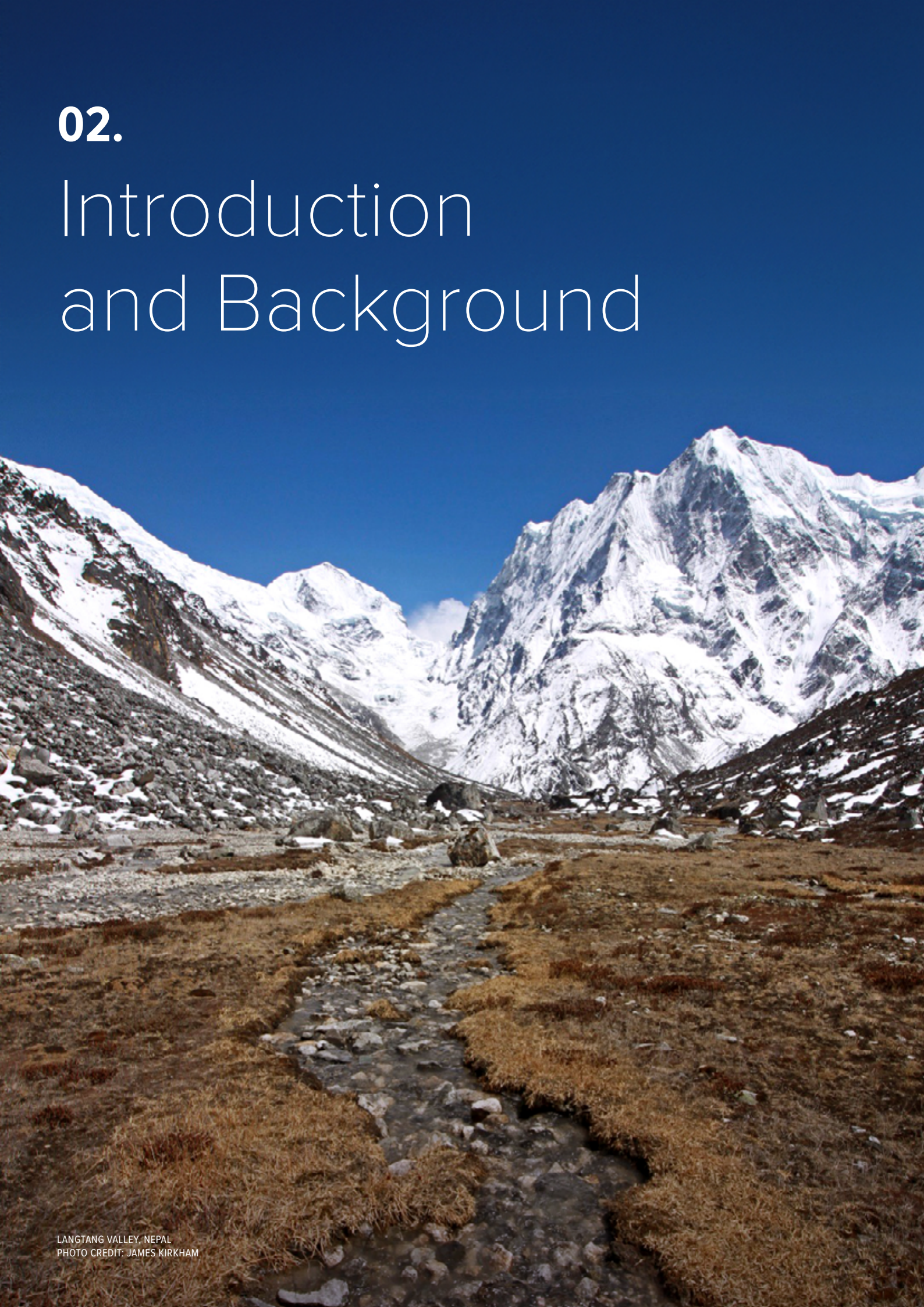
Many of the initial solutions to freeing finance revolve around mobilizing capital through both private and public sectors. Thus far, this has been a balancing act of an overburdened public sector, a private sector seeking near-term returns and competing demands for the same funds. Public institutions, such as multilateral development banks (MDBs), can however identify ways to leverage additional funding together with countries. This can help create scalable mitigation (glacier preservation) and adaptation initiatives. As the realities of climate change and glacier loss grow, along with their implications, all channels of funding will need to reassess personal efficacy, risk tolerance, and the willingness to break down long-standing silos and into new sectors. Building sustainable glacier financing communities, both locally as well as regionally, e.g., across High Mountain Asia, will also require cross-sector and multidisciplinary collaboration. Lastly, countries vulnerable to glacier change may have more immediate existential threats, such as conflict, to which monies are funneled.

This White Paper outlines some of the largest hurdles relating to glacier and mountain cryosphere-related financing, and identifies some of the needs and best practices found globally to ensure glaciers can preserve their vital role in preserving the water towers of the world.

[1] Rae, R. (2025). "High-Level Opening," Launch of the 1st World Day for Glaciers and pivot event World Water Day. International Year for Glaciers' Preservation, 21 March 2025, United Nations Headquarters, New York City.

[2] UNEP (2025). "World Water Day 2025: Why Glacier Preservation Matters for Finance." United Nations Environmental Programme Finance Initiative. https://www.unepfi.org/themes/ecosystems/world-water-day-2025-why-glacier-preservation-matters-for-finance.

02.
Introduction and Background



LANGTANG VALLEY, NEPAL
PHOTO CREDIT: JAMES KIRKHAM

Three-quarters of freshwater around the world is stored in the world's snow and ice. While the majority of this freshwater is held in the polar ice sheets, significant quantities are held within the "mountain cryosphere." That is, the glaciers, snowpack, permafrost and frozen mountainsides in regions, such as the Caucasus, Central and High Mountain Asia, the Andes, European Alps and the North American Cordillera. In this White Paper, the use of "glaciers" should be understood as inclusive of all phenomena comprising the mountain cryosphere.

Nearly two billion people in the Hindu Kush Himalaya alone rely on water resources stored in the area's mountain cryosphere. While this area is known for its reliance on glaciers, snowpack, permafrost and frozen hillsides, these systems impact 164 countries around the world either directly (e.g. loss of drinking water) or indirectly (e.g. changing fisheries).[3] Between 2000 and 2023, Central Europe lost 39% of its ice, the Caucasus 35%, and New Zealand 29%.[4] The Southern Andes contributed to 10% of global glacier mass loss. Under current climate projections, much of the mountain cryosphere is primed to melt throughout the 21st century, with the exact timelines dependent on carbon emission pathways.[5]

Looking forward, in certain areas, notably Scandinavia and western North America, all or nearly all ice is committed to long-term loss at +2°C above pre-industrial temperatures. The Hindu Kush and Karakoram regions, previously considered to be among the most resilient to melt–the "Karakoram Anomaly"–stand to lose 40% of current mass under this same +2°C future. In the great water towers of the central and eastern parts of High Mountain Asia, 60% of today's ice is committed to loss at even a +1.5°C emissions scenario–the lower limit set in the Paris Agreement.[6] Even with 1.5°C pathways, current steep losses will continue through at least mid-century.

While long term projections point toward water loss, this change in water availability may transpire in short-to-medium term flooding, due to increased melt and precipitation falling as rain rather than snow. This forces communities to prepare for drastically different water scenarios that will affect inter alia natural disasters, agriculture, infrastructure, ICT, physical and mental health, economies. With few exceptions, the global community is underprepared for this reality. Among the most urgent needs is for targeted finance to counter glacier-related disasters and increasing physical risks from climate impacts, ranging from glacier lake outburst floods (GLOFs), and infrastructure loss to agricultural collapse and radical changes in economies, including financial consequences of, e.g., food insecurity and new occupations. While glacier loss is one of the most wide-reaching climate catastrophes, there are significant barriers to unlocking this critical finance. These barriers range from money allocation, scales of need, balancing risk and insurance, responsibilities of local and foreign governments, and the mobilization of private sector capital and blended finance solutions applied to a cryosphere context. Despite the number of people across the globe impacted by loss of glaciers, the impacts of their loss continue to evade many governments and financial institutions.

[3] Rae, R. (2025).

[4] GlaMBIE Team (2025). "Community estimate of global glacier mass changes from 2000 to 2023." Nature 639, 382–388, https://doi.org/10.1038/s41586-024-08545-z.

[5] Hock, R., G. Rosul, et al. (2019). "High Mountain Areas." In: H.-O. Pörtner, et al. (eds.), IPCC Special Report on the Ocean and Cryosphere in a Changing Climate. Cambridge University Press, Cambridge, UK and New York, NY, USA, 131–202, https://doi.org/10.1017/9781009157964.004.

[6] Zekollari, H., L. Schuster, et al. (2025).

Consequently, there is no clear pathway to building the resistance of communities relying on these frozen stores in the mountain cryosphere. This newly appreciated reality must be considered in future financing at all levels, initially through an analysis of climate finance needs and sources. A range of relevant sources include multilateral development banks and international finance institutions (MDBs/IFIs), investment guarantee and climate finance mechanisms such as the Green Climate Fund (GCF) and the Global Environment Facility (GEF), sovereigns, national governments, bilateral donors, and the private sector mobilizing capital through market mechanisms. A 2024 study shows that 2021-2022 expenditures across all climate finance streams must at least sextuple to US$8.5tr by 2030 to meet estimated needs.[7]

Preserving glaciers and other planetary ecosystems depends on global emission reductions. Emissions causing global temperatures to peak above the lower Paris Agreement of 1.5°C limit will result in greater and faster glacier ice loss. This underscores the need for urgent collective emissions reductions, including needed mitigation financing, mandating that glacier preservation and impact mitigation be rooted within worldwide climate and economic agendas. It is also clear from latest research that ice loss levels set by peak temperature will be essentially permanent, with regrowth of glaciers not occurring for many centuries, if ever, even with a return to pre-industrial temperatures.

Levels of implemented mitigation today and in future, and resulting peak global temperatures, will determine the rate and scale of glacier loss. Adhering to the most stringent implementation of 1.5°C-aligned emissions pathways will preserve more than twice as much (54%) ice globally compared with policy-aligned 2.7°C.[8] However, it's already too late for many glaciers that existed as recently as 1990 and have either already disappeared or passed critical thresholds of no return. For many mountain and downstream regions, detrimental changes and physical risks associated with such loss are already putting them in very real danger of becoming areas of loss and damage, and eventually of loss of life.

For the most impacted countries, strengthening adaptation and resilience, from internal and external sources, has the highest direct benefit. While localized emission reduction in glaciated regions is not enough, small glacier states have nevertheless spearheaded global mitigation efforts. After the 2022 UN General Assembly designated 2025 as the International Year of Glaciers' Preservation (IYGP), Tajikistan hosted representatives from 80 countries for the first High-Level International Conference on Glacier Preservation, which led to key documents informing necessary global actions for glacier conservation. In May 2025, Nepal hosted the Sagarmatha Sambaad, which concluded with a global call to save the mountain ecosystems. At COP29 in 2024, four carbon-negative nations, including Bhutan, launched the G-ZERO initiative calling upon the world leaders to deliver 1.5°C-aligned emissions reductions by 2035.[9]

[7] Strinati, C. and C. Baudry (2025). "Top-down Climate Finance Needs." Climate Policy Initiative, https://www.climatepolicyinitiative.org/publication/top-down-climate-finance-needs.

[8] Zekollari, H., Schuster, L, et al. (2025). "Glacier preservation doubled by limiting warming to 1.5°C versus 2.7°C." Science 388: 6750, http://doi.org/10.1126/science.adu46.

[9] G-ZERO refers to the condition where a country's emissions are less than or equal to what is absorbed from the atmosphere. Host of the G-ZERO Secretariat, Bhutan is carbon-negative yet still is experiencing drastic losses in its glaciers, highlighting the need for urgent, world-wide carbon reductions.

Among the activities for the IYGP is to raise global awareness about the critical state of mountain cryosphere systems and to foster international collaboration. Activities also include establishing a global trust fund for glaciers. This fund examines financing needs by governments, IFIs and the private sector, looking both to preserve their glaciers and adapt to some level of future loss. Issues of financing related to glaciers require a more dedicated effort, especially in the context of barriers. On January 22, 2025, the International Cryosphere Climate Initiative (ICCI) and the Asian Development Bank (ADB) organized a meeting in Geneva. This brought together MDBs, IFIs and insurance agencies to discuss needs, challenges and barriers to concessional financing in relation to glaciers, snowpack and the essential ecosystem services these provide such as water resources as well as disaster risk management, and has led to the creation of this document.

This document sets out to discuss the needs, challenges and barriers to long-term, high-quality finance in relation to the preservation of glaciers, snowpack and the essential local, regional and national ecosystem services these provide for both mitigation and adaptation, as well as the economic consequences of their loss. This includes concessional and grant financing, and access to financial instruments such as sustainable bonds, budget support and guarantees.

03.

Barriers to Financing Glacier-related Developments

SIERRA NEVADA COCUY O GUICAN, COLOMBIA
PHOTO CREDIT: HEIDI SEVESTRE

A. Known unknowns: gaps in knowledge

1. Lack of attention to cryosphere and competing crises

Although the cryosphere is under significant threat from the global climate crisis with implications for billions of people and global ecosystems, it is not treated as an issue of survival.

Many of the same glacier-vulnerable countries are juggling other life-threatening crises, such as food and energy insecurity, poverty, and civil conflict. When faced with existential threats, countries make rational choices with limited resources, which means glacier-related disasters as a category are deprioritized. Yet, glacier issues can shift very rapidly to become existential when they disrupt–or destroy–rivers, agriculture, economies and lives downstream. On the one hand, this highlights a need for improved communication about the urgency of glacier-related disasters, but on the other it highlights the overwhelming need for fair financing mechanisms that align with national realities and be accessible to local control with tailored support. Recent work by the Organization for Economic Cooperation and Development (OECD) has also warned that crises in nature could potentially implicate the stability of the entire financial system through a lack of awareness of the system's dependency on ecosystem services and impacts on drivers for nature degradation.[10,11,12,13]

In other instances, this shortcoming is due to knowledge. For example, water is on the global agenda through two specific SDGs: SDG6 (Ensure availability and sustainable management of water and sanitation for all) and SDG14 (Conserve and sustainably use the oceans, seas and marine resources for sustainable development). While both have links to the cryosphere, these connections are often excluded from the global discussion and thus, are poorly understood by decision makers, policymakers and financial institutions, especially (but not exclusively) outside glaciated regions.[14]

Despite these challenges, glacier and mountain-related impacts have not yet captured the attention of climate vulnerable funds, such as the Loss and Damage Fund in the same manner as impacts directly related to, for example, sea-level rise.[15] This upstream connection linking the planetary systems is lost in the emphasis on local adaptation, even though some of current sea-level rise already affecting the highly-vulnerable small island and coastal states is a direct result of the loss of melting ice.[16]

[10] Davies, L. and M. Martini (2023). "Watered down? Investigating the financial materiality of water-related risks in the financial system." OECD Environment Working Papers, No. 224, OECD Publishing, Paris, https://doi.org/10.1787/c0f4d47d-en.

[11] OECD (2023). "A supervisory framework for assessing nature-related financial risks: Identifying and navigating biodiversity risks." OECD Business and Finance Policy Papers, No. 33, OECD Publishing, Paris, https://doi.org/10.1787/a8e4991f-en.

[12] NGFS (2023). "Nature-related Financial Risks: a Conceptual Framework to Guide Action by Central Banks and Supervisors." NGFS Technical Document, https://www.ngfs.net/system/files/import/ngfs/medias/documents/ngfs_conceptual-framework-on-nature-related-risks.pdf.

[13] Boffo, R. et al. (2024). "Assessing nature-related risks in the Hungarian financial system: Charting the impact of nature's financial echo." OECD Environment Working Papers, No. 243, OECD Publishing, Paris, https://doi.org/10.1787/24fd70e3-en.

[14] For example, SDG6 captures the 2.4 billion people living in water-stressed countries and the 2.2 billion lacking access to clean drinking water. SDG14 comprises action on algae blooms, ocean acidification and sea-level rise.

[15] The Loss and Damage Fund is a climate-financing mechanism established at COP27 (2022) designed to help vulnerable countries respond to climate disasters.

[16] Next to thermal expansion, melting ice sheets and glaciers are the largest contributor to sea-level rise globally. Compared with the polar ice sheets, glaciers contribute a much smaller amount to sea-level rise, but both demand global mitigation and adaptation.

SIDS (Small Island Developing States) and low-lying, coastal nations have joined together to address shared existential threats. AOSIS, the Alliance of Small Island States, has been a powerful and largely unified UNFCCC negotiating bloc since 1990. The mountain community, although punctuated by some successes as a group, has not acted with the same unified voice, likely impacting their ability to mobilize finance. There remains the need for a strong and coherent mountain country voice, in collaboration with the SIDS, as the risk facing both has the same source and cause in glacier and cryosphere loss.

2. Key information gaps hindering the development of investment strategies in glacier-related and climate-sensitive sectors

Developing robust investment strategies for glacier-related and broader climate resilience initiatives requires accurate, localized, and decision-relevant information. However, several critical information gaps limit the ability of governments, financial institutions, and communities to attract or deploy climate finance effectively. These gaps are especially pronounced in developing countries.

a. Episodic nature of catastrophes & glacier-related extreme events

Most notable are GLOFs, glacier lake outburst floods, for which 15 million people are vulnerable, which can wipe out entire communities, infrastructure with very little–if any–warning. Glacier-related risks involve complex, cascading and multi-hazards. For example, there is a period before 'peak water' when excessive melt and rainfall can yield flooding. Yet, after peak water, the problem is not one of flooding, but of drought.

Why it matters:

Multi-hazards are not consistently fed into infrastructure design or early warning systems (EWS), lowering the likelihood that infrastructure will withstand concurrent impacts.

Solutions may need to accommodate diverging scenarios, such as preparing for a future of drought despite experiencing an increase in flood.[17]

This can lead to premature decommissioning of investments that are unable to live out their expected operational lifespans.

b. Data on physical climate risks

Lack of reliable data on key cryospheric indicators such as glacier mass balance, seasonal snow cover, permafrost thaw, and downstream runoff. Glaciers may be difficult and expensive to access as a result of either geography or geopolitical tensions. Data cannot be generalized and each glacier basin must be studied in its own right. Uncertainty around the timing and magnitude of glacier retreat and water flow reduction, as well as surrounding emissions pathways and peak temperature, hampers the ability to quantify future risks and design appropriate investment responses.

Why it matters:

Without reliable data, decision-makers cannot assess climate hazards, prioritize resources or plan for future scenarios.

[17] In monsoonal areas (and other areas that can experience intense precipitation), flash floods will remain an important risk even after peak water.

Investors cannot accurately price risk or plan long-term infrastructure projects.

Early warning systems and climate-proof designs require accurate and consistent observations.

Without an understanding of glacier dynamics, downstream impacts are not connected to glacier loss.

c. Economic impact assessments

Many countries lack comprehensive assessments of the economic consequences of cryosphere loss. The effects on water availability, energy generation (especially hydropower), agriculture, tourism, and disaster risk are poorly quantified. Additionally, there are few cost-benefit analyses available to support the case for adaptation investments or the deployment of glacier-monitoring systems.
Why it matters:

If the economic impacts are not quantified, glacier-related risks remain invisible to funders and policymakers.

Cost-benefit evidence is essential to justify adaptation spending in budget-constrained contexts. How do we apply a financial value and a time-frame discount rate to a glacier?

A lack of economic framing reduces the perceived urgency and value of glacier-focused investments.

Missing assessment capacity for well particular interventions reduce the risks associated with glacial melt.

d. Pipeline of bankable projects

There is a limited number of well-prepared, fundable projects that integrate glacier or climate-related risks. Currently, glacier-related development is unlikely to draw a profit, leaving a gap with what, especially private, investors require.
Why it matters:

Without a strong pipeline of viable projects, finance cannot flow even when available.

Donors/investors require clear business cases and measurable outcomes to commit resources.

Underdeveloped projects miss out on international climate finance and co-financing opportunities.

Governments need to shape markets and either make catalytic investments or support enabling conditions for investors.

e. Policy and regulatory clarity

Unclear or inconsistent policy frameworks surrounding glacier protection, water management, and climate adaptation create uncertainty for investors. Many national climate strategies do not yet incorporate cryosphere-related risks. Moreover, some mechanisms, such as NbS related to glaciers, post-dates many regulatory frameworks.[18]

Why it matters:

Investors need predictable policy environments to commit long-term capital.

If the cryosphere is not embedded in climate policy, it is not prioritized in planning or funding.

[18] Halpern, G. and A. Al Dwairi (2025). "Integrating Nature-based Solutions in River Basin Management in the Eastern Partner Countries." OECD Green Growth Papers, No. 2025:01, OECD Publishing, Paris, https://doi.org/10.1787/db71d92d-en.

Misalignment between national and international strategies creates confusion and delays.

Solutions need to be supported by regulation to be trusted by investors. NbS, for example, may offer significant cost benefits over technological ones, but need adequate frameworks.[19]

f. Financial risk metrics and tools

There are few financial tools or risk metrics specifically designed to account for slow-onset climate processes like glacier retreat or permafrost thaw. Most standard investment models are not equipped to handle long-term, nonlinear risks.

Why it matters:

Financial institutions avoid investing in areas where risk cannot be quantified or priced.

Infrastructure and adaptation projects remain underfunded or underinsured.

Without proper risk assessment tools, blended finance and private sector engagement are limited.

g. Community-level and Indigenous Knowledge integration

Local and Indigenous knowledge systems are often overlooked in the investment planning process. Data collection efforts and investment designs rarely include co-produced information that reflects the lived experiences and priorities of communities in cryosphere-dependent regions.

Why it matters:

Excluding local voices leads to poorly targeted, unsustainable, or even harmful investments.

Community engagement increases project effectiveness, legitimacy, and long-term impact.

Locally grounded data enhances accuracy and contextual relevance.

At all levels, pooling resources can amplify access, reduce redundancy.

h. Competing disasters with capacity and urgency

There is a gap in capacity and urgency. With many of the same glacier-vulnerable countries juggling other life-threatening crises, such as food and energy insecurity, poverty and civil conflict, glacier-related disasters are deprioritized.

Why it matters:

Glacier issues rapidly become existential when they disrupt rivers, agriculture, economies and lives downstream.

Fair financing mechanisms need to align with national realities and be accessible to local control with tailored support.

The urgency of glacier-related risks needs to be understood clearly to be funded.

[19] GCA (2022). "Doubling Down on Adaptation," GCA Annual Report, 27, https://gca.org/wp-content/uploads/2023/06/GCA-Annual-Report-2022.pdf.

i. Transboundary hazards and need for unification

Glaciers and their watersheds are not necessarily wholly contained within one geopolitical jurisdiction and are, by nature, transboundary. Ideally, joint efforts for research, coordinated development for bridging infrastructure, shared goals and agreements on technical standards can lead to strong outcomes.

Why it matters:

Coordinated efforts increase efficiency and can reduce redundancy.

The mountain community, although punctuated by some successes as a group, has not acted with the same unified voice, likely impacting their ability to mobilize finance.

Transboundary coordination brings together iinter-sectoral and inter-ministerial coordination.

Existing hostilities or tense relations between geopolitical entities can impede action, prevent knowledge-sharing and cause further harm to glaciers.

04.

Existing Funding Structures and Strategies

NGAZUMPA GLACIER, HIMALAYAS

A. Public funding

Glacier-related proposals need to emphasize the environmental, social and economic importance of the cryosphere, the urgency in action and the worldwide consequences for falling short. Otherwise, they risk getting airbrushed with the same issues that trouble many climate finance projects, such as challenges accessing funding mechanisms, political standstills and a high potential for misuse. To be most impactful, public funding agencies need to prioritize collaboration. Currently, aside from domestic resource mobilization (including capital markets), MDBs are the largest source of public funding available, yet they often operate in isolation from each other and prioritize broad, rather than deep, involvement in tackling issues. This limits overall capacity and impact. Part of this broader and isolationist approach stems from the history of MDB development following World War II. Current multisystem issues, such as the climate crisis, however, demand an increased need for cooperation to share resources, practices and priorities to support cross-cutting and deeper-diving approaches. Thus, the financial capacity of MDB/IFIs could be increased with the development of strong coordination to facilitate complementation.

1. Existing public funds are insufficient

There currently exists no funding structure to respond sufficiently to the impacts of glacier and cryosphere loss, both in terms of capacity and urgency. As established in the introduction, the new Loss and Damage Fund has primarily caught the attention of the low-lying SIDS rather than mountain and other vulnerable communities. Still a new fund, it has struggled to have sufficient support and pledges from the global community to meet estimated needs. Consequently, even if the fund were accessed by mountain communities, it would likely move too slowly to help in the immediate future.

There are and have been numerous efforts made to make MDB capital stretch further. The Global Environment Facility Trust Fund (GEF) and the Adaptation Fund have both contributed to numerous projects in mountainous countries, where they target small projects. Their reasoning is that smaller projects with fewer shareholders are more likely to be installed quickly and successfully. While GEF and Adaptation Fund (and others) have different mandates, the current scale of finance needed for glaciers makes it inefficient to meet needs by funding small projects individually. Having greater coordination among MDBs/IFIs is also able to improve efficacy in this regard.

Additionally, the GEF, for example, limits all of its grants to countries categorized by the UN as Least Developed Countries (LDC) through its LDC Fund and its Special Climate Change Fund.[20] Only three of the current LDCs have glaciers, Afghanistan, Nepal and Tanzania, and thus glaciers have not risen to a level mandating focus by the GEF. GEF is, however, interested in water-based risks. Several LDCs, such as Bangladesh and Kiribati, face water risks that stem from downstream impacts from glacier loss, such as poor water sanitation and sea-level rise.[21] These downstream challenges are not viewed through the lens of the cryosphere, as the connections between clean water in a country like Bangladesh and melting glaciers upstream remain poorly understood at the decision-making level.

[20] Afghanistan, Angola, Bangladesh, Benin, Burkina Faso, Burundi, Cambodia, Central African Republic, Chad, Comoros, Democratic Republic of Congo, Djibouti, Eritrea, Ethiopia, The Gambia, Guinea, Guinea Bissau, Haiti, Kiribati, Lao People's Democratic Republic, Lesotho, Liberia, Madagascar, Malawi, Mali, Mauritania, Mozambique, Myanmar, Nepal, Niger, Rwanda, Senegal, Sierra Leone, Solomon Islands, Somalia, South Sudan, Sudan, Timor-Leste, Togo, Tuvalu, Uganda, United Republic of Tanzania, Yemen, Zambia (2025). Nepal is set to graduate from LDCs in 2026.

[21] Sea-level rise attributed to melting glaciers is approximately 0.5m, very small compared with contributions from the larger, polar ice sheets, which are also melting.

Fluctuations in global agendas can also be a barrier to funding.[22] For example, in Spring 2025, government cuts in the United States dismantled many programs that had supported foreign aid and environmental projects under previous administrations (notably USAID). These sweeping cuts have also impacted Multilateral Development Banks, such as the Inter-American Development Bank (IDB). The IDB has 48 shareholders, but the United States owns 30% of the shares, giving the country's current administration broad authority on direction.

Individual governments hold responsibility as well. National governments can contribute through inter alia public investment for capacity building through hydromet agencies, expenditures in infrastructure, management of protected areas and directing subsidies for water-efficient agriculture equipment. Critically, governments have an important role in establishing and strengthening mechanisms within their governance structures to ensure effective use of scientific data and findings for their decision making (i.e., policies, public investment appraisal). Countries also need to be responsible actors for supporting biodiversity and climate action as well as for enhancing investment conditions.

ALETSCH GLACIER, SWITZERLAND

2. Mobilizing public funding

In many cases, existing public funding could be used more effectively through stronger fiscal policies or leveraged through capital markets. This is true for both mitigation- and adaptation-related finance, as both are critical for global issues like glacier loss. For example, harmful subsidies can be removed and repurposed, tax policies can be updated to align with funding gaps and domestic resources can be harnessed.

[22] OECD (2025). "Cuts in official development assistance: OECD projections for 2025 and the near term." OECD Policy Brief, OECD Publishing, Paris, https://www.oecd.org/content/dam/oecd/en/publications/reports/2025/06/cuts-in-official-development-assistance_e161f0c5/8c530629-en.pdf.

Repurposing subsidies is one bright spot with significant potential to mobilize funding while also avoiding further harm. The World Bank Group's Detox Development: Repurposing Environmentally Harmful Subsidies report finds that governments support fossil fuel subsidies sixfold what they promise annually for low carbon alternatives under the Paris Agreement.[23] In total, governments provide a total of US$1.25 trillion annually for agriculture, fisheries and fossil fuels–approximately the size of the entire Mexican economy. Per report, redirecting subsidies in agriculture alone has freed US$635 billion annually. Some of these agriculture subsidies also support chemical fertilizers, which while standard in the industry, produce lower yields than more environmentally-friendly alternatives. Thus, repurposing can both reduce cost and environmental impact while improving crop yields and health.

Similarly, the ADB's Carbon Taxes and Fossil Fuel Subsidies governance brief assesses how carbon taxation and fossil fuel subsidies can improve or hinder climate policies depending on how the funds are leveraged. In 2022, fossil fuel subsidies comprised 7.1% of the world's GDP (US$7 trillion).[24] Fossil fuel subsidies were particularly high in Asia where the total subsidy amount came to 9.5% of East Asia and the Pacific's GDP and 10% of the GDP in South Asia.[25] These percentages highlight the theoretical impact of refocusing such subsidies.

Through its Capital Adequacy Framework, the Asian Development Bank has also unlocked an additional US$100 billion in new funding over the next decade across Asia and the Pacific.[26] The ADB has also launched the Innovative Finance Facility for Climate in Asia and the Pacific (IF-CAP). IF-CAP is the first program by an MDB that uses partner guarantees to leverage billions to address the climate finance gap. This example highlights the position that MDBs/IFIs hold, enabling them to use existing funding to mobilize additional sources of funding.

In capital markets terms, utilizing existing sustainable financing instruments in the sovereign, supranational and agency space is a relevant area of funding to be explored for cryosphere issues. The Sustainable Bond Market is now a mature market consisting of greater than USD 5.7trn issued bonds since the beginning of the Market in 2009.[27] Underpinning this market are international standards that provide the necessary integrity, credibility and standardisation required for such important, yet delicate, mechanisms. These sustainable financing instruments address a host of environmental, social issues and targets that are already, indirectly, addressing cryosphere issues. This is because financing initiatives to tackle cryosphere issues, such as climate resilient infrastructure or ecosystem management and natural resources restoration, simultaneously address the UN SDGs, the basis for existing Sustainable bonds. That said, without a clear and combined view on direct implications for the cryosphere, these financing mechanisms cannot address this issue with the scale and attention it requires.

[23] Damania, R., et al. (2023). "Detox Development: Repurposing Environmentally Harmful Subsidies." World Bank Group, http://hdl.handle.net/10986/39423.

[24] Black, S., et al. "IMF Fossil Fuel Subsidies Data: 2023 Update." IMF Working Papers 2023, 169, https://doi.org/10.5089/9798400249006.001.

[25] Edelman, B. and S. Bhattacharya (2024). "Carbon Taxes and Fossil Fuel Subsidies." ADB Governance Brief 58, https://www.adb.org/sites/default/files/publication/1022066/governance-brief-058-carbon-taxes-fossil-fuel-subsidies.pdf.

[26] ADB (n.d.). "Capital Adequacy Framework." https://www.adb.org/capital-adequacy-framework.

[27] Consisting of "Green", "Sustainable", "Social" and "Sustainability-Linked Labelled Bond" instruments, whereby 100% of the proceeds finance eligible projects under these categories. As aligned with the International Capital Markets (ICMA) principles.

Another example from the IDB highlights several novel instruments, such as debt-for-nature swaps, sustainability-linked bonds and a new pilot program, CLIMA (Climate-Linked Mechanism for Ambition), which pays for results through its own operations. While not yet applied to glaciers, IDB structures are transferable. IDB has found the debt-for-nature swap provides concrete deliverables that are more measurable, guaranteeable and successful than traditional credits and offsets.

B. Engaging private finance

Private finance is one potential avenue that can be well-equipped to deal with large-scale needs. As with publicly-sourced funds, private financing comes with its own set of barriers. These barriers primarily involve the need to make a business case for projects. For example, one MDB cites needing an effective guarantee of a minimum 15% return before it can engage private funds.This can influence decisions and interests, available financial instruments, and expectations on investment returns. Projects that focus on investments in the digitalization of monitoring and warning systems, as well as those with links to insurance and reinsurance agencies can be more attractive to private funders.

Development responding to glacier loss is unlikely to turn a profit, which seemingly makes it unpalatable to many private funders.[28] Ninety-eight percent of currently tracked finance on adaptation is from the public sector because of return expectations, coupled with the lack of standardisation for climate adaptation impact reporting.[29] Despite this, there is a general assumption that private investors will fill gaps left by governments and other public agencies, and thus it is identified as a large source of, albeit nebulous, funding. In order to encourage more private sector investment in, for example, resilient infrastructure for adaptation, governments must shape markets and either make their own catalytic investments and/or encourage enabling conditions either to make investments are more attractive for the private sector or to make it is unattractive for the private sector not to make such investments. Mainstreaming nature-related financial risks into both financial supervisory policies and broader sectoral development policies may offer strong potential to change behaviors of IFIs and corporations in coming years but is still in a nascent stage.

An area of encouraging development on the links between sustainable investment from the private sector and issues related to adaptation through the lens of water and nature more broadly. At a macro level, over 600 organizations have committed to progressing nature reporting in line with TNFD recommendations, representing over USD 20 trillion in AUM. On water specifically, BNP Paribas sustainability research notes that the "Valuing Water Finance Initiative" now has over 100 investors involved (with circa USD 18 trillion in assets under management).[30] However, although 83% of the 71 assessed companies have water use targets, only half have targets that consider the local conditions of high-risk areas. Therefore, ensuring the links between investor decision-making on water engagement related to glacier basin scientific modeling is important in the engagement between investors, companies and governments when it comes to scaling cryosphere financing from the investor community. This is critical given that 60% of annual freshwater flows come from mountain regions and two thirds of agriculture depends on mountain waters.

[28] Organizations are increasingly framing ecosystem preservation as reduced or avoided losses–e.g., mitigation of crop failures or less damage to infrastructure that could be otherwise costly. This framing has yet to be competitive.

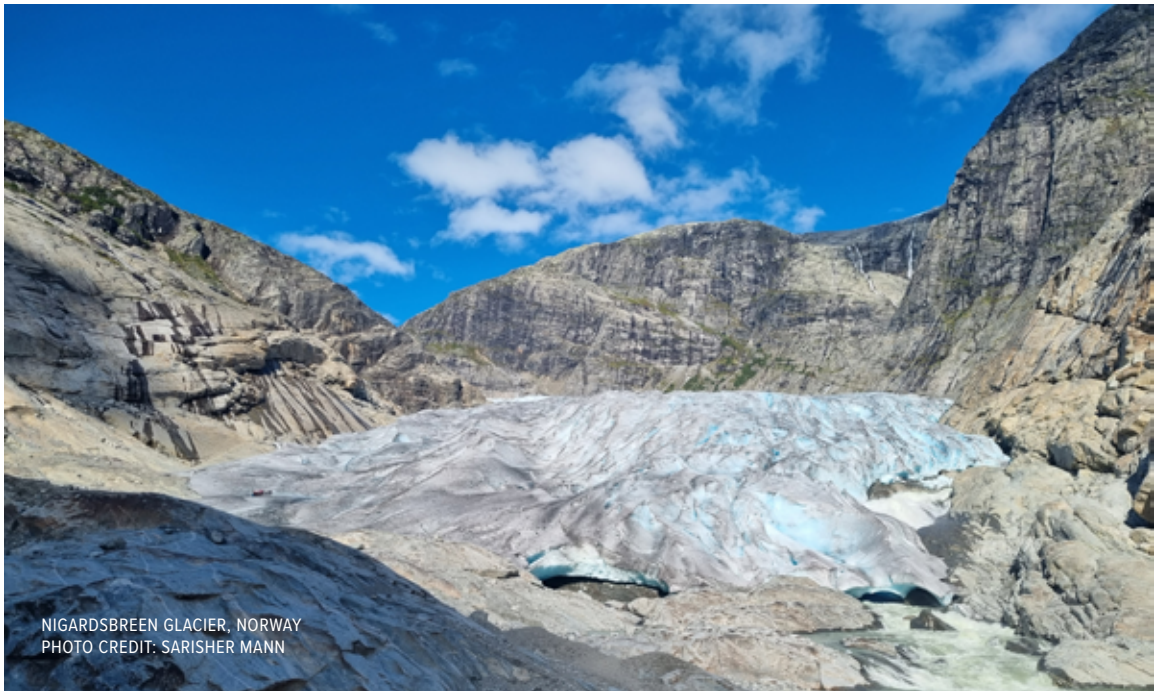
[29] Macquarie, R. et al. (2020). "Updated View on the Global Landscape of Climate Finance 2019." Climate Policy Initiative, https://www.climatepolicyinitiative.org/publication/updated-view-on-the-global-landscape-of-climate-finance-2019.

[30] CERES (2025). Valuing Water Finance Initiative, https://www.ceres.org/water/valuing-water-finance-initiative?utm_medium=email&utm_source=vwfi-benchmark&utm_campaign=water_vwfi-benchmark_engagement_ecomm&utm_term=pardot&utm_source=vwfi-benchmark.

1. Challenges with private finance

Decisions on private projects are client-driven and proposals for funding are expensive, and thus require the client to have upfront liquid assets. In addition, there may be discord between the motivation of financiers and areas of need. Donors typically ear-mark funding to go to a particular geographies or thematic regions, which are not necessarily areas of objective greatest need or how monies could objectively be best used. For example, low-income developing countries may receive less financing despite being most at risk, either because they lack the initial resources to apply for loans or are captive in existing debt that may be unsustainable.

There is also discrepancy about what constitutes climate funding and how even to track it. The Dutch not-for-profit, Recourse, notes that alleged climate finance is being used to support polluting and extractive industries while also not prioritizing the most vulnerable regions of the world.[31] Thus, targeted projects may vary in potential impact and have loose accounting, which can lead to reduced efficiency and impair the likelihood of future support. The Center for Global Development, for example, found that 52 percent of climate finance from 23 wealthy states was simply redistributed money that had already been designated to support other development, such as education and healthcare.[32] In fact, only seven percent of climate finance was additional support.[33]



NIGARDSBREEN GLACIER, NORWAY
PHOTO CREDIT: SARISHER MANN

[31] Wright, P. (2024). "A Safe Pair of Hands? How the Multilateral Development Banks Fail to Live Up to Expectations in Climate Finance." Recourse, https://re-course.org/wp-content/uploads/2024/11/A-safe-pair-of-hands_Recourse_November-2024.pdf.

[32] Ramachandran, V. (2023). "Why Is Climate Finance Such a Mess?" Center for Global Development, https://www.cgdev.org/blog/why-climate-finance-such-mess.

[33] Ramachandran, V. (2023).

2. Insurance, guarantees and risk

Given the expectation of returns, private investment also incurs insurance and guarantees in order to reduce or spread risk. Insurance is particularly valuable for highly exposed projects, such as those relying on a crop yield with an uncertain harvest due to water flow or a large infrastructure project in an area vulnerable to flooding. There is the need for insurance and guarantee agencies to collaborate with IFIs and MDBs more deeply due to knowledge acquired during protracted timeframes in communities.[34]

Insurance protects against loss whereas guarantees are irrevocable agreements underwriting a contract to continue payments if expected revenue stalls. Both can help alleviate some risk and provide a level of security for financiers in event of non-fulfilment. These tools can be especially important given that adaptation finance streams (and mitigation to a lesser degree) are rarely income-generating. However, insurance and guarantees can be challenging and expensive to access.

Insurance is offered only for projects expected to provide a return on investment. Rising temperatures and changing conditions (e.g. reaching and surpassing peak water) mean that projects are increasingly uninsurable. While the need for insurance is increasing with missed mitigation targets, uncertainties in projections mean it is hard to gauge appropriate levels (and thus premiums) of insurance and guarantees.

Parametric insurance–where payouts are linked to pre-defined thresholds related to specific environmental criteria–is relevant in the context of adaptation and glaciers. BNP Paribas notes the adoption of parametric insurance globally is rising by 20% annually, and could be a relevant mechanism to support glacier related financing, especially in terms of addressing insurance to deal with physical risks and adaptation challenges linked to water, agriculture and climate impacts.

Reinsurance remains an underexploited option although it also raises the upfront expense of any project. Reinsurance agencies are highly exposed to the exponentially rising costs of climate change, yet the sector has increasing opportunities to effect positive change. For example, increased payouts due to the physical damages from climate change provide a strong incentive for reinsurers to invest in green bonds. Green bonds are products that either reduce the risk of climate change or involve projects where the impacts from climate change are well managed.

Insurance and reinsurance rely on the ability to accurately assess risk. Yet, there is a disconnect between perceived and actual risk related to degradation of mountain cryosphere, whether directly related to glacier melt, or other aspects such as permafrost thaw, slope instabilities and changes to levels of snowpack complicates. The episodic nature of disasters related to these changes can make both planning and obtaining adequate financing difficult.

Natural hazards often bring keen attention to certain kinds of risks, such as GLOFs, and these may dominate the insurance industry especially. However, longer-terms risks involving dynamics such as peak water or widely variable snowfall, may not be perceived as an equal threat to downstream infrastructure projects. This difference between perceived and actual risks is especially important to longer-term projects such as hydropower plants, flood control systems and irrigation projects, which may become unworkable later in their lifetimes if risks are not properly understood.

[34] Bessent, S. (2023). "The Role of Insurance in Scaling Investments to the SDGs in Emerging Markets." Convergence: Blending Global Finance, https://www.convergence.finance/news/4OI6O5osq4S3JhMUgXifZC/view.

3. Blended finance

One solution to reducing risk while mobilizing the private sector is blended finance. Blended finance can have slightly different definThere is the need for insurance and guarantee agencies to collaborate with IFIs and MDBs more deeply due to knowledge acquired during protracted timeframes in communities.[35]refers to the use of public funds to derisk private capital. By bringing together numerous avenues of support, blended finance has been shown to have potential to scale necessary funding to close some of the larger funding gaps, such as that of the Sustainable Development Goals or the New Collective Quantified Goal on Climate Finance. MDBs are positioned well to lead blended finance projects because of their mandate, international reach, as well as their engagement with philanthropists, impact investors, governments and insurance agencies.

Although there are several key instruments for blended finance, a basic model supports the initial public underwriting of a project, which then spurs further private backing. Together, assuming both are integrated early and well in projects, this mixture safeguards against market failures while reducing investment risk.

Blended finance should be used to support otherwise sensible projects either deemed too risky or fall short on investors' return demands. Such models can be difficult to scale but this narrow focus maintains quality and improves positive outcomes.

Combining finance streams adds additional challenges. Several MDB joint papers and market practices have established common principles and mutually agreed upon definitions that establish pathways forward. While blended finance has been the subject of much hope, it has at times fallen short of its promises, especially in the LDCs. There is considerable room for improvements regarding transparency of transaction costs, long-term compatibility of funders, market distortion and public trust.

Cumulatively the ratio between private and public contributions is US$0.75 private for each US$1.00 in public money. In the LDCs, blended finance only comprises an average of US$0.37 of private funding for each US$1.00 of public funding. In lower-middle income countries, each US$1.00 of public funds is met with US$1.06 in private capital.[36],[37] This suggests significant perceptions of risk and lack of investment opportunities where finance is most urgently needed. Thus, blended finance may fail to translate the billions of available public finance into the trillions that is needed. One risk of this is that public financiers may choose projects based on return potential rather than need in order to secure private finance.

[35] Bessent, S. (2023). "The Role of Insurance in Scaling Investments to the SDGs in Emerging Markets." Convergence: Blending Global Finance, https://www.convergence.finance/news/4OI6O5osq4S3JhMUgXifZC/view.

[36] Attridge, S. and L. Engen (2019). "Blended finance in the poorest countries: The need for a better approach." ODI, https://media.odi.org/documents/12666.pdf.

[37] For high income countries, the ratio is US$0.65 private for each US$1.00 in public.

4. Loans and grants

Loans and grants are often preferred by private financiers due to the tethered return on investments and are currently key to get funding to scale. Both are important instruments for responding to glacier loss.

Loans incur debt for the receiving communities, and while this debt can be important, it is imperative that it is sustainable. In some cases, loans may be used on projects that have goals of driving profit (e.g. improving climate resilient agriculture which improves farming productivity). However, in cases of loss and damage, loans are often used for non-profit generating projects like infrastructure.

All MDBs have instruments to ease burden on countries, especially those with lower GDPs. Terms on loans, for example, are differentiated depending on the recipient country's capital. An example of one such program is the aforementioned internal IDB program, CLIMA.[38] CLIMA is being piloted in 2025 in ten countries and on loans targeting a country's NDC or biodiversity. CLIMA loans are financed like a traditional loan with a standard 20-25 year pay-back period. If at the end of the initial five-year grace period the country has met sustainability KPIs linked to the grant, the IDB converts 5-10% of the loan into a grant that is returned to the borrowing country.

Grants, on the other hand, can appear egalitarian without the debt though are rarely offered at the scale needed for impact. They can, however, be used for leveraging loans. Grants are typically associated with the philanthropic interests of the enterprise. Therefore, projects can stop prematurely if they are no longer aligned with funders' interests.

5. Carbon offsets and bonds

One way to leverage additional private funding is through offsets. Offsets are a type of carbon market that enable funders to support projects that reduce emissions elsewhere. One challenge, however, is that there is sometimes poor management of offsets to ensure that emissions are actually reduced or avoided. For example, in recent years, offsets that have relied on protecting the Amazon Rainforest or Canadian old growth forests have received attention for failing when forests burn (thus contributing to atmospheric carbon) or the same area/project is counted as an offset for multiple polluters. Carbon bonds are another option that may be a preferable solution over carbon credits or offsets. This is because these bonds have more concrete deliverables and usually stronger regulation than credits. In the carbon bond market, a project owner issues bonds to generate funding to finance a project, which in turn, provides carbon credits that can be sold. Selling credits provides income to sustain the bonds. In both circumstances, there is the risk that companies invest in offsets or bonds to avoid reducing emissions at home–and thereby not reducing the global emissions that are critical to mitigate warming and atmospheric carbon.

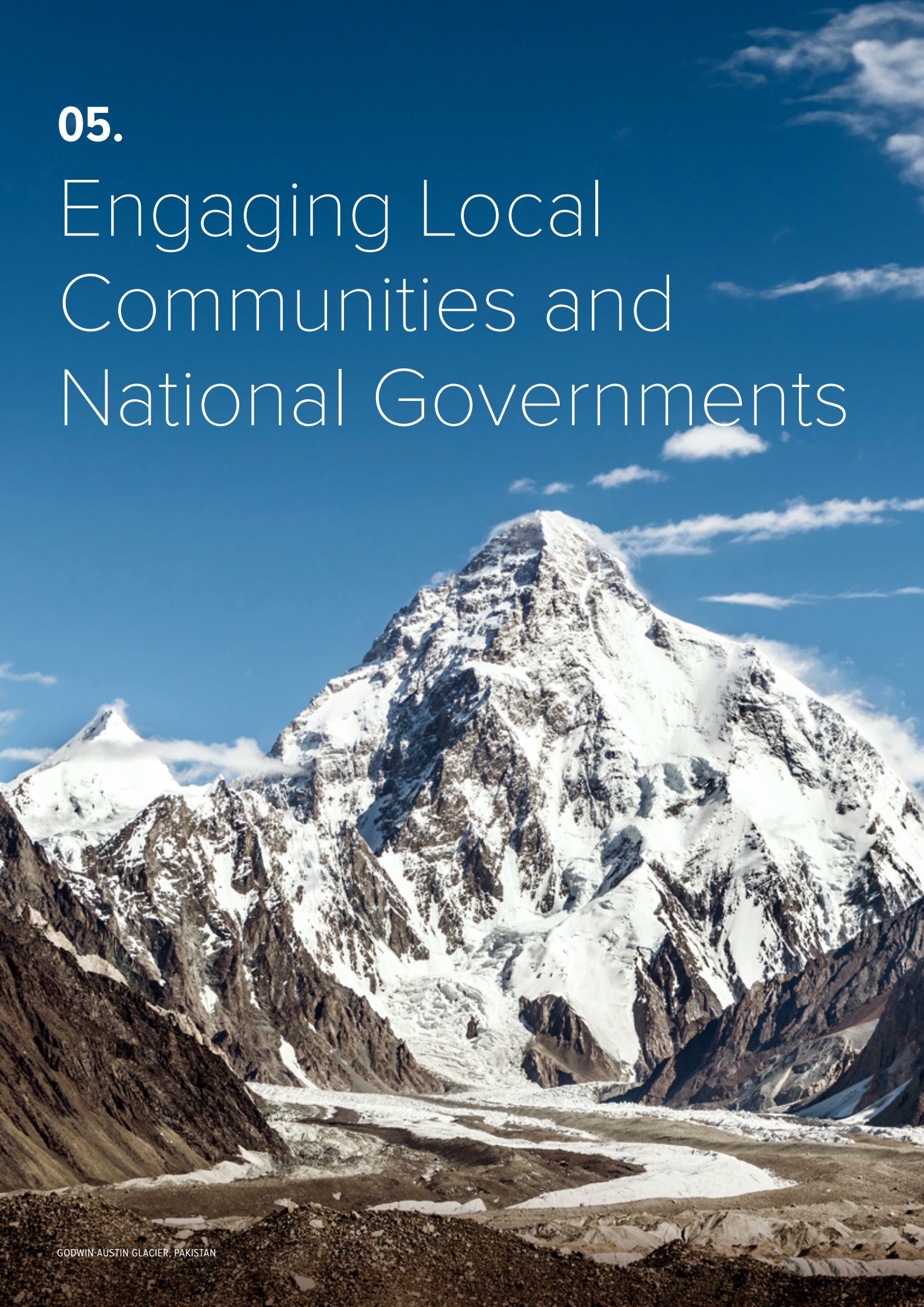
[38] Brusa, F., et al. (2025). "The Case for IDB CLIMA." Inter-American Development Bank, http://dx.doi.org/10.18235/0013778.

Neither carbon offsets or bonds are well developed to preserve glaciers compared with those in place to support aforestation, for example (i.e. REDD+, IFM, ARR). However, there are some projects in place that tangentially support glacier preservation that are through both offsets and bonds. Two such mechanisms are programs that provide clean cookstoves and water sanitation. Clean cooking devices reduce black carbon and emissions, both of which directly lead to glacier loss. By reducing indoor pollution, these systems also improve health–especially among women and children–for community members. By reducing boiling, clean water initiatives can save energy while improving community well-being.

As mitigation related to glacier preservation really needs to be a global effort, there are also sub- and supra-national systems–typically offsets–which can bind companies and institutions. The China Emission Trading Scheme (China ETS) is one of the world's largest cap-and-trade systems and affects its power generation sector (2025)–covering approximately 40% of the country's emissions. Such large systems–others cover the European Union, Australia and the state of California, for example–can be impactful for reducing global emissions necessary yet are vulnerable to shifting politics and loopholes. High emitters such as South Africa, Brazil and India have planned similar schemes.

05.

Engaging Local Communities and National Governments



GODWIN-AUSTIN GLACIER, PAKISTAN

A. Who owns the project? The case for local control

Many applications for funding are made by clients, which may not be recipient countries. This requires stringent coordination with the borrower to ensure appropriate consultations ensuring strong alignment between the interests of the funders and the local communities. For public financing, this disparity is lessened somewhat. As will be discussed later, GEF, for example, has its constituent in situ agencies co-create proposals with local leadership, largely following the lead of on-ground experts.

B. Mitigation versus adaptation

Many client countries prefer to focus on mitigation rather than adaptation, despite increased (and increasing) adaptation needs. Some of this stems from the continued pressure exerted by climate vulnerable states for rapid, global decarbonization. Some is because mitigation projects tend to be in sectors with a sellable product, e.g., energy, thereby generating a revenue stream. This contrasts with the broader momentum on adaptation finance within the development and blended finance context, especially in relation to water and infrastructure resilience, and investment solutions that also focus on future needs. Adaptation approaches present several challenges for client countries as well. For instance, there is often a lack of capacity to create future-looking projects and/or to absorb funding for such projects. This issue is notable because governments often cite the lack of funding as a reason not to prioritize adaptation.

Additionally, governments may have poor understanding of adaptation needs. For example, they may have unrealistic expectations on future water supply given that glacier melt before peak water is associated with flooding and excess water, whereas post-peak water leads to drought. Therefore, in this case, adaptation planning asks governments to prepare for a lack of water while simultaneously addressing an excess of water.

Similarly, it can be hard for client countries to look forward to adaptation needs when fiscal space is constrained. For example, with ample fiscal flow, one might justify the additional cost of stronger water supply infrastructure that can still deliver necessary services when pressured. However, the economic return is harder to justify without sufficient fiscal capacity. A lack of fiscal space can come from numerous channels, including high debt, high spending in other areas (e.g. subsidies) or low tax revenues. Given that adaptation is often seen as secondary to mitigation, countries already burdened with debt may rather seek debt relief than accumulate more debt. This is one situation where debt-for-nature swaps could bring especially positive outcomes. However, these swaps may not be feasible at scale due to the high transaction costs.

Regardless of adaptation or mitigation, to monitor success, it is imperative to have follow up consultations with target communities to assess impact. This can help provide feedback, support, an open dialogue, and offer a sense of control for the local organization or country that is living with limited financing options.

C. Pay-for-access: can it encourage stewardship?

Another type of community engagement could be a "user pays" system to protect the ecosystem of a glacier's watershed. For example, beneficiaries of glaciers, such as downstream countries relying on a supply of clean water, could pay upstream "providers" for the protection of that source. This can be extrapolated to operate at a country level and effectively force recipient countries, such as the United States, to fund glacier preservation. Given that glacier preservation cannot be exclusively local due to the transboundary nature of warming, payments generated through a larger system of reciprocity could go toward mitigating different contributors of melt, including air pollution and black carbon, which simultaneously improve inter alia health, economies, agriculture, biodiversity. Such pay-for-ecosystem services have proven successful throughout the world, for example, in Peru through drinking water taxes.[39]

[39] Dextre, R. M., et al. (2022). "Payment for ecosystem services in Peru: Assessing the socio-ecological dimension of water services in the upper Santa River basin." Ecosystem Services 56: 101454, https://www.sciencedirect.com/science/article/pii/S221204162200050X.

06.

Mitigation and Adaptation Policies in Relation to Glacier Financing

PERITO MORENO GLACIER, PATAGONIA

Action on mitigation and adaptation has been traditionally siloed but there are increasing opportunities for the two to support each other either in parallel or through multifocal projects.[40] One still-unsettled area of the Paris Agreement is the financial divisions of mitigation and adaptation. While climate vulnerable regions may need immediate mitigation relief, greater political pressures can influence decisions. For example, high-emitting countries and those still resisting the phase-out of fossil fuels tend to emphasize adaptation. This is because it puts less pressure on them to reduce their own emissions. Other countries, such as the members of the Bhutan-led G-ZERO or Japan-initiated AZEC (see below), prefer mitigation and assume the responsibility of becoming carbon negative.

A. Mitigation: on a lifeline

Mitigation finance is challenging because it supports emissions reductions, such as investments in renewable energy or more efficient production, and has struggled to impact the policy level at the global scale needed. Smaller glaciated nations are not responsible for worldwide emissions, and thus have limited capacity for worldwide reductions in greenhouse gases. Bhutan, for example, is already carbon-negative, although it is still making further reductions by leading other countries achieving net-negative emissions through the G-ZERO initiative launched in 2024 at COP29 with other carbon-negative states, Suriname, Panama and Madagascar. Proposed by Japan in 2022, the Asia Zero Emission Community (AZEC) is another group of nations that aims to push mitigation by achieving carbon neutrality through holistic approaches to country-tailored low-carbon energy security.[41]

There are some avenues for locally-driven mitigation, for example, reducing black carbon deposits on glaciers and snowpack, which accelerate melt. Projects that target fire-free agriculture near glaciated regions are one way that communities can directly contribute toward preservation of their own glaciers. Regardless, for countries on the frontlines, it is incredibly difficult to mitigate while also needing to adapt and deal with urgent loss and damage.

1. Global SOS: The need for mitigation

Given the transboundary nature of rivers and basins, countries reliant upon glaciers do not necessarily have glaciers within their geopolitical borders. Mitigation for glaciers is needed by countries that may not even realize they are glacier-dependent. Even high emitters that are heavily reliant upon glaciers and snowpack, such as China, Canada and the United States, the need for mitigation to preserve their water is not translating into notable shifts in policy.

For wealthier states with financial options as well as for financiers, there is a need for cost-benefit analyses of mitigation and adaptation projects in relation to peak temperature and resulting glacier and snowpack levels. For example, this would consider the relative costs of adaptation and mitigation with aggressive (1.5C consistent) versus delayed (2°C and above) mitigation levels at the country and regional levels.

[40] For example, see OECD (n.d.). "Development finance for climate and environment." OECD, https://www.oecd.org/en/topics/sub-issues/development-finance-for-climate-and-the-environment.html.

[41] Australia, Brunei Darussalam, Cambodia, Indonesia, Japan, Lao PDR, Malaysia, Philippines, Singapore, Thailand, Vietnam.

2. Regional success: localized mitigation strategies

One such example on local mitigation projects comprises the reduction of black carbon emissions near mountain cryosphere. The reduction of black carbon (soot) is among the most effective ways to reduce anthropogenic warming globally. On the Tibetan Plateau, 39% of pre-monsoonal glacier mass loss is the result of black carbon deposits.[42] The Arctic is also warming approximately four times faster than the planetary average, significantly as a result of black carbon on the glaciers, ice sheet and sea ice.[43] Action-oriented solutions currently exist to reduce black carbon deposits up to 80% of 2010 levels by 2030. According to the Clean Air Fund, there are several cited barriers for increasing funding for these black carbon solutions. Identified barriers include black carbon not being on the radar of MDBs/IFIs or other public funders, despite a 2015 study led by the World Bank Group establishing the need for black carbon-related finance.[44] This lack of funders corresponds to a lack of access to funding for resource-scare countries as well as low-levels of funding when offered for air pollution. Only 0.1% (US$18mn) of monies awarded by MDBs/IFIs for outdoor air quality concerned black carbon, despite applications.[45] Without large-scale funding, smaller organizations, such as the Climate and Clean Air Coalition (CCAC) have stepped in. Through CCAC's funding, Nepal has been able to renovate cookstoves leading to a 60% reduction in black carbon.[46]

B. Adaptation: looking ahead

Although there is an increasing push for adaptation as atmospheric carbon levels continue to rise, reflecting the overall failures on global mitigation, adaptation efforts present significant complexities. Governments in climate vulnerable regions are still nevertheless focused on adaptation, especially as concerns mount over missing the necessary targets for effective and long-term mitigation. Additionally, seeing the shortcomings of [global] mitigation efforts, some investors consider climate adaptation a necessity with demand for innovative financial instruments related to climate and nature. Despite some of these investment demands, the Climate Policy Initiative found that only between 4-8% of tracked climate finance is directed solely toward adaptation.[47] Certain global funds, such as the Adaptation Fund, Climate Investment Funds and Green Climate Fund, are all focused on leveraging funding for adaptation. Despite the limited investments thus far, adaptation funding is expected to grow. Analyzing 320 projects in 12 highly-vulnerable countries in Africa, Asia, and Latin America and reflecting 48% of the global population, the World Resources Institute found that each dollar invested in adaptation generates in excess of $10.50 in benefits over a ten-year period.[48] This model, part of the Adaptation Triple Dividend of Resilience (AdapTDR) database, calculates impacts across three areas: avoided losses, economic gains, and social and environmental benefits.

[42] ICIMOD (2025). "Urgent action needed on black carbon: a key driver of glacier melt and monsoon disruption." https://www.icimod.org/press-release/urgent-action-needed-on-black-carbon-a-key-driver-of-glacier-melt-and-monsoon-disruption.

[43] Rantanan, M. et al. (2022). "The Arctic has warmed nearly four times faster than the globe since 1979." Communications Earth and Environment 3: 168, https://doi.org/10.1038/s43247-022-00498-3.

[44] CCAC (2015). "Black Carbon Finance Study Group Report." Climate and Clean Air Coalition, https://www.ccacoalition.org/news/black-carbon-finance-study-group-report-2015.

[45] Clean Air Fund (2024). "The State of Global Air Quality Funding." Clean Air Fund, https://www.cleanairfund.org/resource/air-quality-funding-2024.

[46] CCAC (2018). "Nepal brick kilns rebuilt to be energy efficient, pollute less." Climate and Clean Air Coalition, https://www.ccacoalition.org/resources/nepal-brick-kilns-rebuilt-be-energy-efficient-pollute-less.

[47] Macquarie, R., et al. (2020).

[48] Brandon, C., et al. (2025). "Strengthening the Investment Case for Climate Adaptation: A Triple Dividend Approach." World Resources Institute Working Paper, https://doi.org/10.46830/wriwp.25.00019.

1. Challenges of adaptation: uncertain trajectories

Adaptation for glaciers is especially challenging given the lack of clear trajectories of both emissions and glaciers/snowpack loss. This means that adaptation needs are highly uncertain. As established earlier, not only are the trajectories uncertain, but preparation needs to be made for changing–and even contrasting situations. Governments and funders may be misled by current peak water conditions, and either are dealing actively with flooding or experiencing sufficient quantities of water. Thus, they may have unrealistic expectations regarding future water supply and not adequately prepare for a future with drought. Infrastructure, for example, might be built to match current or short-term water supply and thus become obsolete prematurely when conditions change.

MDBs/IFIs and other organizations may not have avenues to respond to glacier loss directly. For instance, The World Bank Group's structure channels any glacier-related adaptation through the Bank's disaster risk response team. This means that money is predominantly available only following a declarable disaster and thus is not available for adaptation-related investments like early warning systems that could forestall the human toll of any disaster.

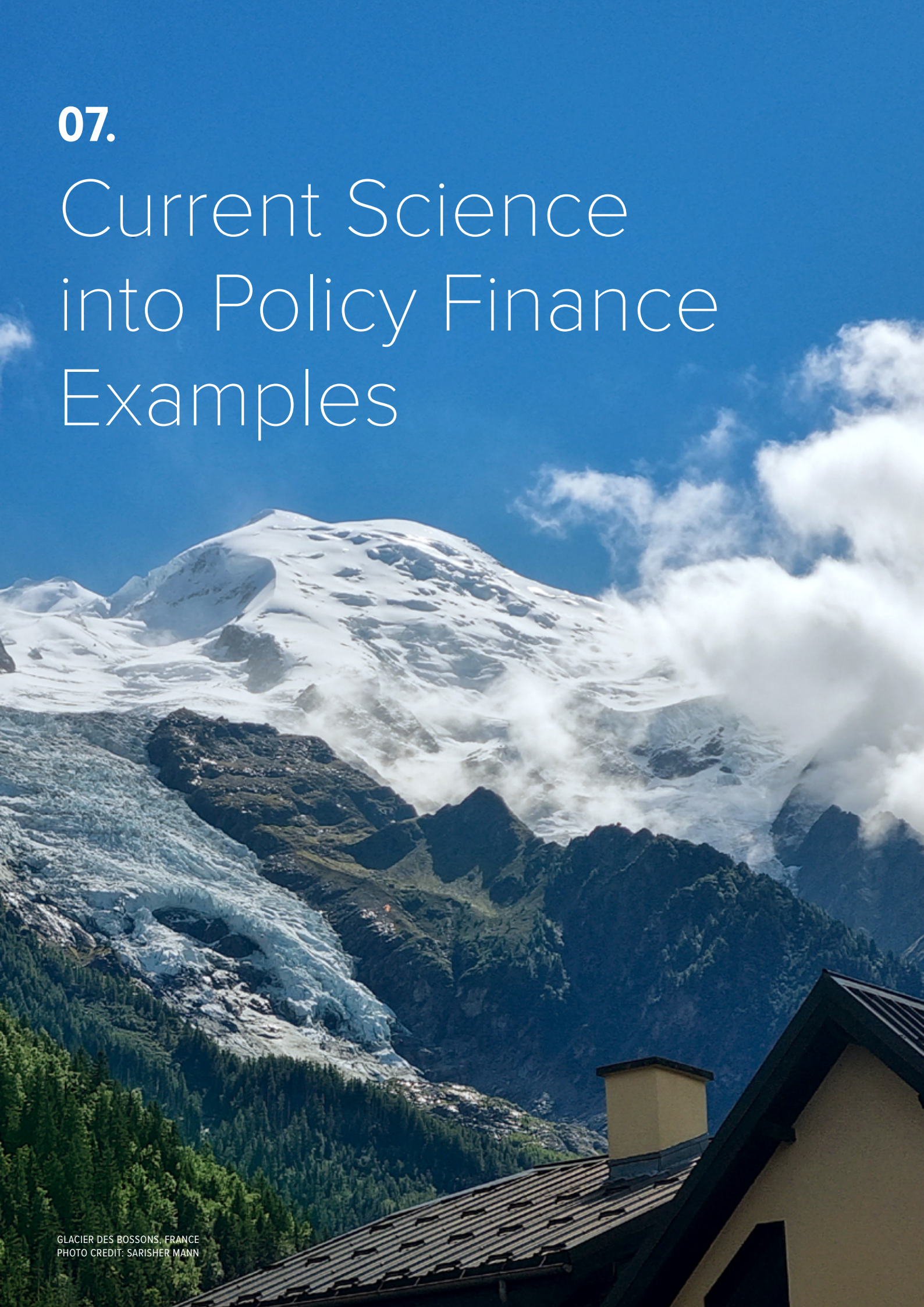
2. No two the same: adaptation across river basins

Adding to the uncertainty is that the loss of glaciers and snowpack is different for each water basin and cannot be generalized across regions. This requires significantly more research and data–and thus, expense, to understand effectively. In addition to numerous basins needing to be assessed simultaneously, multiple sectors are also simultaneously impacted and need to be understood, from agriculture and water security to industry and hydropower.

As one cannot just repair economies with drastic climate changes, adaptation also forces the development of new economies and ways of life. Thus, adaptation may also require significant restructuring of communities with new trades, industries and governance.

07.

Current Science into Policy Finance Examples



GLACIER DES BOSSONS, FRANCE
PHOTO CREDIT: SARISHER MANN

There are several financing efforts related to mountain cryosphere losses that are currently active. Additional ones, also described below, have not yet been applied to glaciers but have frameworks that could be transferable to glacier preservation.

A. Glaciers to Farms

The Glaciers to Farms (G2F) initiative was put forward at COP29 (2024) by the Asian Development Bank to assess water and food security resulting from significant glacier loss throughout nine countries of Central Asia. G2F aims to mobilize $3.5 billion through ADB's own resources, as well as support of governments, the private sector and other development partners, such as GCF. These monies will be invested in water and agriculture, as well as in communities endangered by glacial melt and its upstream and downstream impacts.[49]

While G2F's initial focus is in Central Asia, its reach may be expanded to other parts of Asia, especially through connections with ADB's Building Adaptation and Resilience in the Hindu Kush Himalaya. Initiated in 2024, Building Adaptation and Resilience in the Hindu Kush Himalaya focuses on strengthening capacity for adaptation in Nepal and Bhutan. This project looks at decision-making in disaster risk reduction, and includes financing aspects, notably measures for adaptation and risk transfer solutions, such as insurance.

B. Swiss and Peruvian hydropower

Switzerland has been taking future cryosphere loss into account for some of its developments, such as hydropower and dam projects. Hydropower currently accounts for just over 57% of domestic electricity production in Switzerland, and all primary rivers that feed hydropower projects rely on snowpack and glacier ice.[50],[51] As with other areas yet to experience peak water, Switzerland is preparing for short-term increases in water supply followed by a longer term loss and is feeding these metrics into its design plans and energy grid.[52]

Switzerland is not the first state to do this work. For example, as early as 2007, studies focusing on the tropical glaciers of the Andes, showed that the yearly output for the hydropower plant on Perú's Rio Santa with a 50% loss of glacier meltwater would go from producing 1540 gigawatt hours to 1250 (±10.9%) gigawatt hours.[53] However, despite the data being established early in the twenty-first century, the focus was on the future of rising costs of energy and has only recently been used to shift policy on glacier preservation.

[49] ADB (2024). "ADB Launches Major Initiative to Build Resilience to Melting Glaciers." https://www.adb.org/news/adb-launches-major-initiative-build-resilience-melting-glaciers.

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C. Tarayana Foundation

In 2003, Her Majesty The Queen Mother Ashi Dorji Wangmo Wangchuck of Bhutan founded the Tarayana Foundation. It aims to underscore political commitment on the Third Pole as affected by the glaciers through economic, energy and social development. The Foundation leads both mitigation and adaptation projects and awards microfinance grants to support development initiatives. It also aims to connect grassroots efforts for local needs with national and international infrastructure.

D. Sustainability-linked KPIs

The IDB has been developing its sustainability-linked bonds as a way to free money for climate resilience while also working toward KPIs established in the country's NDC. This system critically links the ministries of finance and the environment, enabling the two to collaborate, such as offering lower rates for achieving KPIs that would increase the value of the underlying bond. To be successful, the Bank helps ensure that countries have very clear KPIs, any necessary links with research institutions and the financial capacity to track progress. This process aims to ensure that money is freed for local projects while also aiming multiple ministries toward the respective country's UN climate commitments. IDB attributes connecting the finance ministry with the environmental ministry to its success in finding available funding. Without this link, the bank has found that finance officers are disconnected from NDCs and environmental commitments.

E. Use of proceeds-themed bonds

The use of proceeds-themed bonds earmarks dedicated proceeds towards eligible sustainable activities, which are aligned to the ICMA principles.[54] It provides a best-in-class tool for public sector issuers, such as MDBs, to raise financing specifically for Sustainable purposes. From an investor's perspective, by explicitly directing funding to projects with defined environmental or social outcomes, buying themed bonds or private placements allow investors to align their capital with targeted impact areas. Subsequently, these instruments are a very effective tool in capturing private investment. Glacier-related financing could benefit from accessing this mature market. Eligible projects for a "Glacier bond," for example, should adhere to the existing standards, whilst capturing the most material projects and impacts that the cryosphere requires. Examples could include, but are not limited to, i) Environmental: Ecosystem management and natural resource restoration, and climate change adaptation (i.e. strengthening agricultural resilience); and ii) Social: supporting vulnerable communities threatened by glacial melt, particularly in fragile mountain regions. These eligible projects must be material, precise and impactful. As a result, impact reporting indicators must be looked at, aligning to the ICMA impact report handbook. These should include both environmental impacts and, importantly, social co-benefits.

[54] ICMA principles ensure that green bonds finance environmentally responsible projects. Examples of aligned projects include investments in the renewable energy sector, improvements in efficiency, clean-running transportation and healthy water and sanitation management. ICMA stands for the International Capital Market Association.

08.
Possible Solutions

SIERRA NEVADA COCUY O GUICAN, COLOMBIA
PHOTO CREDIT: HEIDI SEVESTRE

A. Funding

Improving efficacy in funding highlights the importance of first building up a complete picture of what infrastructure is exposed to higher multi-hazard risk due to glacial melt. Then we need to start generating estimates of what the adaptation investment needs will be for future infrastructure. More core finance is needed, which can be in turn used to mobilize other resources, including concessional and private-sector finance. Innovative financing systems driven by various MDBs, whether regional or global in scale, such as leveraging international carbon markets and connecting debt conversion to sustainability, could provide alternative funding streams for glacier preservation initiatives.

B. Shaping markets for high-quality finance

Supporting strong finance for climate requires increases in both the quality and volume of available finance. Well-shaped markets can support transformational change through a systems-approach that works beyond isolated interventions. At the national level, governments at all levels can implement or improve glacier-related policies that influence financial flows. This can include policies that can provide or contribute to the necessary enabling conditions to attract finance for glacier protection. Such streams can also stymy negative outcomes and improve resilience for floods and droughts, for example, the support for water allocation schemes.

C. Technology

To close some of the knowledge gaps, Kayrros-style satellite monitoring can be effective to increase monitoring capacity, share data and gain access to remote locations, all at significantly lower costs. Harnessing quantum computing and artificial intelligence for processing also reduces the strain on human capital, though AI data centers are significant sources of water waste and energy consumption. Data would be accessible to governments, infrastructure agencies, researchers and decision makers. Both would require private money upfront by funders convinced of the need for more glacier data for global benefit.

D. Communication

While barriers are many, so are solutions. Better communication is essential to mobilize climate finance: success is only possible when cryosphere change and impacts in the medium- and long-term are shared clearly. Additionally, communication helps establish links across corporate supply chain resilience, physical risk assessments related to water vulnerability and infrastructure, momentum on nature-based solutions/nature-related financial disclosures, and adaptation plans. Each of these is a relevant consideration for scaling climate finance in the cryosphere context. Furthermore, investment in glaciers can support many Sustainable Development Goals, a cross section of key sustainable mandates that mimic many of the largest ESG and impact funds.

As the hazards and preservation needs are complex and at times opaque, communication on sustainable projects could yield a pipeline for other financial institutions that could be interested in glacier melt and conservation but need guidance on priorities.

E. Development of strong coalition of mountain countries

The global mountain community is very geographically, economically and culturally diverse. However, the development of a negotiating bloc or coalition that draws upon numerous mountain and glaciated countries representing different parts of the world can push the urgency of the mountain and glaciers agenda in ways that can help mobilize finance. The Alliance of Small Island States and the Coalition of Rainforest States, are two examples of like-minded groups that have used this system successfully to advance their needs on the global scale.

F. Knowledge

Interdisciplinary research collaborations are essential to bridge the gap between scientific findings, interventions and effective policy implementation. For example, multi-hazard risk assessments must be fed into the design of infrastructure and early warning systems at the earliest stages, which can be otherwise approached in a siloed manner. Interdisciplinary knowledge can also help improve NbS, which similarly are sometimes less desirable by funders due to appearing [at times superficially] more complicated as they need to be tailored to individual locations or do not align with pre-written risk assessments.

G. Integrating community

Integrating local communities into solutions, ideally from the problem identification and project planning phase, enhances the effectiveness and sustainability of financing strategies and supports the intersectional impact across both social and environmental contexts. In addition, traditional knowledge from Indigenous communities can enhance adaptation strategies and ensure culturally appropriate solutions. The GEF, for example, addresses this by having its 18 agencies work directly with local communities and governments to co-create proposals. This collaboration assumes the local groups understand the needs best with the agents merely supporting the application process.

H. Adaptation and mitigation in nature investments

Within the adaptation investment sphere, there is growing demand for innovative financial instruments related to climate and nature. Capitalizing on glacier loss and its impacts may help drive this, as includes both adaptation and nature investments, with potential alignment to investors' current sustainability preferences across several thematic areas simultaneously.

Understanding the true cost of adaptation may also spur action. This has been calculated for some countries, but it still needs to be done for others–and done for various emissions pathways. If adaptation is shown to cost more than mitigation, this presumably would help with the mobilization of resources. However, this argument is more nuanced, as both adaptation and mitigation work on different timelines and scales and within unique region-specific frameworks. Additionally, the knowledge of cost does not in itself overcome budget, political or priority barriers. Mitigation efforts may also be boosted by increasingly accessible renewable energies, which may also increase engagement among the private sector.

Regardless of mitigation or adaptation, the private sector (including banking, insurance and reinsurance) may support both schemes increasing standards for infrastructure development. These increased standards would encourage the inclusion of hazard risk assessments and management, which would increase the likelihood that any construction is able to fulfil its expected operational lifetime. Increased standards will have cost implications but will have longer term benefits.

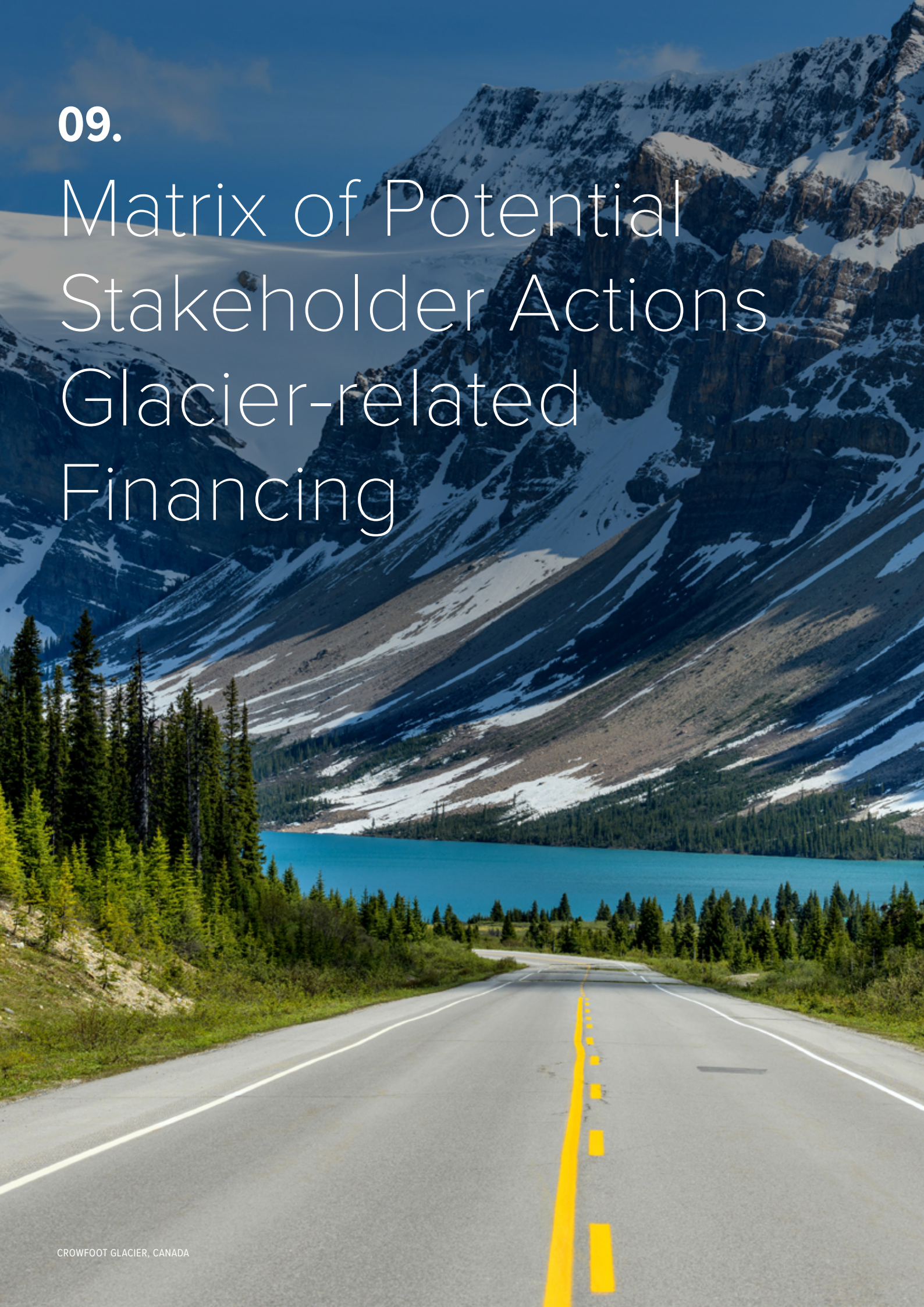
I. Adapting successful schemes to glaciers

One of the innovative funding mechanisms of the IDB, debt-for-nature swaps, has been successful so far in Barbados, Ecuador and the Bahamas and could be a model for glacier communities. Through its debt-for-nature swaps, the IDB provides a policy-based guarantee that enables bonds to be issued with lower rates, while simultaneously reducing the country's debt. In its first conversion with Barbados, co-supported by The Nature Conservancy, this debt conversion generated US$50 million in savings, which Barbados put toward its own marine conservation interests.[55] A second conversion for Barbados is being used to generate savings to establish a waste-water treatment system that protects coral reefs. The IDB currently does not require the debt conversion to align with the KPIs associated with the policy-based guarantee. Keeping this model, a country could have an energy-based policy KPI and use the savings to develop a fund for glaciers. This example of debt conversion has not been applied to glaciers but the knowledge is transferable. However, its use may be limited in that scaling globally may be prohibitive.

[55] International Monetary Fund (2024). "Barbados." IMF Country Report 24/368, https://www.elibrary.imf.org/downloadpdf/view/journals/002/2024/368/002.2024.issue-368-en.pdf.

09.

Matrix of Potential Stakeholder Actions Glacier-related Financing



CROWFOOT GLACIER, CANADA

Across a spectrum of investors, governments, MDBs/IFIs, insurers, infrastructure companies, scientists, and policy makers there are several action areas that can be addressed to scale glacier related financing as covered in this paper.

Glacier Financing Action Matrix

STAKEHOLDER	TOP 3 POSSIBLE ACTIONS TO SUPPORT GLACIER RELATED FINANCING
Investors	Support a market for NbS-focused financing products (e.g., glacier bonds, credits focused on nature adaptation projects in glacier regions) Track water-security and potentially glacier-risk KPIs where relevant in portfolios, including integration of physical risk metrics based on cryosphere science Partner with MDBs on blended-finance pilots
MDBs/IFIs	Support partial guarantees/first-loss in glacier financing instruments Support glacier-specific CBA toolkit that values water-security and disaster-aversion Issue adaptation related bonds to support adaptation investment in glacier regions (including related to water issues)
Governments	Support regional 'mountain-country blocs' to advocate within existing governance mechanisms (UNFCCC/ L-&-D Fund etc) Embed glacier-risk & water-security metrics in budgeting & infrastructure planning. Explore glacier related financing in sustainable finance mechanisms at country/regional level Re-allocate harmful subsidies (fossil-fuel, fertilizer) toward NbS and water-efficiency programmes in glacier regions
Commercial Banks	Develop sustainable finance innovations including sustainable bonds and outcome-based financing to support cryosphere issues related to physical risk, water and glacier basins Develop parametric/catastrophe-bond structures Support stronger market related use of glacier-hazard analytics
Insurers	Launch parametric GLOF insurance for municipalities & critical assets Create a regional glacier-risk re-insurance pool

10.
Recommendations and Conclusions: Where Now?

WEDDELL SEA, ANTARCTICA
PHOTO CREDIT: JAMES KIRKHAM

To expedite the necessary funding and the scale and efficacy required, there are several key recommendations:

It is imperative to improve economic analyses for resources. For example, the perceived barriers of nature-based solutions in relation to glaciers and glacier-financing need to be reduced, so they are more approachable and understood; including their limitations especially with different temperatures/emissions scenarios. Economic analyses are also needed to ascertain the financial (and social impacts) of glacial melt. What infrastructure and assets or communities are exposed hazards resulting from the glacier loss? What is the estimated investment cost required in order to tackle these hazards and their impacts?

A revised cost-benefit analysis mechanism is needed that accounts for glaciers. Glaciers have extreme value to protect, which can somewhat be monetized in terms of saving disaster and adaptation costs, but have no inherent financial value themselves. In a typical CBA, glaciers would not merit protection. Without this protection, they will disappear entirely. It is critical to foster better knowledge sharing between investors, governments, MDBs and scientists when it comes to channeling capital to glacier issues, especially given the environmental, social and economic implications of glacier loss on water, physical risk and the adaptation financing imperative.

Recipient countries need to continue to develop their own resources, shape private sector markets, and use MDB core funding as a basis to bring in others. This can help develop the architecture in capital markets to raise funds for glaciers. One way to do so could be through sustainable capital-market issuance.

Largely designed for post-war reconstruction, the skeletal framework of the MDBs needs to shift to meet the current challenges of the climate crisis. This is especially in the context of rapid glacier loss and large infrastructure projects (such as dams, large-scale irrigation) that assume largely linear conditions. Changing physical glacier realities require MDBs to reassess their efficacy and risk tolerance, and to explore cross-cutting opportunities. This includes identifying ways to leverage further funding; work with developing countries to mobilize more of their own resources; and help mobilize private capital.

In breaking down silos, finance ministries need to be engaged with environmental ministries and other sectoral ministries as relevant (e.g., water, energy, agriculture) on climate matters to enable creative and appropriate funding solutions. Without this collaboration, mechanisms like sustainability-linked KPIs and the redistribution of available money “within” the financial system, e.g. IDB’s CLIMA or the reallocation of subsidies, would not be possible.

IFIs and other financial institutions need to be linked with communities through partnerships to identify unique challenges of glacier-based needs that separate the glacier landscape to avoid the climate finance “trap.” MDBs are, perhaps, particularly well positioned to assist IFIs and governments with such engagement, and likewise to set frameworks for the private sector to collaborate with communities. This will improve the transparency and efficacy of funding, ensuring it benefits communities where it is needed most.

The underlying message is that without urgent action to protect the glaciers, many mountain and downstream regions are moving beyond the limits of adaptation. This issue will thus become one of loss and damage, as indeed it has already become in some regions.

Glacier mitigation cannot be done at the landscape level. It is truly global. High emitters, such as the United States and Canada need to understand that they are just as important in the preservation of glaciers in the Hindu Kush Himalaya as local emitters, such as India or China. According to ECOSOC, 164 out of 193 UN-recognized countries are either glaciated or impacted by glaciers, and so understanding the importance of their protection needs to be made clear to policymakers.[56]

Already, some downstream water security issues, for example, clean water in Bangladesh, are "glacier issues" but are not treated as such because this connection is not understood. Therefore, any "solution" presented (and funded) is not actually addressing the core issue.

Nature-based solutions need to be considered more closely. These are overlooked in favor of technical solutions due to perceived risk and knowledge gaps. However, NbS generally offer higher return on investment, to the tune of four- to seven-fold. This higher investment return could make nature-based solutions financially exciting to private investors, opening opportunities of leveraging additional funds or opportunities for blended finance.

Similarly, each river basin needs to be independently assessed. Although this has an upfront cost, not doing this means that viable solutions are overlooked in favor of what may seem to be "easier" options; and some solutions seen as viable will no longer function as designed, especially on longer time scales. Unfortunately, these "easier" options are often employed even if known to be more costly or less effective.

Lastly, there are various innovative funding opportunities that have been tested successfully elsewhere in the world for different landscapes and which could be applied in the glacier context. One example of this is the mobilization of funding for coral restoration in Barbados, which generated US$50billion from a debt-for-nature swap. Given the high degree of poverty in many areas affected by rapid glacier loss, examining mechanisms that both reduce debt and support glaciers should be considered.

Without urgent action, the impacts of glacier loss will be increasingly felt globally. With the appropriate allocation of resources, we have capacity to improve resilience, save lives and lessen the damages. However, this will only be possible with the appropriate resource mobilization. This will require new collaborations, comfort with discomfort and the courage to try new models going forward.

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