

to disappear. The anthropologist Karsten Paerregaard, interviewing Andean pilgrims worshipping summit divinities, frames both the humans and the glaciers as victims. The glaciers are “crying”, and this has consequences on communities:

*In their natural state, glaciers produce a constant flow of meltwater that supplies almost one-quarter of the world’s population with fresh water. But as they recede, the glaciers’ tears turn into flooding and natural disasters, reminding people that the socio-natural order to which they trust their lives is breaking up. Mountain pilgrims are among the first to observe this drama, and their encounter with the retreating glaciers’ bedrock exemplifies how humans become aware of climate change and its consequences for the world they live in and take for granted.*

While some organisms will thrive under new climatic conditions, for example, the yareta plant (*Azorella compacta*) that grows in the Andean highlands, most of the voices in this book are victims of tropical glacier loss to some extent. One interviewed is Benjamín Morales Arnao, a living example of resilience following a tragic event that left thousands of victims.

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## Scientists

by Carolina Adler  
and Ignacio Palomo

Over the millennia, Indigenous Peoples and local communities have developed and accumulated knowledge, providing us with fundamental lessons, observations and information to understand our surroundings. This knowledge also relates to changes in the climate and

the environment and has helped to shape the norms and cultural practices that today reflect how we live and relate within social communities.

Modern science took some time to become interested in tropical glaciers. Fortunately, scientific practice means that as new theories and empirical evidence come to the fore, science can correct itself, and what was believed to be false at a certain time – such as the existence of glaciers in the tropics – can later be proved to be true. Science-based knowledge has been a major driver of and contributor to human progress and our understanding of the planet. The scientific method, based on developing a testable hypothesis that can be proven or refuted, allows knowledge to build upon previously developed knowledge: as Isaac Newton put it in 1675 in a letter to Robert Hooke: “If I have seen further it is by standing on the shoulders of Giants.”

Glaciology, hydrology, climatology, ecology, anthropology and environmental science are some of the many scientific disciplines that have engaged with the study of tropical glaciers directly or indirectly. These individual disciplines have given us many insights. But understanding glacial retreat, its impacts on nature and people, and how to adapt to it, requires taking a systems-oriented, interdisciplinary approach. This is a challenging but important endeavour to pursue and support. Interdisciplinarity requires scientists from different fields to interrelate, to understand each other’s language and codes, and to be able to challenge previously held assumptions stemming from individual disciplines.

Science and policy, and their interactions, have become increasingly relevant as a way to not only inform but also engage with decision-making processes in the context of climate change. For example, the IPCC brings together and assesses the state of knowledge on the biophysical processes that lead to a changing climate,

their impacts on ecosystems and society, and ways to address these impacts. Since its creation, the IPCC has evolved from its purely biophysical science origins and currently has one working group on the physical science basis, one on impacts, adaptation and vulnerability, and one on mitigation. In its current (seventh) assessment cycle, the IPCC is placing particular emphasis on determining the scope and effectiveness of adaptation and mitigation in view of identified climate risks, including the conditions that enable decisive action. A key component of the evidence to be assessed includes Indigenous and local knowledge.

This long-standing science-policy interaction has led many scientists to realise that broad political interests are often not aligned with the scientific messaging that is based on planetary boundaries, and that global conservation objectives are often unmet. This misalignment has contributed to creating “ecological grief” and “eco-anxiety” among many – a feeling of uneasiness, frustration and alarm considering the threats to the environment and our future society and the limited concerted climate action that has been taken. This emotional response is a real issue, particularly among young people. One response is that scientists are increasingly trying to reduce the carbon footprint of their work, although we do not always succeed. Another equally important response is to challenge the dominant paradigm of scientific objectivity as devoid of values and recognise that science “requires emotions too” if we are to engage proactively and decisively to find solutions. Perseverance and a sense of purpose are key, fuelled by the convictions and emotions that motivate us to be part of the collective action that is desperately needed to at least preserve what we can for future generations.

What is the future of science on tropical glaciers once the ice is largely gone? As glaciers recede, scientists will

need to adapt and formulate research questions fit for the new conditions and environments that emerge. These may relate to very different and new aspects, from the redrawing of national borders, to the uses and governance of novel ecosystems and resources that provide livelihoods for local communities, to understanding people’s identity, sense-making and attachment to mountains without ice. This socio-ecological systems approach demands a broadening of scope and problem-orientation that goes beyond disciplinary and interdisciplinary research practices. In this respect, transdisciplinary research – i.e. research with and for society – plays and will continue to play a fundamental role in yielding the insights that make scientific and other ways of knowing both relatable and actionable.

The UN International Year of Glaciers’ Preservation is an invitation to the scientific community not just to highlight the importance of both monitoring glacier change and the mitigation efforts needed to preserve as much ice as possible, but to go beyond this and continue moving towards inter- and transdisciplinarity. It has been recognised that we know many things about glacier loss and its impacts, but now need to accelerate adaptation and mitigation actions. In many parts of the world, particularly in the tropics, we are not prepared for the types and magnitude of risks that lie ahead. Scientists also need to adapt and step up to these new challenges and engage in processes where new research questions and hypotheses can be co-designed with societal actors and together contribute to a just transition and build resilience to these changes.

The voices of scientists interviewed in this book provide a deep dive into the lived experiences of science and scientists in practice. They include glaciologist Donaldi Permana from Indonesia; hydro-glaciologist Álvaro Soruco from Bolivia; earth scientists Isabel Moreno from

# The Voices of Glaciers

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