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ADAPTATION AT ALTITUDE

Adaptation Solutions

Climate Resilience in the **Andes**

María Andreína Salas-Bourgoin

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Adaptation Solutions

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Acronyms

AICCA	Adaptation to the Impacts of Climate Change on Water Resources Project
A@A	Adaptation at Altitude Program
AVINA	AVINA Foundation
CAF	Development Bank of Latin America and the Caribbean
CC	Climate Change
CONDESAN	Consortium for the Sustainable Development of the Andean Ecoregion
CRD	Climate-Resilient Development
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
IFAD	International Fund for Agricultural Development
GEF	Global Environment Facility
IAvH	Alexander von Humboldt Institute, Colombia
IISD	International Institute for Sustainable Development
IPCC	Intergovernmental Panel on Climate Change
IUCN	International Union for Conservation of Nature
NbS	Nature-based Solutions
SDC	Swiss Agency for Development and Cooperation
SDG	Sustainable Development Goals
TNC	The Nature Conservancy
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization

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1.

Presentation

Adaptation to climate change (CC) is one of the great challenges of our time. Currently, adaptation to CC in general, and ecosystem- and community-based adaptation in particular, encompass a very broad set of land management strategies, many of which have a significant history under the general category of sustainable rural development. These range from ecosystem conservation and restoration tools to institutional strengthening and governance strategies. However, all these strategies share the common goal of reducing exposure or impacts of CC and strengthening the resilience and adaptive capacity of socio-ecological systems. For this, concrete measures can be taken, directed either to answer to conjunctural challenges generated by CC, or to promote deeper structural changes. The latter requires the development of long-term programs in learning sites and the integration of local adaptation processes into subnational, national, and international policies and strategies.

In the case of the Andes, there have been very significant advances in adaptation to CC over the past two decades, both from the perspective of national adaptation policies and the implementation of successful experiences in the territory. However, we still face significant challenges on several key fronts, including the analysis of the strategies that have been implemented so far, the dialogue of scales and knowledge for adaptation at multiple levels, or the monitoring and evaluation of adaptation processes, in order to assess their effectiveness and promote true adaptive management strategies (Llambí and Garcés, 2021; Dupuits et al. 2022, 2024).

In this publication, María Andreina Salas-Bourgoin, a recognized specialist in the field and professor at the Institute of Geography and Natural Resource Conservation at the University of the Andes (Mérida, Venezuela), takes us on a journey through a series of twelve adaptation experiences implemented throughout the Andes, in the seven countries that make up the longest and most diverse mountain range on the planet. Through this journey, we explore a wide diversity of socio-environmental contexts for the implementation of solutions, from the humid páramos of the northern Andes to the dry punas of the altiplano, to address the current climate crisis, which is particularly acute in the tropical high mountains. We will find on these pages initiatives where multiple stakeholders participate, testing different strategies that incorporate aspects such as the restoration and management of diversity, integrated water management, promotion of climate-resilient agricultural and livestock practices, capacity building and institutional strengthening, and risk management, among many others. Although the solutions presented here share in most cases features such as significant community participation, they also illustrate different realities in terms of the duration and depth of adaptation processes in the territory, their articulation with national programs and policies, or the effective use of monitoring and evaluation strategies to assess their environmental and social impacts.

First, in the introductory section, a general conceptual discussion on adaptation to CC and climate-resilient development is presented, exploring the theoretical bases from which the solutions were selected and analyzed. Thus, it is emphasized that adaptation to climate change is part of a progression (the progression of safety, Wisner et al., 2012) that ranges from purely adaptive processes to deeper transformational processes, which obviously pose much greater challenges to address the underlying structural causes of vulnerability, inequality, and injustice, in the access of Andean people to power and resources. At the same time, key concepts which underlie most of the solutions presented here, linked to adaptive management and nature-based solutions, are addressed.

In the next chapter, the spectacular setting in which our actors develop their projects is presented: the Andes, diverse in spatial and temporal scales, life spaces for cultures rich in traditions and exceptionally exposed and vulnerable to the acceleration of climate change in recent decades. It discusses what makes Andean socio-ecosystems especially vulnerable and what makes adaptation to CC different in this context, so diverse in biophysical, cultural, and historical use and transformation.

Next, in the core of the book, the conceptual, geographical and thematic representativeness criteria used for the selection of the twelve initiatives presented in this book are discussed, based on a set of 40 solutions (most of them available on the Adaptation at Altitude Solutions Portal). The solutions are presented through summary sheets that introduce their implementation context and the actors involved, what makes them particularly interesting, their benefits, open challenges, and potential for replication. Finally, an interesting comparative synthesis of the 40 solutions analyzed is presented, offering a window into the path taken by adaptation to CC in the Andes in recent years in terms of their geographical distribution and working ecosystems, the thematic approaches developed, the type of actors involved, their requirements in terms of human and financial resources, and their implementation timeframes, in order to explore their contributions in the advance towards more climate-resilient development in the region. This comparative analysis also allowed the author to outline some of the strengths and weaknesses of the adaptation processes carried out, and to present a series of recommendations for program implementers and decision-makers.

This publication is part of the work we have been developing under the Adaptation at Altitude (A@A) program in the Andes to promote processes of knowledge generation and synthesis, science-policy dialogue, and exchange of experiences around climate change adaptation in the region (https://adaptacion-alturas.condesan.org/). The 40 solutions analyzed were systematized for dissemination on the A@A Solutions Portal linked to weADAPT (which comprises more than 100 solutions from all the major mountain regions of the world), under the A@A project, by Raúl Córdoba (Northern Andes), Wetlands Foundation (Central Andes), Emilie Dupuits, Julia Aguilera, and the AICCA project team, to whom we are deeply grateful. At the same time, these solutions are the result of the efforts of a broad group of institutions and people who have been working with dedication and commitment throughout the Andes. We hope to contribute, through this publication, to disseminating their efforts and achievements and promoting a greater appropriation, replication, and sustainability of these processes, which are fundamental to advancing towards greater resilience of the Andean ecosystems and societies, in the face of the new and not-so-new challenges that climate change entails.

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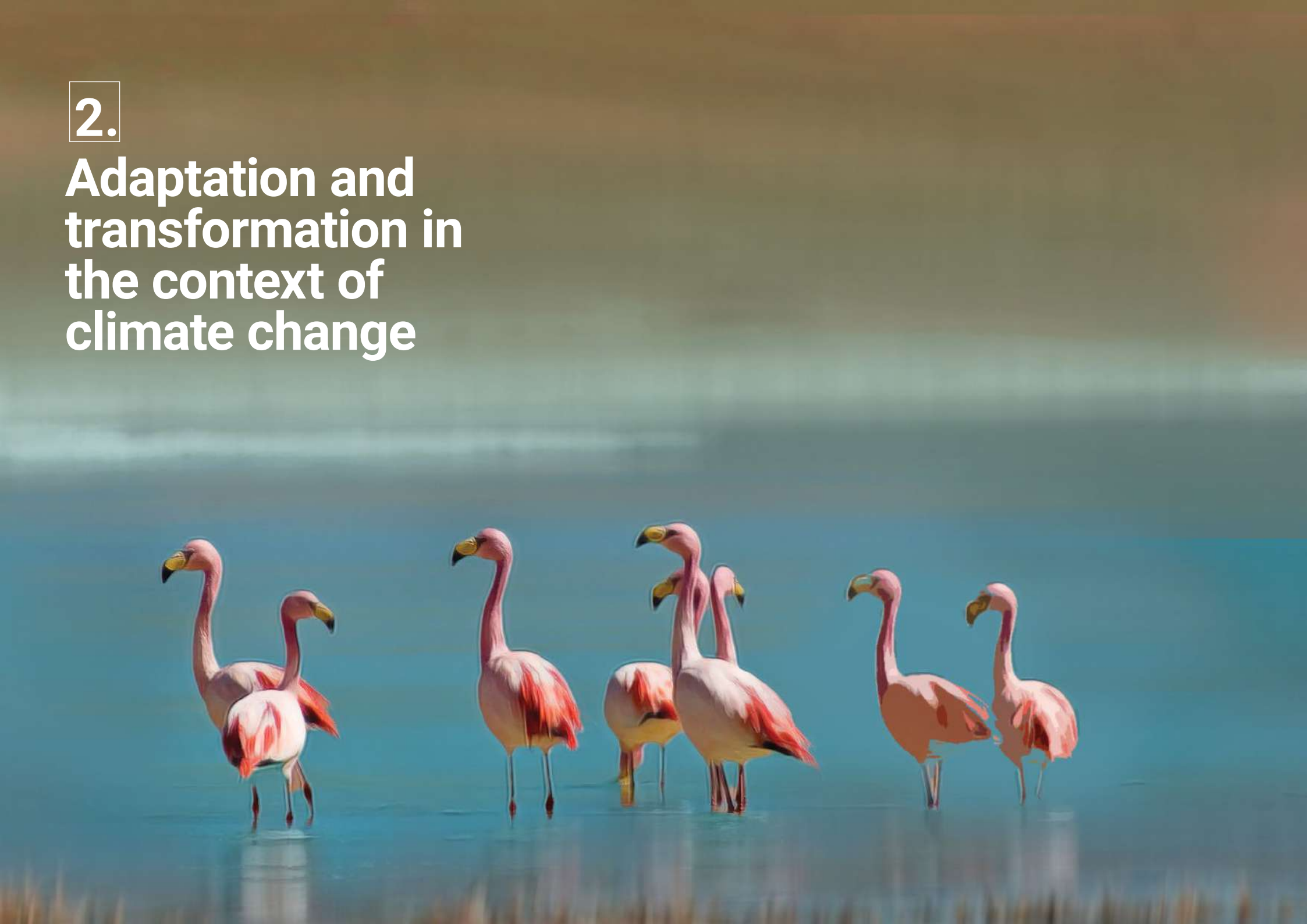
Dr. Luis Daniel Llambí.
Andes Coordinator
Adaptation at Altitude
CONDESAN

2.
Adaptation and transformation in the context of climate change



The magnitude of climate change impacts is such that terms like risk, vulnerability, and climate resilience are the focus of attention even in small, isolated rural communities

Huaraz, Perú
Marylin Vergel

Since approximately the 1970s, we have been hearing warnings about greenhouse gases (GHGs) and global warming. However, it was towards the end of the 20th century that the term "Climate Change" burst into our lives, referring to changes in Earth's temperatures and weather patterns with multiple repercussions. CC affects nature, people, and infrastructure worldwide, making it increasingly difficult to meet basic human needs (Ara, 2022). As warned by the Intergovernmental Panel on Climate Change (IPCC):

"...our world is warming and dangerous climate change and extreme events... are causing severe and widespread disruption in nature and in society; reducing our ability to grow nutritious food or provide enough clean drinking water, thus affecting people's health and well-being and damaging livelihoods." (IPCC, 2023, p. 1).

Today, the magnitude of climate change impacts is such that terms like risk, vulnerability, and climate resilience are the focus of attention even in small, isolated rural communities. Thus, we speak of **Climate-Resilient Development (CRD)** as a development alternative where climate action and sustainable development are interdependent processes (Schipper et al., 2022).

There are several paths for advancing in CRD; however, they all seem to converge into two major sets of actions: mitigation and adaptation. Mitigation, as a set of actions aimed at reducing our GHG emissions and enhancing their sinks, and adaptation as a process where we adjust to the actual or expected climate to moderate its damages (IPCC, 2022). According to this development approach, while we adapt to the effects of CC, we simultaneously adjust the anthropogenic activities that have driven it towards GHG generation.

Both adaptation and mitigation of CC are multidimensional processes that combine, among others, climate risk management, environmental governance, conservation, ecosystem restoration, land use planning, energy transition, and more sustainable livelihoods, aiming to reduce their strength and increase our resilience to their impacts.

In the case of adaptation, we need to make structural adjustments or changes in various areas or, better yet, in all areas in an integrated manner. However, the approach we adopt will make a difference in what we should do and how we should do it. Hence, it is useful to review some of the available approaches and alternatives, including progressive adaptation, transformational adaptation, progression of safety, nature-based solutions, and adaptive management.

Over time, scientific evidence on climate change accumulated overwhelmingly, and the issue became a global concern and a political agenda item, both nationally and internationally. Urgent action was needed, and in order to act, informed decisions on climate policies were required—in other words, policies to mitigate CC and adapt to its negative effects.

This motivated the United Nations to establish the Intergovernmental Panel on Climate Change (IPCC) in 1988, as an international body aimed at providing governments worldwide with a solid scientific basis for deciding and designing mitigation and adaptation measures.

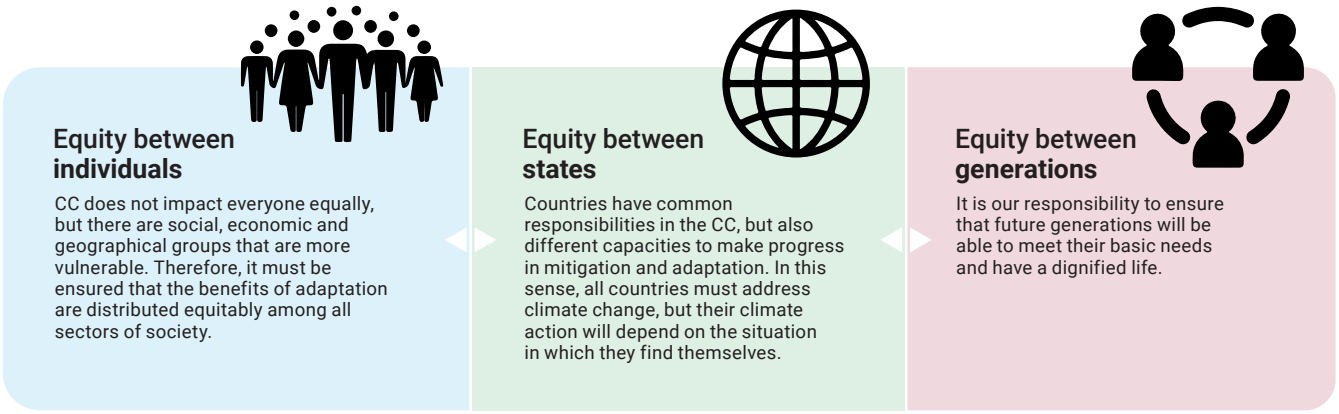


Figure 1: ***Principles of distributive justice particularly relevant in CC adaptation***

Source: elaborated based on the discussion by Ara Begum et al. (2022).

Progressive vs. Transformational Adaptation

According to the IPCC, the success of adaptation varies depending on the level of benefit it generates for human systems, ecosystems and their services, and vulnerable groups (based on race, gender, age, income, among others, New et al., 2022). It is better when we plan it considering requirements, available resources, local knowledge, and possible options in an integrated manner; when we seek it jointly across various sectors and scales, and when we aim to achieve two essential conditions: justice and transformation (Ara Begum et al., 2022).

Adaptation is considered fair when it is equitable from three perspectives: among individuals, among states, and among generations (Figure 1). It is considered transformational when, in anticipation of CC and its impacts, it generates profound structural changes in the fundamental attributes of socio-ecosystems, resulting in different ones (Aldunce, 2019). This contrasts with progressive or incremental adaptation, which implies partial and less extensive changes that preserve the intrinsic characteristics of social and ecological systems, as well as the economic and political structural conditions that define them.

When progressive adaptation is insufficient to avoid intolerable risks, in other words those that threaten basic social objectives associated with health, well-being, security, or sustainability, transformational adaptation becomes an option, perhaps harder to achieve but with greater potential to expand the possibilities of sustaining socio-ecosystems. Although both types of adaptation do not compete with each other, in the realm of sustainable development, transformation is favored because the Sustainable Development Goals (SDGs) require changes that are not possible unless we significantly reduce climate risk and transition towards greater social justice and poverty reduction (Ara Begum et al., 2022).

> **The international community is increasingly insistent in pointing out that, to achieve sustainable development, "...will require transformative change in socio-ecological systems at scales ranging from the community to the globe." (Ara Begum et al. 2022, p. 135).**

In the context of CRD, transformation represents an essential component because it jointly pursues mitigation, adaptation, and sustainable development, leveraging synergies and reducing the need for trade-offs between actions. Additionally, through a process called "system transition," it contemplates the social, institutional, and technological transformation of social systems, including their goals and values (Ara Begum et al., 2022).

Given the factors involved in CC, the transformation we refer to includes transitions in areas such as energy, agriculture, land use, urban development, infrastructure, transportation, industry, and society (Ara Begum et al., 2022), and we can drive it through three pathways (Schipper et al. 2021):

1. The implementation of multidimensional sustainability and emission reduction policies, involving all sectors.
2. Citizen participation, motivating people to create and implement transition initiatives.
3. Sustainability-oriented innovation, expanding the range of opportunities to overcome obstacles to change.

Progression of Safety

This adaptation approach represents a route to counteract vulnerability to disaster risks, and by extension to climate risk, by modifying the internal and external factors that produce it. Vulnerability is considered a result of susceptibility to damage, and stems from processes that create and maintain this susceptibility over time. To overcome it, these processes must be reversed and deconstructed. (Wisner et al., 2012).

The natural environment provides a variety of opportunities but also of dangers. But all humans do not have the same capacity to face this dual condition or take advantage of it, due to the differential access to the resources needed for achieving a quality life and diverse, sustainable, and resilient livelihoods. Hence, some people are more vulnerable than others (Wisner et al., 2012).

Such capacity depends on the resources and assets we possess, can access, or can use to resist, cope with, and recover from the disasters we experience, as well as on the scope, resilience, and stability of our own livelihoods (Wisner et al., 2012: 24). Therefore, although we all have the capacity to use resources and assets (natural, human, social, economic, physical, and political) to cope with and recover from a disaster, not all of us have the same possibility of accessing them or counteracting the structural limitations that prevent us from overcoming our own susceptibility.

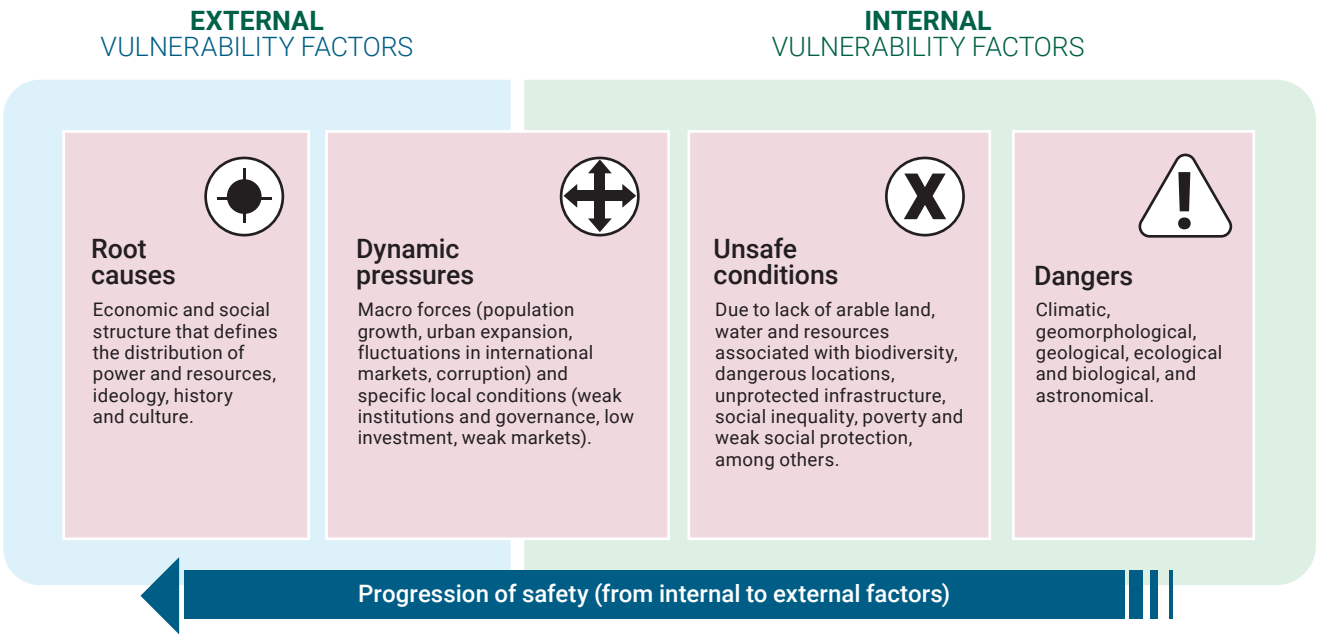


Figure 2: ***Internal and external factors of vulnerability, according to the "Progression of Safety" approach***

Source: elaborated based on Wisner et al. (2012).

Based on this reasoning, "Progression of Safety" proposes to successively neutralize the internal and external factors of vulnerability to reduce disaster risk (Figure 2) through measures or solutions that: prevent and control hazards; contribute to ensure safe places and sustainable livelihoods; reduce the dynamic pressures that maintain our susceptibility to damage, and address the root causes that create and sustain it over time.

Disaggregating vulnerability into these factors will allow us to understand their characteristics in a broad context; to propose solutions to reduce it considering the integrated social, political, economic, and environmental relationships, as well as the sources of insecurity; to better fight against risk and its impacts, and to strengthen our resilience (Bustamante and Garcés, 2021).

To the extent that our ability to leverage resources and opportunities to adapt and counteract the dangers of CC is greater, we will be less susceptible to its effects. At the same time, we must pay attention to the conditions of the immediate and mediate environment that influence our susceptibility to CC, to design and develop mechanisms that allow us to progressively counteract them.

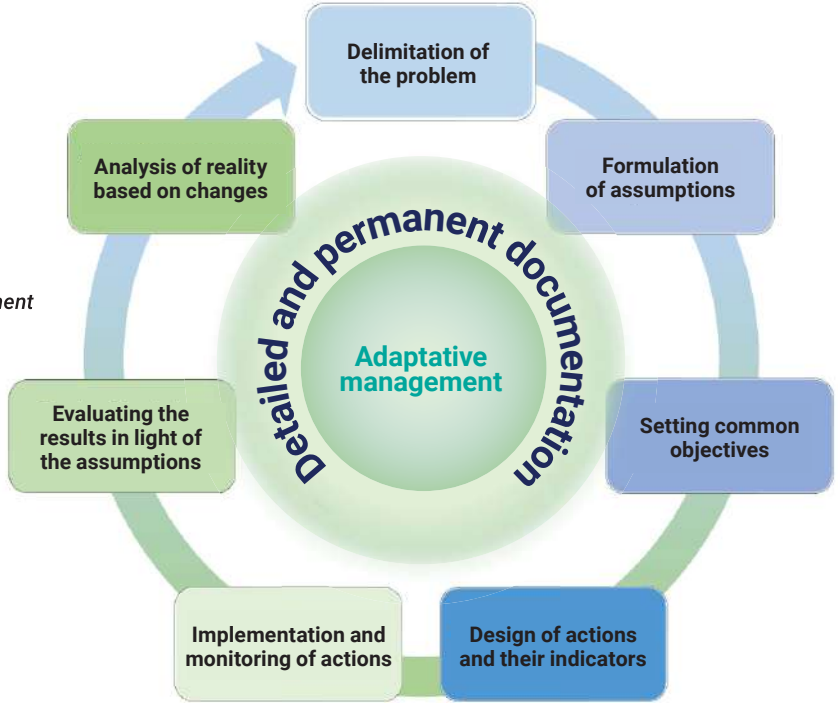


Figure 3: ***General process of adaptive management***

Adaptive Management

If we talk about key terms, perhaps *uncertainty and capitalization of learning* are the ones that best characterize the essence of this adaptation pathway. The starting point is the premise that natural resource management develops without certainty about the causes of the complex problems it faces, and about the effects of the actions it undertakes. It assumes also that the processes of implementation, monitoring, and continuous evaluation of specific actions generate learning in a deliberate and incremental manner (Stankey et al., 2005; Bustamante et al., 2013).

Although not new, adaptive management has recently been applied in various sectors and countries as a useful strategy in situations with high levels of uncertainty. It is assumed that natural resource management "...is always experimental, that we can learn from the activities implemented, and that natural resource management can improve based on what is learned." (Borrini-Feyerabend et al., 2001, p. 5).

Its design follows a process that may vary among specialists, but has in common essential steps such as: problem delimitation, formulation of assumptions about the most influential factors in the problem and the response of adaptation, design of objectives and actions, continuous monitoring of actions and evaluation of their results based on assumptions and objectives, reflection on the reasons why actions worked or not, and restarting the process based on what was learned and the new problem situation (Figure 3). Some specialists add the adjustment of the political and legal framework, as a strategy to support actions in the public and private spheres (Llambí & Garcés, 2021).

This shows that, as the IPCC states, adaptive management is "A process of iteratively planning, implementing and modifying strategies for managing resources in the face of uncertainty and change. Adaptive management involves adjusting approaches in response to observations of their effect on, and changes in, the system brought on by resulting feedback effects and other variables." (2022, p. 2899).

Regarding CC adaptation, specialists offer three approaches to this method (Llambí and Garcés 2021; Evans et al. 2015):

1) Top-down, which uses large-scale scenarios on CC and vulnerability for planning.

2) Bottom-up, employing vulnerability and adaptive capacity analysis at the local scale, which generally involves the participation of various actors.

3) Co-adaptive management or collaborative adaptive management, which integrates researchers, community, and decision-makers so that everyone participates, contributes their knowledge, and learns to solve problems collaboratively.

In adaptation processes carried out in the Andes, its implementation has allowed to (Bustamante et al. 2013):

- Achieve collaboration and equity in power relations when designing common objectives.
- Detect sources of uncertainty.
- Define goals consistent with the objectives and available knowledge.
- Simulate the effect of management options by incorporating uncertainty when making decisions.
- Strengthen the political-institutional framework that supports management measures.
- Implement, monitor, and evaluate measures based on the stated objectives.

Regardless, Bustamante et al. (2013) also note that the complexity of the adaptive management approach, its high costs, and its long-term nature have limited its practice in the Andes to partial implementation of the cycle, without the monitoring and evaluation it requires.

Reforestation in Tiquipaya, Bolivia
AICCA

Nature-Based Solutions

Known by their acronym NbS, this type of measure is an adaptation approach that combines environmental conservation and the generation of tangible and sustainable social benefits through actions that protect, restore, and manage the environment while addressing current social challenges in a sustainable and adaptive manner, and generates benefits for our well-being and that of nature (IUCN, 2016). NbS are considered a general framework; "...an umbrella concept that encompasses several approaches related to ecosystem management in the context of CC..." (Llambí and Garcés, 2020, p. 18). They include, among others, ecosystem-based adaptation (EbA), ecosystem-based disaster risk reduction (Eco-DRR), regenerative landscape management, and ecosystem-based mitigation, and exclude solutions of the type "derived from nature" such as wind or solar energy, and "inspired by nature" such as the design of materials based on biological processes (IUCN, 2020a; 2021).

Given that NbS have spread worldwide, becoming part of national climate action strategies, the IUCN has designed a Global Standard (IUCN 2020b) to establish a governance system that ensures their careful and robust management globally. This is useful because it allows us to verify, through eight principles and criteria, that our solutions are indeed NbS.

In mountain ecosystems, this adaptation approach finds a 'niche' of options, especially for EbA, thanks to its ability to provide a wide diversity of services. This represents a broad spectrum of opportunities to increase the climate resilience of their socio-ecosystems; however, for this, EbA must (IUCN, 2022a):

- Reduce social and environmental vulnerabilities.
- Generate social benefits in the context of CC adaptation.
- Restore, maintain, or improve ecosystem health.
- Have policy support at multiple levels.
- Support equitable governance and expand capacities.

Reportar su implementación es tan esencial como divulgar sus resultados, pues solamente a partir de ello podremos acumular evidencias sobre los efectos deseados y no deseados de las acciones, así como aprender y mejorar. En este sentido, si bien es importante conocer, p. ej., que las SbN implementadas en diferentes zonas de montañas del mundo están "tan basadas" en la naturaleza como en la gente que las habita, también lo es conocer su verdadero potencial transformador; una cuestión que parece aún poco explorada (Palomo et. al., 2021).

Al margen de lo anterior, gracias a sus cualidades, las SbN son una puerta para una adaptación 'sin arrepentimientos' porque generalmente no empeoran la vulnerabilidad al CC, aumentan la capacidad adaptativa y generan efectos positivos en los medios de vida y los ecosistemas, independientemente de cómo cambie el clima (Zapata et al., 2016).

Thanks to the IUCN's dissemination of the results of its "Mountain EbA Program" (IUCN 2022b), we know that:

- **Long-term EbA allows for precise and sustainable impacts and co-benefits, justifying the development of long-term projects.**
- **Adaptive management is fundamental for EbA projects because there are external variables that cannot be predicted or controlled.**
- **Working jointly with communities, local government, and national government allows building strong multilevel relationships, strengthening the integration of EbA actions at these levels.**
- **Sharing the knowledge generated during the implementation of EbA actions and disseminating the lessons learned drives the development of such projects in other places.**
- **When evaluating EbA actions, it is also necessary to evaluate the links with biodiversity conservation and CC.**

3. The Andes: A diverse and threatened region

To speak of the Andes is to speak about diversity, expressed in social, cultural, economic, and natural terms across 8,500 km, seven countries, an altitudinal range between 300 and 6,962 meters above sea level (masl), and a great variety of natural and anthropogenic biomes. The Andes are therefore divided into three subregions: Northern or Septentrional Andes (from Venezuela to northern Peru); Central Andes (from Peru to the northern border of Chile and Argentina); and Southern or Meridional Andes (from the northern border of Chile and Argentina to Isla de los Estados, in Argentina) (Figure 4).

Figure 4. The Andes and their subregions. Adapted from Josse et al. (2009)

Nature and diversity in the Andes

The extensive literature on the Andes often begins with expressions highlighting their exceptional biophysical conditions. But why are they so extraordinary? Because their topography can influence wind circulation as well as the hydrological regimes of South America, and the variability of temperature, precipitation, and winds in its mountains has given rise to a diversity of climatic regimes, associated with unique ecosystems that act as environmental controls, limiting the movement of species and causing the biota, which is diverse and often endemic, to be restricted to specific regions (Anderson et al., 2012; Young, 2012).

A large part of South America's river systems originates in the Andes. In fact, the mountain range acts as a watershed for the basins that drain into the Pacific and Atlantic, and is considered a major reservoir and provider of water (Mountain Partnership, 2014). Additionally, in southern Peru, southeastern Bolivia, northern Chile, and northwestern Argentina, and above 3,000 masl, there is a large mountainous plain or Altiplano, which along with Tibet is one of the most extensive and elevated plateaus in the world (Mourguiart et al., 1997; Hegoburu et al., 2021).

Andean glaciers play a crucial role in water regulation, as the water stored as snow melts in summer and supplies streams and rivers, sometimes during periods of low rainfall (Mountain Partnership, 2014). Thus, the water security of cities like Lima, Santiago, and La Paz depends, in part, on the water provided by these glaciers (Aedo & Montecinos, 2011).

From an ecosystem perspective, in the Northern and Central Andes, 133 ecosystem categories have been identified (113 Andean and 20 transitional with lowlands), forming larger groups with well-differentiated characteristics: Páramo, Humid Puna, Xerophytic Puna, Cloud Forest or Yunga, Dry Andean Forest, Inter-Andean Valleys, and Aquatic Habitats (Josse et al., 2009). Meanwhile, in the Southern Andes, other ecosystems are found: Shrub Steppes (Open, Shrub-Herbaceous, and Herbaceous), Grasslands, and Forests (Hydrophilic, Mesophilic, and Xerophilic) such as the Valdivian Forest and the Magellanic Forest, and tundra (Coronato et al., 2017).

Each group is in itself a 'world' of biophysical particularities. The páramo, for example, stretching from the Cordillera de Mérida in Venezuela to northern Peru, and over an extension of more than 2,000 km, exhibits an enormous diversity of abiotic and biotic conditions at various spatial scales. At a continental scale, these are associated with geological, edaphic, climatic, and biogeographic changes; at a regional or landscape scale, with variations in altitudinal gradients, topography, and distance to populated centers; and at a local scale, with exposure, slope, drainage, soil fertility, and dominant vegetation (Llambí & Cuesta, 2014).

The flora and fauna in all these ecosystems are highly diverse. In the Tropical Andes, a biogeographical region that comprises the North and Central subregion, and the north of Chile and Argentina, more than 45,000 species of vascular plants (44% approx. endemic) and 3,400 species of vertebrates (46% approx. endemic) have been reported (Myers et al., 2000). On the other hand, in the North subregion near 11% of the palm species of the world can be found, and 15% of the world's avifauna (World Wildlife Found, 2001). In the Central subregion, specifically in Chile, 49% of endemic species of vascular plants, nearly 14 endemic species of terrestrial mammals, and 9 endemic species of birds, have been recorded (Bonacic & Ibarra, 2010).

Associated with this biophysical richness are core functions such as provisioning, regulating, cultural, and supporting ecosystem services, highlighting an undeniable fact: our survival depends, directly or indirectly, on the Andes.

In general, these services provide us with water, food, and various raw materials; regulate the climate, control floods, purify water, and capture carbon; allow us to develop productive and extractive activities of various kinds; and provide us with places of great spiritual value, as well as for recreation and leisure (Anderson et al., 2012). In the Andes, specifically the glaciers, páramos, punas, and montane forests perform exceptional functions of regulating, providing, and maintaining water quality for various uses, while the páramos along with peatlands or bofedales constitute major global carbon reservoirs (Cuesta et al., 2009 and 2012; Llambí & Cuesta, 2014).

Cuyuja and Papallacta paramos, Napo province, Ecuador
AICCA

"The Tropical Andes are the biogeographical region of greatest biological diversity on Earth, while representing only 1% of its surface..." (Llambí & Cuesta, 2014).

People and economic activities

By 2022, nearly 68 million people inhabited the Andes, and of these, 83% resided in urban areas and large cities[1] that have expanded rapidly in the last 70 years, not without problems of planning, quality of life, environmental sustainability, and poverty (Andean Mountain Initiative, 2022a). At the same time, approximately 52% of its population is located in mountain zones, and of this, about 74% live above 1,000 masl (Mountain Partnership, 2014).

In this vast territory, six anthropogenic biomes converge: dense human settlements, rural human settlements, agricultural areas, grazing areas, semi-natural areas, and natural areas. Among these, grazing areas are dominant and are combined, in the Northern Andes, with high-density human settlements, and in the south, with medium-density human settlements and rural settlements. Agricultural areas are relatively smaller in extent, with maximum coverage in Ecuador (10%), and although natural areas are extensive, only in Argentina and Chile do they exceed the coverage of their respective grazing areas (Andean Mountain Initiative, 2022a).

In 2014, the indigenous population of the Andes was approximately 18 million people, heirs to a history of thousands of years of coexistence in a natural environment that, from 3,000 masl, hardens and shapes living conditions in terms of food, religion and rituals, resource use, community organization schemes, solidarity and dependency relationships, adaptability, and resilience (Mountain Partnership, 2014). Hence, their traditions are expressed in the land, in the territory, and in social roots (García, 2013), forming a unique identity, with knowledge and traditions that should be valued, respected, and considered in any action for development and environmental protection/recovery.

Their spatial distribution allows for the identification of geocultural zones in which 130 different languages converge, in some cases shared by two or more countries (Mountain Partnership, 2014). Thus, the Andes are also a melting pot of cultures, languages, and traditions.

[1] Medellín, Bogotá, Quito, Lima, Arequipa, La Paz, Mendoza and Santiago.

In rural Andean areas, and even more so in mountainous areas, poverty has always made indigenous communities "...the most vulnerable and marginalized within nation-states." (Mountain Partnership, 2014, p. 63), and in contrast to a diverse environment rich in natural resources strategic for development, their inhabitants experience great inequalities and limitations to overcome them.

But among the population affected by poverty, women suffer the most, particularly indigenous women from mountainous areas. Apart from the fact that their access to land ownership is limited by legal and cultural factors, women have the lowest schooling rates, the highest illiteracy rates, the greatest wage discrimination for equal work, and the heaviest workload due to family care (Mountain Partnership, 2014). To this is added that their burden of responsibilities limits their access to information and training spaces to face current challenges, and that for cultural reasons, their work and opinions have traditionally been less valued (Hildahl et al., 2017). Hence, the significant gender gap experienced in the region (Saber Andino, 2021).

Despite this, the role of Andean women has evolved significantly in recent years. At home, they ensure food security and maintain the family structure. In the community, they preserve cultural traditions and lead productive, conservation, and social development projects, standing out for their attachment to traditions, ancestral knowledge, and values such as honesty, justice, and responsibility. Finally, at the national level, they hold high-level political positions in countries like Peru, Bolivia, and Ecuador (Mountain Partnership, 2014).

Regarding the productive activities of the region, specifically in mountain areas, these range from subsistence to mining of various metals. In the lower areas, towards the foothills, large hydroelectric developments and expanding irrigated agriculture are found (Mountain Partnership, 2014).

In the Tropical Andes, productive systems are divided into four categories that refer to general, non-static patterns: exclusive pastoral, agro-pastoral, agricultural, and livestock. Land tenure is a mix of communal and private property, and social, environmental, economic, and political changes have increased the exclusion and poverty of Andean peasants, due to a tendency to retreat from more traditional systems to lands with low agricultural potential (Cuesta et al., 2012).

Mining, on the other hand, is a long-standing activity in the Andean region of countries like Peru, Bolivia, Ecuador, Colombia, and Chile. It has been a source of controversy due to its negative impact on ecosystem services and biodiversity, and its failure to favor the socioeconomic well-being or quality of life of the most vulnerable communities in its surroundings (Andean Mountain Initiative, 2022b). Mining is therefore considered to trigger a series of social impacts that includes transformations in community life, economic relations, and territory, with negative implications for future generations (Yeckting & Ramírez, 2012).

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Las Alfombras paramo, Boyacá, Colombia
AICCA

Threats to Andean diversity

While more than 68 million people get some type of direct benefit from the Andes, their natural spaces are heavily under pressure from human activities. Although there are 1,356 protected areas safeguarding representative areas of their diversity across more than 31 million hectares, this diversity is in danger (Cuesta et al., 2012; Andean Mountain Initiative, 2022b).

Mining, unsustainable agricultural production, overgrazing, urban expansion, hunting, the introduction of exotic species, and forest fires are some of the anthropogenic threats (Andean Mountain Initiative, 2022b). Mining, for example, besides significantly affecting glaciers, impacts important mountain ecosystems, including salt flats and high-altitude wetlands (Aedo & Montecinos, 2011).

The negative impact of mining on glaciers is mainly observed in Chile, Peru, and Argentina. Rapid melting is not only related to climate change, but is also a consequence of ice removal and the accumulation of waste materials on it, and indirectly, of the accumulation of dust on the ice due to road construction, drilling, and the use of explosives (Aedo & Montecinos, 2011).

The pressure on Andean ecosystems and their services has been so great that the region is home to three Biodiversity Hotspots: Tumbes-Chocó-Magdalena, Tropical Andes, and Chilean Winter Rainfall-Valdivian Forests. As Hole et al. (2012, p. 24) state: "It is unlikely that the historical rate of change in the vegetation cover of tropical landscapes has been as rapid as in the last 50 years. Deforestation and land conversion have led in recent decades to an unprecedented loss of natural habitats. Ongoing and projected climate change adds a substantial new component to this mix."

Forest fire brigades. Azuay, Ecuador (2021)
AICCA

Andean cock-of-the-rock

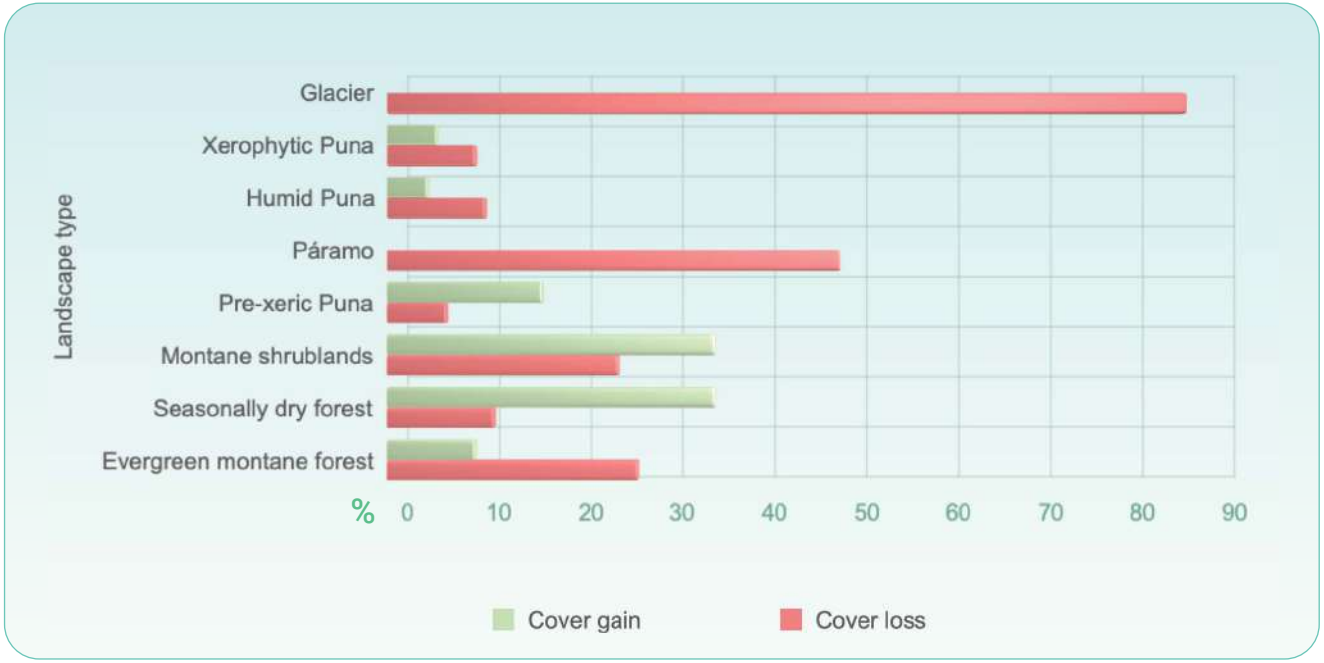
Biodiversity Hotspots are biogeographic regions with an exceptional concentration of endemic species (>1,500 endemic species) that have also lost more than 70% of their native vegetation due to human intervention (Myers et al., 2000). They constitute, in this sense, islands of life in an environment of destruction.

4.

Climate Change in The Andes: vulnerability and adaptation

The Andes are among the regions most exposed and sensitive to CC in the world, which, combined with the accelerated change in land cover, represents an unprecedented pressure factor on its biodiversity, people, and economy (Cuesta, 2017).

Figure 5. ***Expected changes in the coverage of eight landscape units in the Tropical Andes***



Source: Based on Tovar et al. (2013).

Vulnerability of Andean socio-ecosystems

Evidence indicates that, in general, CC is causing changes in species distribution, glacier loss, and changes in both the timing and magnitude of precipitation, as well as in extreme temperatures in the region (Castellanos et al., 2022).

In the Tropical Andes, changes in temperatures have been observed for decades. Available estimates indicate that in the last 70 years, average temperatures have increased by 0.25–0.70 °C per decade (Buytaert & Ramírez-Villegas, 2013; Cuesta et al., 2019). Greater variability in precipitation patterns has also been detected, with increases in some areas and decreases in others. Thus, in the altiplano, aridity has increased and is likely to worsen by the second half of the 21st century, with a decrease in precipitation of up to 10% (Herzog et al., 2010), while in the yungas and pre-puna zones, an increase in average annual precipitation and violent storm events is expected, with a higher risk of floods and erosive processes (Hegoburu et al., 2021). Additionally, the following are expected (Anderson et al., 2012):

1. Changes in cloud condensation as well as in the sun/shade relationship.
2. Increase in extreme events (drought, heavy rains, and heat waves).
3. Increased evaporation in lakes and wetlands.
4. Initial increase in river flows fed by glaciers due to their melting, followed by a reduction as they disappear.
5. Increased erosion and landslides in slope areas due to changes in precipitation regimes.

However, not all ecosystems in the region are equally vulnerable to these changes (Young et al., 2012). In fog-dominated ecosystems such as cloud forests, an increase in vertical precipitation relative to horizontal precipitation could negatively affect their ability to infiltrate and retain water. In aquatic ecosystems, on the other hand, rising temperatures could decrease dissolved oxygen in the water and increase eutrophication, affecting water quality, while in wetlands and páramos, drought and rising temperatures could turn them into carbon emitters (Anderson et al., 2012).

Simulation models suggest that by 2040, CC will impact eight landscape units in the Tropical Andes, as some ecosystems will lose coverage while others will gain it (Figure 5). Due to projected changes in rainfall and drought regimes, seasonally dry forests, montane shrublands, and pre-xeric puna will increase in area, while páramos will lose nearly half of their area before 2070, and glaciers will shrink by more than 80%. During this process, the species composition of these ecosystems will also change, as will their environmental services (Tovar et al., 2013; Cuesta et al., 2023).

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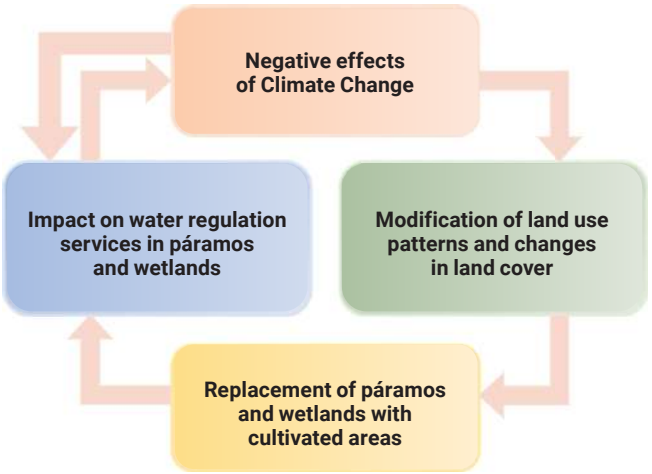
Among the ecosystem services of the Andes potentially affected by CC are (Anderson et al., 2012):

- Provisioning services such as water-related services (water supply, flow regulation, energy generation, and waste assimilation) and those related to agricultural production (increased susceptibility of crops to herbivorous insects and parasites, reduced pollination, reduced agricultural biodiversity, and -food security).
- Regulating services such as carbon storage (climate regulation) and downstream security (decreased stability and safety on slopes).
- Supporting services such as soil fertility.
- Cultural services, such as recreation and cultural-spiritual values.

It is also expected that the negative impacts of CC will intensify due to increased human pressure on ecosystems through a negative feedback cycle. For example, a transformation in land use and land cover patterns due to CC will add pressure to páramos and wetlands already affected by temperature and precipitation variations (De Bièvre et al., 2013), (Figure 6). In this context, rural Andean populations will face greater vulnerability due to poverty and diminished adaptive capacities, as a result of modernization processes "...that have disrupted their social organization, limited their access to multiple production zones, and reduced both the availability of labor and their access to productive resources." (Postigo et al., 2013, p. 142).



Landslides. Cuyuja and Papallacta paramos, Napo province, Ecuador.
AICCA

Figure 6: ***Example of negative feedback between CC and anthropogenic pressure on páramos and wetlands***

Source: Based on the discussion by De Bièvre et al. (2013)

Adaptive responses

Adaptation to CC in the Andean mountains is unique compared to other terrestrial landscapes because (Llambí & Garcés, 2021):

- Topographic conditions and marked variations in climatic regimes lead to high uncertainty in climate scenarios, especially related to precipitation.
- Temperature rise due to CC increases with altitude.
- Glacier and permafrost melting processes activate significant risks, and on the other hand affect water regulation services and wetland dynamics.
- Soils are highly vulnerable to erosion and loss of organic matter.
- The connective role of mountains requires the implementation of multiscale research and management approaches.
- They host biodiversity hotspots highly vulnerable to CC and the vertical displacement of thermal floors.
- They are home to a great diversity of cultural, agricultural, and crop genetic resources.
- Rural populations depend on activities such as agriculture and grazing, which will be directly affected by CC.
- Issues such as deforestation, degradation of high-altitude wetlands and pastures, mining, and infrastructure development are additional pressure factors on biodiversity that compound CC.
- Large cities and electricity generation systems depend on the mountain's water provisioning services.
- Their communities show particularly high levels of poverty and, although they have developed various adaptation strategies and social organization throughout their history, they are especially vulnerable.

These represent a wide range of challenges, but also a fertile ground for designing and implementing diverse adaptation measures at multiple scales, with significant benefits for socio-ecosystems. Hence, a variety of adaptive responses have been implemented in the Andes, thanks to international cooperation and joint work with national and local government entities, which has allowed for (Dupuits, 2021):

1. The integration of Ecosystem-based Adaptation (EbA) strategies into various planning and management instruments aimed at reducing the vulnerability of local communities to CC.
2. The preservation of carbon reservoirs in soils and high Andean ecosystems through sustainable management policies and practices.
3. The preservation of the water regulation capacity and biodiversity of páramos.
4. The transfer of information for adaptation to variability and CC.
5. The increase in resilience and adaptive capacity of mountain communities and ecosystems to CC.
6. The integration of climate considerations into decision-making processes.

At the local level, responses have been based on the ancestral knowledge and practices of indigenous and peasant communities. These include agricultural diversification through the use of different thermal floors; diversification of seeds, crops, and livestock management; and changes in the agricultural calendar. Additionally, significant efforts have been made in meteorological monitoring, observation, and quantification of glacial retreat, and climate forecasting within the framework of the El Niño-Southern Oscillation phenomenon (De Bièvre et al., 2013).

Conservation strategies *in situ*, monitoring of ecotones, and the creation of protected areas including complete altitudinal gradients have also been implemented, as in the case of the Río Abiseo, Yanachaga-Chemillen, and Manu National Parks in Peru; the Madidi, Carrasco, and Amboró National Parks in Bolivia; and the Cofanes-Chingual Reserve in Ecuador (Hole et al., 2012). Similarly, efforts have been made to control the negative effects of land use and land cover change through the promotion and implementation of traditional good land management practices: crop rotation, wetland fencing, and watershed protection declarations (De Bièvre et al., 2013). Thus, the experience in CC adaptation in the Andes is vast, as evidenced by the solutions highlighted in this catalog.

Drinking water system. Cuyuja ecosystem. Ecuador.
AICCA

Between 2015 and 2021 alone, at least nine international cooperation initiatives for CC adaptation converged in the region:

1) Between 2015 and 2021 alone, at least nine international cooperation initiatives for CC adaptation converged in the region: 1) Regional Program "Ecosystem-based Adaptation," IUCN.

2) EcoAndes-CONDESAN Project.

3) Páramos, Biodiversity, and Water Resources in the Northern Andes Project, EU, IAvH, IUCN.

4) Adaptation to the Impacts of Climate Change on Water Resources (AICCA) Project, CONDESAN.

5) A@A, SDC.

6) Andean Forests Program (PBA), CONDESAN-SDC

7) Regional Initiative Andes Resilient to Climate Change (ARIACC), SDC, AVINA, IISD, IFAD.

8) Strengthening Links between Science and Governments for Climate Policy Development in Latin America Project, UNESCO-AVINA.

9) Support Community for National Adaptation Plans in Latin America (PNACC), UN Environment (Dupuits, 2021).

5.

Adaptation Solutions at High Altitudes: experiences in The Andes

To select the CC adaptation measures included in this catalog, we relied on two sources and systematization processes. One, the "Adaptation Solutions Portal"[2] of the Adaptation at Altitude program funded by SDC in four mountainous regions of the world, which brings together measures implemented in the seven countries that make up the region. The other, the AICCA project[3], which has implemented adaptation initiatives in Colombia, Peru, Ecuador, and Bolivia, and has disseminated them through various publications, one of which is the *Catalog of Climate Change Adaptation Measures for the Tota Lake Basin* (AICCA, 2020)

In total, we analyzed 40 measures (see Annex), which provide a broad overview of the various strategies that have been implemented and continue to be developed in the region for CC adaptation. The analyzed measures range from local to multinational scales, with short- to long-term trajectories, in both unique and multiple locations. They include solutions that impact various sectors, addressing CC effects such as heat stress, droughts, floods, vegetation fires, loss of productivity and crops, soil erosion, and reduced food security, with numerous environmental, social, economic, technical, and political benefits and co-benefits.

From these 40 solutions, we selected a representative sample through a multi-criteria analysis, followed by a representativeness and requirements analysis, to support the dissemination of a diverse set of measures implemented across the Andes.

The multi-criteria analysis was conducted considering the requirements of CRD and the typical characteristics of actions promoted by the adaptation approaches we have reviewed here (Table 1). For this, we used additional supporting materials: the IUCN Global Standard for Nature-based Solutions (NbS) (IUCN 2020b), the IUCN criteria for selecting Ecosystem-based Adaptation (EbA) measures in mountains (2022a), and other mountain adaptation catalogs, such as those created under the Adaptation at Altitude program for East Africa (UNEP, 2022a) and the South Caucasus (UNEP, 2022b). This analysis, in addition to allowing us to characterize and compare the 40 solutions in terms of CC adaptation and sustainable development, led us to identify for the Andes: their common features, their scope and strengths, as well as some open challenges.

[2]https://adaptationataltitude.org/solutionsportal/?status=full&sort_by=A-Z
[3]https://aicca.condesan.org/regional/

Dimension	First-order Criteria	Second-order Criteria
Technical Aspects	Results can be tracked, measured, and evaluated	----
	Flexible to adapt to changing, unpredictable, and complex circumstances	----
	Viable, sustainable over time, and reversible	----
	Promotes innovation	----
	Leverages local/community and scientific knowledge and experiences	----
	Responds to a wide range of future scenarios and anticipates expected climate changes	----
	Integrates mitigation, adaptation, and sustainable development, considering CC issues	----
	Replicable	----
	Includes monitoring	----
Socio-environmental Aspects	Reduces the vulnerability of socio-ecosystems	Contributes to: 1) Reducing economic vulnerability through, e.g., strengthening livelihoods. 2) Reducing social vulnerability via strengthening social capital, fostering learning. 3) Reducing political vulnerability by decreasing social tensions due to CC effects.
		Contributes to reducing physical vulnerability to CC
		Contributes to reducing exposure
	Seeks to eliminate socio-economic pressures	----
	Restores, maintains, or improves ecosystem health and services	----
Socio-economic Aspects	Considers fair resource distribution	----
	Includes intergenerational and gender equity	----
	Contributes to overcoming poverty	----
	Generates social benefits in the context of CC	----
	Promotes changes in consumption and development patterns	----
	Involves communities	----
	Promotes empowerment	----
	Maintains cultural diversity	----
Political Aspects	Supports effective governance	Strengthens decentralized political structures.
		Promotes cooperation and coordination (horizontal and vertical) among civil society groups, private organizations, and public institutions
		Promotes transparency and broad, active participation
		Promotes changes in power relations
	Has backing of, or aligns with, policies at various scales	----

Table 1. **Criteria for the multi-criteria analysis of the 40 adaptation measures in the Andes**

The representativeness and requirements analysis, on the other hand, focused on "more practical" criteria that highlight the various possibilities offered by the measures in terms of thematic diversity, ecosystem of implementation, impacts addressed, and complexity of requirements in terms of design and implementation (Table 2), among other characteristics. This analysis was also applied to the 40 solutions and ultimately led us to select measures highly consistent with CRD, ranging from measures accessible to a rural community, with "simple" actions and relatively quick results, to more complex, longer-term measures aimed at government entities or organizations with greater financial resources.

By combining these two analyses, we selected 12 adaptation measures, which include: each country, local and sub-national scales, and various ecosystems (Páramos, Xerophytic Puna Wetlands, Wet Punas, Grasslands, Agricultural Lands, Cloud Forests, and Peatlands). Solutions that, in addition, address various climate risks and environmental and social challenges, with the participation of actors from different fields and through actions with medium to high design and implementation requirements. Finally, we decided that, due to the variety of the resulting group, their presentation should follow a north-south direction along the Andes (Figure 7).

Selection Criteria	Breakdown
Geographic Representativeness	Country(ies) of implementation in the Andes
Thematic Representativeness	Water resource management, ecosystem and biodiversity management, monitoring, livelihoods (agriculture, livestock, tourism, poultry farming), financing mechanisms, risk management, infrastructure development, research, community awareness/training, and technical training for public organizations and decision-makers
Adaptation Measure Focus	Progression of safety, progressive adaptation, transformational adaptation, nature-based solutions, and adaptive management
Implementation Requirements	Technical, technological, economic, infrastructural, logistical, and political
Implementation Scale	Local, sub-national, national, and transnational
Climate Impact Time Scale	Slow start, fast start, fast-slow start
Actors Involved	Community members, NGOs, academics, private agents, and public organizations
Implementation Timeframe	Short (<3 years), medium (3 to 5 years), and long (>5 years)

Table 2. **Criteria for the representativeness and requirements analysis of the 40 adaptation measures in the Andes**

Agrobiodiverse gardens. Boyacá, Colombia.
AICCA

Adaptation Experiences in The Andes

1. Participatory zoning of páramos and wetland protection, **Venezuela**
2. Phenological Bird Monitoring Network and Birdwatching Tourism, **Colombia**
3. Agroecological conversion of production systems and conservation of Andean tubers, **Colombia**
4. Participatory care of páramos and improvement of farmers' livelihoods, **Colombia**
5. Covered crops with drip irrigation to address heavy rains and frost, **Ecuador**
6. Climate-smart livestock farming, **Ecuador**
7. Funding conservation of mountain ecosystems and poverty reduction through a community fund, **Ecuador**
8. Sustainable watershed management in glacial mountain ecosystems, **Peru**
9. Conservation/restoration of Queuña Forests (Polylepis Spp.) and creation of private conservation areas, **Peru**
10. Multipurpose water management in the context of climate change, **Bolivia**
11. Sustainable grazing and wetland management with restoration actions, **Argentina**
12. Strengthening municipal environmental governance and promoting good productive practices, **Chile**

Figure 7: **Location of the 12 adaptation experiences in the Andes selected for this catalog**

Solution 1

Participatory zoning of páramos and wetland protection, Venezuela[4]

Specific location	**Rangel Municipality. Mérida State.**
Implementation period	**2007-2019**
Framework project	"Andean Páramo Project" (PPA). Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN).
Adaptation at Altitude Portal Solution	Management and conservation of wetlands and paramos in Venezuela: Successful experiences of adaptation to climate change in the Mixteque – Mérida paramo
Involved actors	- Association of Environmental Coordinators of Rangel Municipality (ACAR), irrigation committees, communal councils, small agricultural producers, local educational institutions (Mixteque school and college), and other community members. - National Parks Institute (INPARQUES). - Ministry of Popular Power for - Ecosocialism (MINEC); Ministry of Popular Power for Agriculture and Lands (MPPAT), and Rangel and Municipality Mayor's Office. - Institute of Environmental and Ecological Sciences of the University of the Andes (ICAE) - Center for Popular Education for the Integral Development of the Family (CEPDIF). - Integral Producers of the Páramo (PROINPA). - CONDESAN
Funding agencies	- GEF, through UNEP. Andean Páramo Project (PPA). - Irrigation committees.
Compiler of the measure for Adaptation at Altitude	**Raúl Córdova**

[4] https://adaptationataltitude.org/solutions-portal/management-and-conservation-of-wetlands-and-paramos-in-venezuela-successful-experiences-of-adaptation-to-climate-change-in-the-mixteque-merida-paramo/

Gavídia, Venezuela
Alejandra Melfo

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (agriculture and livestock)
- Infrastructure development
- Research
- Monitoring
- Community capacity building/awareness

Ecosystems

- Páramos
- Wetlands

Timescale of climatic impact

Fast
Slow

Scale

Local

Level of requirements

Technical	★★☆	Infrastructure	★☆☆
Technological	★★☆	Logistic	★☆☆
Financial	★★☆	Politics	★★☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, heat stress, altered growth regimes, loss of productivity, changes in rainfall patterns

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

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ODS

1, 4 , 6, 8, 11, 12, 13, 15, 17

The páramos and wetlands of the Mixteque micro-basin in Rangel Municipality, located within the Sierra Nevada National Park, are important socio-ecosystems that provide multiple services, including water regulation and supply, both for ecosystem functions and for domestic consumption and agriculture, on which most of the population depends.

However, in this municipality, agricultural intensification and extensive grazing, combined with the indiscriminate use of agrochemicals, threaten the functionality and integrity of the páramos and wetlands, especially during the dry season. Aware of this problem, the Mixteque community took the initiative to **implement various conservation strategies, such as fencing and protecting wetlands, controlling extensive grazing, and community water management**, to contribute to the preservation of these ecosystems and ensure the quality and quantity of water needed for their well-being.

Fencing and protecting wetlands is a widely used measure that has reported significant benefits in terms of ecosystem restoration. It prevents access by livestock and people to the wetland and marks a limit to the expansion of agriculture, giving vegetation, fauna and soils, the opportunity to regenerate naturally. In turn, the fenced wetland can better regulate water supply and filter sediments and contaminants from the water.

Rotational grazing, on the other hand, reduces soil erosion, allows forage plants to recover and deepen their roots, and reduces pressure on wetlands, which are the main source of forage in the high Andean zone during the dry season. Finally, community water management promotes an active role for the community in the administration, operation, and maintenance of irrigation systems and water management and monitoring, fostering community empowerment in natural resource management.

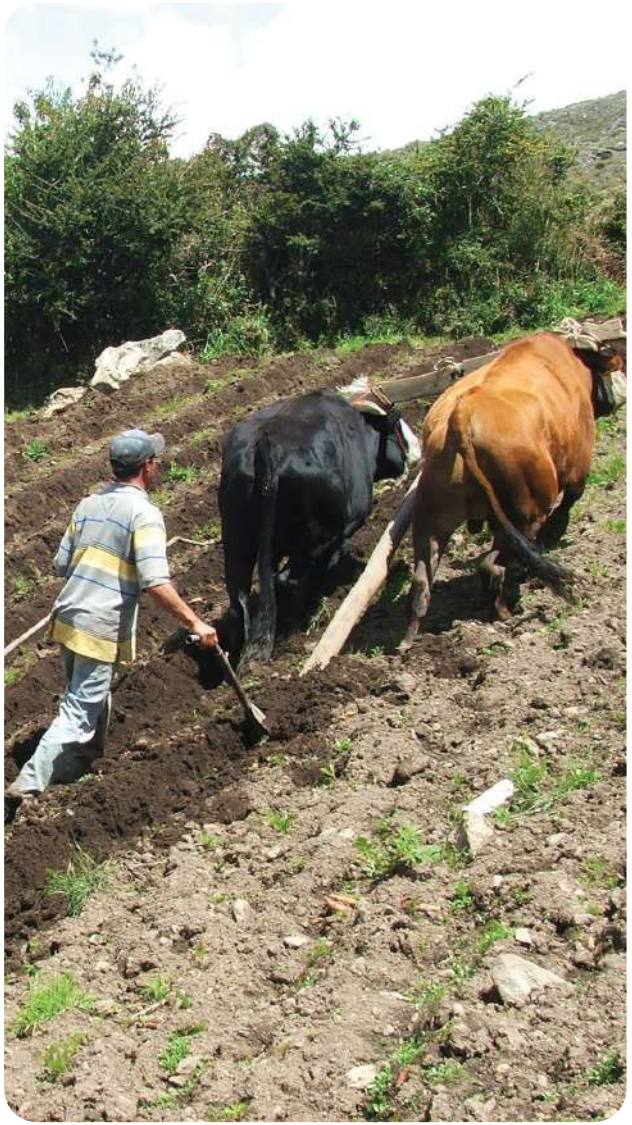
What makes this experience interesting?

The participatory zoning of páramos and wetland protection in Mixteque is the result of a long-term effort by community organizations in Rangel Municipality, including the Association of Environmental Coordinators of Rangel Municipality (ACAR), which was later supported by the Andean Páramo Project (PPA), implemented in Venezuela by ICAE (University of the Andes). Thus, it is rooted in the local tradition of community work.

Its actions promote the community's recognition of its territory, its characteristics, its farms, and, within them, its activities, through an innovative participatory mapping methodology (Smith et al., 2014). This allows for the efficient, reliable, and cost-effective creation of maps using high-resolution satellite images and local knowledge and perceptions of the environment. For example, it has enabled the Mixteque population to apply participatory territorial planning strategies. The measure has the additional virtue of allowing the community, including children, adolescents, and older adults, to participate in water management. It introduces rotational grazing as a sustainable practice and develops activities that recover local ancestral memories and revalue the environment.

Its design makes it a solution with low to medium technical, technological, economic, logistical, infrastructural, and political requirements. This, along with the diversity of actors involved, makes it replicable by stakeholders with varying implementation capacities.

Luis Daniel Llambí



Agricultural intensification and extensive grazing, combined with the indiscriminate use of agrochemicals, threaten the functionality and integrity of the páramos and wetlands.

Core activities

The work behind this measure was promoted and organized through the communities and their organizations, and involved:

- **Participatory mapping of the micro-basin**. This was done through collective workshops in which participants delineated and sectorized their farms using high-resolution remote images printed on a large scale. This was accompanied by agricultural and quality-of-life surveys of the population, allowing for the collection of detailed and sectorized information to design interventions tailored to different levels: farm, community, and territory. The information collected included: agricultural yields, cultivated area by productive category, animal load, quantity and types of fertilizers applied, irrigated area, economic diversification of income, poverty levels, and coverage of basic services, among others (Smith et al., 2014).
- **Participatory zoning and land-use regulation**. Based on the above information, a participatory analysis of the community's historical processes was conducted, including its problems, conflicts, and possible solutions, as well as its vision for the future. Then, proposals for territorial zoning were developed in working groups, and the most complete and detailed proposal was selected by consensus in a collective workshop. Based on the final zoning, a Land Use Regulation was established for 12 zoning categories, which was later approved by the irrigation committees and the Mixteque Communal Council for implementation and monitoring (Llambí et al., 2013).
- **Environmental education**. This included the formal education system through educational units, as well as work with the general population to recover and revalue traditions and environmental culture. Children, teenagers, adults, young and older adults had the opportunity to interact with each other through literary and artistic creation, and reflection workshops, collecting a variety of information related to myths and legends associated with environmental themes, páramo conservation, and páramo management strategies, as well as community issues. This resulted in the book *Mixteque: Life Among the Stones*, which compiles the results of reflections on the environment, using literature and art as a vehicle.
- **Participatory hydrometeorological monitoring of páramos and wetlands**. This involved the installation of a network of rain gauges and weather stations, protected and monitored with community support; the construction of the first and only automated high-mountain spillway in the country; and training in the management of data collection, processing, interpretation, and publication equipment. This training involved members of the irrigation committees and the general community.
- **Fencing of wetlands and livestock rotation**. This included, as part of a broader wetland protection program by ACAR, the installation of fences or protective barriers using barbed wire and plastic posts, as well as the marking of spaces undergoing regeneration. On the other hand, livestock rotation involved the development of a sustainable grazing experience by rotating animal loads in pastures, with the aim of increasing livestock efficiency and reducing grazing pressure in the higher zones.

Benefits

The population of Mixteque consists of peasant communities whose livelihoods are primarily based on agriculture, paid agricultural work outside the farm, commerce, construction, and transportation. This solution has provided the following benefits:

Socioeconomic

- Direct benefits to 730 community members and indirect benefits to 19,634 inhabitants of Rangel Municipality.
- Recovery of historical memory and community traditions, strengthening cultural identity and sense of belonging.
- Increased local capacity for sustainable community water management.
- Strengthening of local initiatives for páramo and wetland management and conservation.
- Promotion of dialogue between local empirical knowledge and scientific knowledge related to the hydrological aspects of the micro-basin, allowing for a better understanding of the socioeconomic, biophysical, and environmental aspects of the páramo and wetlands.
- Encouragement of local initiatives for the construction of water storage tanks for irrigation, based on 3 years of meteorological data, and the recycling of agrochemical plastic containers for the production of posts.

Environmental

- Protection of wetlands and improvement of their water regulation capacity, water storage in soils, and carbon storage.
- Reduction of extensive grazing pressure on wetlands.
- Research in the area has shown that fencing wetlands to prevent trampling has allowed for: significant recovery of water storage and regulation capacity; restoration of continuous soil vegetation cover (and improvement of forage quality for grasses); increased biomass and canopy height or vertical stratification; and reduced erosion, bulk density, and soil compaction. This has increased water retention capacity at saturation and favored its storage, up to 8 times more than in areas with grazing outside the fence (Valero 2010, Acevedo et al., 2019).

Political-institutional

- Strengthening of cooperation and coordination between public agencies, grassroots community organizations, irrigation committees, small agricultural producers, and the general community.
- Strengthening of decision-making mechanisms and local governance, thanks to the promotion of participatory territorial planning tools that consider local socioeconomic, cultural, and environmental contexts.

Main challenges

The most important challenge of this measure was ensuring the sustainability of the actions given the socioeconomic and political situation of the country, which directly impacted public, private, and community actors, as well as academia.

Other challenges included preventing the elimination of extensive grazing from negatively affecting the local economy, especially households with less diversified livelihoods, and preventing the fencing of wetlands from leading to more intensive use of the surrounding non-fenced areas.

Potential for expansion and replication

The processes of participatory mapping and zoning (Smith et al. 2014; Llambí et al. 2013) have a high potential for replication due to the simplicity of the method and its low costs compared to other field mapping and data collection methods, such as traditional rural door-to-door surveys. These methodologies have been included in the formal education and training programs of the Bachelor's Degree in Biology and the Postgraduate Program in Tropical Ecology at ICAE, and have been replicated in the community of Tuñame (Trujillo state, Venezuela). Additionally, the National Parks Institute (INPARQUES) has widely recognized the adaptation experiences implemented in Mixteque, particularly their participatory nature (e.g., within the framework of the celebration of the 60th anniversary of the Sierra Nevada National Park).

On the other hand, the community-based wetland fencing strategy has proven to be effective in rehabilitating ecosystems and restoring the water regulation functions of wetlands. Moreover, it is easy to implement and low-cost, which gives it great potential to be replicated in other sites in the Venezuelan Andes and the Andean region.

Gavídia, Venezuela
Alejandra Melfo

Solution 2

Phenological Bird Monitoring Network and Birdwatching Tourism, Colombia[5]

Specific location	**Municipalities of Aquitania, Cuitiva, and Tota. Province of Boyacá.**
Implementation period	**2021**
Framework project	"Adaptation to the impacts of climate change on water resources in the Andes." (AICCA Project) CONDESAN.
Adaptation at Altitude Portal Solution	Network for phenological monitoring of birds as bioindicators of the effects of Climate Change in the Tota Lake basin, Colombia
Involved actors	- Ministry of Environment and Sustainable Development (Minambiente), Institute of Hydrology, Meteorology, and Environmental Studies (IDEAM), and the Autonomous Corporation of Boyacá. -Beneficiary communities and tourism operators in the basin - CONDESAN.
Funding agencies	GEF, through CAF.
Compiler of the measure for Adaptation at Altitude	**AICCA Project - Paola Andrea Pérez Lora, Julio Cesar Álvarez Peña, Lorena Sofia Martínez.**

[5] https://adaptationataltitude.org/solutions-portal/network-for-phenological-monitoring-of-birds-as-bioindicators-of-the-effects-of-climate-change-in-the-tota-lake-basin-colombia/.

Phenological Bird Monitoring Network, Colombia
AICCA

Themes

- Livelihoods (tourism)
- Monitoring
- Research
- Community capacity building/awareness

Ecosystems

- Páramos
- High Andean Forests
- Wetlands

Timescale of climatic impact: Fast / Slow

Scale: Local

Level of requirements

Technical	★★★	Infrastructure	★☆☆
Technological	★★☆	Logistic	★★☆
Financial	★★☆	Politics	★☆☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, changes in rainfall patterns, heat stress, forest fires, changes in temperature, changes in migration seasons

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target: N/A

ODS: 4, 5, 15

In the Tota Lake basin (municipalities of Cuitiva and Tota), around 168 bird species have been identified, some endemic and others migratory, which depend on wetlands and páramos to carry out their biological cycles. However, the alteration of these ecosystems, along with changes in temperature and rainfall, has been affecting their populations and favoring the access of other species from lower thermal zones. Given the uncertainty about these and other changes, it was proposed **to create a phenological bird monitoring network in the basin, and at the same time develop the capacities of the local community, its institutions, and academia to take advantage of its benefits**.

Phenology is an essential science in the face of variability and CC. By studying the periodic phenomena of living beings and their relationship with the climate, it provides the opportunity to understand and predict how species and ecosystems are responding and will respond to its effects. Additionally, it allows for the detection of the early signs of its impact on ecosystems and their services, facilitating the development of adaptation strategies in various sectors, such as agriculture, forestry, and biodiversity conservation.

Given that birds are excellent biological indicators and that the basin is home to a rich avifauna, it was considered that establishing a survey and monitoring network for the functional group of birds, combined with birdwatching tourism, would reduce uncertainty about the effects of CC at a local scale and, at the same time, promote the socio-economic development of the communities.

Phenological Bird Monitoring Network, Colombia
AICCA

What makes this experience interesting?

The phenological bird monitoring and birdwatching tourism network is a measure that exemplifies the combination of research/monitoring-NbS-progressive adaptation. It allows for the reduction of uncertainty regarding the effects of CC at a local scale and informed decision-making on adaptation, while promoting the economic exploitation of this monitoring through a cultural-environmental service: birdwatching. This is an activity with a growing audience, and its development contributes to strengthening the livelihoods of the basin's inhabitants.

The measure is innovative, flexible, reversible, viable, and sustainable measure. Beyond its scientific nature, it brings together community, public, and private actors to take advantage of an opportunity to generate social benefits in the context of CC.

The measure has high technical requirements, as its design and implementation require a group of specialists to ensure its proper functioning; however, it consolidates a methodological and practical proposal to strengthen the knowledge of birds as bioindicators of CC, and contributes to develop citizen science.

Phenological Bird Monitoring Network, Colombia
AICCA

Core activities

Concerning research and monitoring, this measure involved various activities:

- **Basic studies:** territorial analysis of the basin for CC adaptation purposes and diagnosis of potential areas for bird monitoring.
- **Design of the phenological monitoring network:** selection of CC bioindicator species (three resident and three migratory)[6], design of the monitoring protocol to operate the network, and creation of materials for the training of phenological observers.
- **Launch of the network:** identification of community actors to be trained as phenological observers, conducting training workshops, and field outings to record species, both in a field notebook and in mobile applications (eBird and Merlin).

To integrate research/monitoring with socio-economic development, this solution also included the design of a 'birdwatching tourism' proposal with the participation of the communities and tourism operators in the basin.

[6] Residents: Pied-billed Grebe (Podilymbus podiceps), Apolinar's Wren (Cistothorus apolinari), Carib Grackle (Quiscalus lugubris). Common Migratory Species: Blue-winged Teal (Spatula discors), Fork-tailed Flycatcher (Tyrannus savana), and Yellow-billed Cuckoo (Coccyzus americanus), (AICCA, 2020).

Benefits

The implementers of this measure estimate that the benefits of the network, in terms of baseline data on species, their reproduction and migration periods, will be tangible within about 10 years. In other areas, the perceived benefits have been:

Socioeconomic

- Strengthening of the local tourism value chain and, consequently, the livelihoods of the basin's inhabitants.
- Contribution to citizen science, as it expands knowledge of birds as bioindicators of CC.
- Participation of communities in research processes through birdwatching.
- Recognition of local and ancestral knowledge about the basin's biodiversity.
- Creation of skills in observation, identification of vocalizations, and species recording among 20 community members.
- Support for entrepreneurship in 'birdwatching tourism' by training communities in sustainable tourism and specific topics related to the subsector: profile of the client interested in birdwatching, required infrastructure, and requirements to offer quality services.

Environmental

- Awareness of the importance of protecting the basin's biodiversity.
- Conservation of vulnerable ecosystems.
- Generation of information to understand the effects of CC on birds and how they are responding to its effects through adaptation processes.
- Generation of information on the CC-habitats relationship, necessary for making decisions on the protection and conservation of strategic areas for biodiversity in the Tota Lake basin.

Political-institutional

- Strengthening of the technical and organizational capacity of the beneficiaries (tourism operators, nautical operators, hotel operators, tour guides, students, and local leaders).
- Articulation of the Tota Lake Basin Bird Phenological Network with the Technical Board of the National Strategy for Bird Conservation (ENCA).

Main challenges

The main barrier in implementing this solution was the lack of equipment for observing and recording bird behavior. Therefore, it was necessary to provide the 20 phenological observers with a Tota Lake Basin Bird Guide, binoculars, and a field notebook, as well as a web platform.

Potential for expansion and replication

It is recommended to expand and replicate this solution, as the projected increase in temperatures and precipitation worldwide may have strong impacts on the phenology of the functional group of birds, especially in sensitive ecosystems.

Its development will allow for the collection of essential phenological information to identify climatic changes affecting birds and strengthen decision-making on biodiversity and ecosystems. Additionally, it can serve as a strategy for information and community awareness to promote changes in habits in favor of ecosystem conservation in the long term.

Phenological Bird Monitoring Network, Colombia
AICCA

Red Fenológica de Aves
Lago de Tota, Colombia
AICCA

Solution 3

Agroecological conversion of production systems and conservation of Andean tubers, Colombia[7]

Specific location	**Municipalities of Ventaquemada, Turmequé, and Tibasosa.**
Implementation period	**2022**
Framework project	Initiative of the Innovative Association of Andean Tubers of Boyacá (AITAB) and Corporation for the Sustainable and Participatory Development of Small Farmers (Corporación PBA).
Adaptation at Altitude Portal Solution	Reconversion of conventional production systems to traditional -- agroecological systems, with emphasis on in situ conservation of Andean tubers as a climate change adaptation strategy for small producers in Boyacá-Colombia
Involved actors	- Innovative Association of Andean Tubers of Boyacá (AITAB), Seed Association, Community Action Board (JAC) of Supata, Association of Peasant Markets of Tibasosa (ASOMERCAMPO), Association of Artisans of Tibasosa (ARTIBASOSA), Agroecological Association of Turmequé (ASOAGROTURMEQUÉ), and the general community. - Government of Boyacá, Secretary of Agriculture of the municipality of Turmequé, and Colombian Corporation for Agricultural Research (AGROSAVIA). - Pontifical Javeriana University, National University of Colombia, and Juan de Castellanos University Foundation. - Agrosolidaria, Corporation for the Sustainable and Participatory Development of Small Farmers (Corporación PBA), Rural Diversity, and Victoria Agroecological Farm
Funding agencies	Corporation for the Sustainable and Participatory Development of Small Rural Producers (Corporación PBA)
Compiler of the measure for Adaptation at Altitude	**Raúl Córdova**

[7] https://adaptationataltitude.org/solutions-portal/reconversion-of-conventional-production-systems-to-traditional-agroecological-systems-with-emphasis-on-in-situ-conservation-of-andean-tubers-as-a-climate-change-adaptation-strategy-for-small-producers/

Tubers, Colombia
AITAB

Themes

- Ecosystem and biodiversity management
- Livelihoods (agriculture)
- Research

Ecosystems

- Páramos
- Grasslands
- Cloud forests
- High Andean Forests
- Agricultural land

Timescale of climatic impact

Fast
Slow

Scale

Local

Level of requirements

Technical	★★☆	Infrastructure	★☆☆
Technological	★☆☆	Logistic	★☆☆
Financial	★★☆	Politics	★☆☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Altered growth regimes, loss of productivity, crop loss, heat stress, changes in rainfall patterns

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

N/A

ODS

1, 2, 3, 5, 8, 11, 12, 13, 15, 17

This measure was implemented **to preserve Andean tubers and promote their cultivation and consumption**. It is based on the revival of self-sufficient agroecological production and the use of local traditional knowledge, with the aim of increasing climate resilience and food security for the communities of Ventaquemada, Turmequé, and Tibasosa.

Andean tubers[8], often categorized as marginal, undervalued, or underutilized, have been cultivated in the mountainous regions of Boyacá since pre-Hispanic times and are an important part of the food and medicinal culture of its inhabitants. The techniques of their cultivation, management, and uses, including plant genetic material (species and morphotypes) have been inherited and passed down from generation to generation.

Due to their significant adaptability to different climatic conditions, resistance to pest attacks, and drought tolerance, these tubers can be cultivated in different ecological zones distributed between 2,400 and 4,000 meters above sea level. These characteristics, along with their nutritional and medicinal properties, give them high potential to both reduce the climate and food vulnerability of communities, and strengthen the adaptive capacity of farmers.

However, leveraging these qualities and reintroducing these tubers also involves promoting the transformation of the prevailing production systems. To address this, the solution was accompanied by an agroecological conversion process to make agricultural practices more sustainable and resilient, improve production, and strengthen the relationship between communities and their natural environment.

[8] Ibia/oca (Oxalis tuberosa Molina), cubio/mashua/isañu (Tropaelum tuberosum Ruíz & Pavón) y ruba/melloco/olluco/papa lisa (Ullucus tuberosus)

What makes this experience interesting?

This solution synthesizes the initiatives of the Innovative Association of Andean Tubers of Boyacá (AITAB) and other public and private actors, especially academia (Pontifical Javeriana University of Colombia), around the revaluation of the cultivation and use of Andean tubers through participatory information generation processes.

It is an NbS that combines climate action, reversal of ecosystem degradation, promotion of socio-economic development, and strengthening of food security through actions with moderate technical and economic requirements, and much lower requirements in technological, infrastructural, logistical, and political areas, making it accessible to actors with different implementation capacities.

Leveraging local inherited knowledge about crops resistant to different climatic conditions and pests, it seeks to popularize the consumption of Andean tubers and an agriculture that has benefited communities for centuries without putting pressure on the ecosystems. Additionally, it promotes a change in diet, gender and generational equity, and innovation in various areas (participation, socio-ecosystem analysis, and promotion of healthy, under-marketed foods).

Tubers, Colombia
AITAB

Core activities

The activities in this solution can be grouped into four categories: one aimed at understanding the relationship between the natural environment and agroecosystems; another at understanding agroecosystems, the communities that develop them, and food; another at conserving tubers in situ; and the last at promoting their consumption, especially among children and young adults, and generating new market niches. Namely:

- **Regarding the relationship between the natural environment and agroecosystems:** analysis of landscape conditions and the connectivity of Andean tuber agroecosystems with different types of surrounding natural vegetation, forest remnants, páramos, and water bodies.
- **Regarding agroecosystems-communities-food:** application of participatory techniques involving all family members for the collection and analysis of farm-level information. This included: mapping of farms before and after the implementation of the agroecological approach; creation of timelines to analyze changes in crop management and preferences over the last 50 years; and analysis of daily menus to understand the socio-cultural and economic dynamics of family diets, as well as the role of Andean tubers in the local diet.
- **For *in situ* conservation:** creation of seed banks.
- **To promote consumption and create new market niches:** conducting cooking workshops focused on new ways to prepare dishes with tubers and strengthening associative channels for their exchange and commercialization, both locally and in nearby urban centers.

Tubers, Colombia
AITAB

Benefits

The cultivation of Andean tubers has always been part of Andean production systems; however, the production preferences of local farmers have been changing, leading to the reconfiguration of their systems. Now, with the revival of the agroecological system that involves the production of these crops, the community has achieved several goals:

Socioeconomic

- Direct benefits to approximately 100 inhabitants of 30 households or small farms of traditional farmers who participated in various initiatives for the management, cultivation, and processing of Andean tubers.
- Indirect benefits to 37,000 inhabitants of the three municipalities where Andean tubers are produced and marketed.
- Revaluation of local knowledge about the use of different species and morphotypes of Andean tubers to promote their consumption, especially among children and young adults, and to generate markets.
- Conversion from conventional-commercial production systems to agroecological-self-sufficient systems, and diversification of production.
- Revaluation of the role and importance of women in the management and conservation of Andean tubers, thanks to their traditional interest in caring for household nutrition and health.

Environmental

- Maximization and in situ conservation of agrobiodiversity through the introduction of polycultures, crop rotation, soil fertilization through the preparation and application of organic fertilizers (compost, manure, humus), and ecological control of pests, weeds, and diseases.
- Reduction of pollution from chemical fertilizers and pesticides used in conventional-commercial systems.

Political-institutional

- Formation of various local producer organizations.
- Strengthening of cooperation between municipal government authorities, non-governmental organizations, academia, private companies, and community-based organizations

Main challenges

Despite significant support from academia and other public and private actors in the conservation and use of Andean tubers, the lack of involvement of other institutions responsible for generating incentives and public policies—such as governments at different territorial levels—represented an obstacle to promoting initiatives aimed at their recovery and revaluation, as well as fostering agroecological practices for their cultivation.

On the other hand, implementers perceived that, in the long term, the lack of generational succession in households of Andean tuber producers will impact the sustainability of the measure. Young people are losing interest and appreciation for these foods, and their migration to cities is increasing.

Potential for expansion and replication

Due to the high resilience of Andean tubers and the ease and low cost of their agroecological techniques and practices, the possibilities for scaling up and replicating this measure are very high, both in the mountainous regions of the Andes and in other regions. Additionally, the cultivation techniques of these tubers, widely spread throughout the Andean region, are part of the farmer's traditional knowledge.

The use, revaluation, and *in situ* conservation of Andean tubers have high potential to reduce food vulnerability and increase the adaptive capacity of Andean livelihoods, mainly due to their resistance to pest attacks and droughts, which could intensify due to CC. This favors the sustainability of their cultivation and use by local populations, for whom their value is not only commercial but also socio-cultural and nutritional.

Tubers, Colombia
AITAB

Solution 4

Participatory care of páramos and improvement of farmers' livelihoods, Colombia[9]

Specific location	**Departments of Meta, Huila, Cundinamarca, and the Capital District of Bogotá**
Implementation period	**2014-2020**
Framework project	"Conservation, Restoration, and Sustainable Use of Ecosystem Services in the Páramos of Sumapaz, Chingaza, and Guerrero, the Cerros Orientales of Bogotá, and their Areas of Influence." Bogotá Water and Sewer Company (EAAB-ESP)
Adaptation at Altitude Portal Solution	Adaptation experiences to climate change with peasant communities in the Sumapaz – Chingaza – Guerrero and Cerros Orientales Páramo Corridor
Involved actors	- Community Action Boards (JAC) of the municipalities participating in the project, boards of directors of aqueducts and local irrigation systems, and the general community. - Governments of the 13 involved municipalities (Bogotá D.C., La Calera, Nemocón, Sesquilé, Sopó, Tausa, Fómeque, Guasca, Junín, Coachi, Ubaque, El Calvario, and San Juanito); departmental governments of Meta, Huila, and Cundinamarca, and territorial environmental authorities (Autonomous Regional Corporation of Cundinamarca (CAR), Autonomous Regional Corporation of Guavío (CORPORGUAVIO), Autonomous Regional Corporation of Orinoquía (CORPORINOQUIA), and Corporation for the Sustainable Development of the Special Area of La Macarena (CORMACARENA). - National University of Colombia and Pontifical Javeriana University. - Various consortia, NGOs, and consulting firms contracted for the generation of socio-economic and environmental
Funding agencies	- Bogotá District, through the General Royalties System. - Bogotá Water and Sewer Company; Foundation for the Research, Conservation, and Protection of the Andean Bear Wii. - Pontifical Javeriana University.
Compiler of the measure for Adaptation at Altitude	**Raúl Córdova**

[9] https://adaptationataltitude.org/solutions-portal/adaptation-experiences-to-climate-change-with-peasant-communities-in-the-sumapaz-chingaza-guerrero-and-cerros-orientales-paramo-corridor/

Espeletia, Guerrero paramo, Colombia
Luis Alveart

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (agriculture, livestock, poultry, tourism)
- Infrastructure development
- Risk management
- Community capacity building/awareness
- Technical training of officials and decision-makers

Ecosystems

- Páramos
- Wetlands
- Peatlands
- Cloud forests
- Agricultural land
- Grasslands

Timescale of climatic impact

Fast
Slow

Scale

Sub-national

Level of requirements

Technical	★★☆	Infrastructure	★★☆
Technological	★★☆	Logistic	★☆☆
Financial	★★★	Politics	★★☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, landslides, forest fires, loss of productivity, diminished food security

Progression to safety

- Risk mitigation and preventions
- Contribution to safety and sustainable livelihoods
- Reduction of dynamic pressures
- Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

B

ODS

1, 2, 3, 5, 6, 8, 9, 11, 12, 13, 15, 16, 17

The páramo corridor of Chingaza, Sumapaz, Guerrero, and Cerros Orientales faces a series of environmental challenges that endanger its biodiversity, water regulation capacity, and the quality of life of multiple communities, due to increasing anthropogenic pressures and CC that is altering its hydrological cycle.

This corridor is home to around 20% of Colombia's population; it has key socio-economic and environmental importance because it supplies water to more than 10 million users in 22 municipalities—including rural and urban areas of the Capital District of Bogotá—and possesses great ecosystem and socio-cultural diversity. However, it is threatened by the expansion of the agricultural frontier (extensive livestock farming and industrial monoculture of potatoes), pollution, logging, vegetation fires, and the development of mega-projects related to transportation, energy, mining, urban development, and agro-industry.

Faced with this problem and due to the socio-economic and environmental importance of the corridor, the Bogotá Water and Sewer Company (EAAB-ESP) implemented the project "Conservation, Restoration, and Sustainable Use of Ecosystem Services in the Páramos of Sumapaz, Chingaza, and Guerrero, the Cerros Orientales of Bogotá, and their Areas of Influence," also known as the Páramos Project.

In this case, **the solution focused on the participatory care of the páramos and the improvement of rural livelihoods for small farmers, to ensure the supply and quality of water for the inhabitants of Bogotá D.C. and the population living in the corridor**. To achieve this, a series of actions were designed and implemented, aimed at: ecological conservation and restoration, productive reconversion and sustainable land use, socio-environmental management, and institutional strengthening.

Participatory care is a model of attention that involves all stakeholders, ensuring that their needs and interests are considered. It considers care as a collaborative and co-responsible process, where each individual contributes with their knowledge, skills, and experiences. It promotes equity, inclusion, and empowerment; improves the quality of life of those involved by allowing them to better identify and understand their needs; helps create and strengthen social capital, as well as ensures the sustainability of care actions over time and space.

Spectacled bear
Sonja V

What makes this experience interesting?

This solution, which groups several adaptation measures, is the result of the joint effort of various actors to integrate environmental conservation, climate action, and sustainable development, through activities with a high potential to promote transformation in the involved communities, and generate benefits beyond the local scale.

It is an NbS that counteracts several internal and external vulnerability factors, and seeks to restore and improve the health of the páramos in the corridor, as well as eliminate the socio-economic pressures on them. This is complemented by various efforts to prevent hazards, achieve safe places and sustainable productive practices in line with cultural diversity, and promote a fair distribution of resources through environmental compensation schemes.

Although its implementation requires high economic resources, it demands little in terms of technical, technological, infrastructural, and political requirements. It is flexible, reversible, viable, and sustainable, and its design aims at more effective governance, strengthening decentralized political structures, multisectoral and multiscale cooperation and coordination, and changing power relations.

Core activities

The activities developed within the framework of this solution included:

- **In terms of infrastructure:** provision of infrastructure and equipment to support production (greenhouses, stables, irrigation systems, reservoirs, biodigesters, biofactories, composters, milk cooling tanks, and worm beds, among others), and construction of infrastructure for water supply and environmental sanitation (sanitary facilities, septic tanks, aqueducts, storage tanks, sand removers, distribution systems, among others).
- **In the area of ecological conservation and restoration:** installation of nurseries for seedling reproduction; revegetation and enrichment of species in degraded or ecologically important areas; creation of civil society natural reserves (RNSC) with their respective management plans; design of an environmental in-kind compensation mechanism, to stimulate ecological conservation and restoration of rural properties, including river and stream areas; environmental education and research.
- **For productive reconversion and sustainable land and water use:** productive interventions that combine and complement family and traditional practices; pasture renewal; promotion of ecotourism and rural tourism, and creation of a Participatory Guarantee System with the label "Healthy Production of the Páramo Corridor," to identify agroecological production.
- **For frost and landslide prevention:** implementation of a Participatory Early Warning System.
- **In the area of institutional strengthening and community training/awareness:** creation and publication of manuals and brochures to facilitate environmental management of the corridor, as well as to strengthen the sense of ownership and identity among residents. Among the publications are: 1) "Biodiversity and Ecosystem Services in 30 Natural Reserves in the Páramo Conservation Corridor"; 2) "Biodiversity and Ecosystem Services in the High Mountains"; 3) "Water Resource Management"; 4) "Territories in Dispute: Socio-environmental Conflicts in the High Mountains"; 5) "Fauna of Civil Society Natural Reserves, Mammals and Herpetofauna"; 6) "Natural Sciences Booklet"; 7) "Education and Participation for Climate Change Adaptation"; 8) "Participatory Early Warning System, Valle de Jesús"; and 9) "We Are Páramo, We Are Community". In addition, a technical document was prepared with recommendations for restoration, including: nursery management, propagation techniques and procedures (germination and growth), production monitoring techniques, and environmental, nutritional, and phytosanitary management of seedlings.
- **In the area of strengthening local-traditional knowledge:** implementation of the "Reappropriation of Territory" strategy, which allowed for the identification and visibility of territorial identities formed in the high mountain zones, through the recognition and reappropriation of languages, discourses, practices, beliefs, principles, and cognitive frameworks socially constructed in the corridor.

Empresa de Acueducto y Alcantarillado de Bogotá

Benefits

So far, these actions have reported the following benefits:

Socioeconomic

- Improvement of local living conditions and strengthening of the livelihoods of small farmers. This allowed for the adoption and popularization of some sustainable practices such as living fences, greenhouse reproduction, coops for a "happy chicken" system, and pasture renewal.
- Strengthening of female leadership, both in decision-making processes and in productive initiatives.
- Training and development of important initiatives in topics related to conservation and environmental education.
- Reconstruction of 13 timelines (one in each municipality, including Bogotá D.C.) and, with them, the detection of the main milestones that have modified culture-ecosystem relationships over the last century and marked the history and identity of each municipality.

Environmental

- Conservation, ecological restoration, and improvement of the connectivity of the páramos in the corridor.
- Control of gray water discharges.

Political-institutional

- Strengthening of cooperation between departmental and municipal government authorities, environmental authorities, non-governmental organizations, academia, private companies, and community-based organizations.
- Establishment of strategic alliances between the different political-administrative entities of the corridor, under a micro-watershed or watershed approach.
- Restoration of community trust in the public entities intervening in the watersheds.

Main challenges

The challenges faced by the implementers of this solution were twofold. The first was achieving the adoption of the various conservation and ecological restoration activities, especially those related to productive-agroecological reconversion, to ensure their sustainability. The second was the integration of the initiatives and actions of the solution into the development and CC policies of the departments and municipalities that make up the corridor.

In addition to these challenges, there is another one of greater scale and difficulty, which threatens the very conservation of the corridor: controlling mining activities, extensive livestock farming, and industrial monoculture.

Potential for expansion and replication

Some methodologies and participatory approaches for the collection and analysis of local socio-economic and environmental information can be replicated in other similar high mountain zones, given their integrative nature and ability to motivate the local population, as well as their relatively low costs.

Among the replicable methodologies and approaches are:

1. The exchange of scientific/technical and local/traditional knowledge.
2. Low-input agroecological practices for soil fertility maintenance and pest control, through nutrient recycling and the production of organic fertilizers, bio-inputs, and biocides.
3. Participatory processes for environmental territorial planning through chronological mapping, analysis, reflection, and conflict resolution proposals, for the construction of future plans.
4. Fencing of riverbanks and streams for their protection, as well as for the restoration and connectivity of ecosystems.

The recognition granted by the National Planning Department to the framework project also promotes the replicability and scaling up of its interventions in the páramo corridor. This recognition was given as part of the "Well-Invested Royalties" award in 2019, under the "Environmental Sustainability" category, for being the most outstanding project in terms of effectiveness and efficiency in promoting public participation, regional integration, equity, innovation, sustainable income generation, and environmental sustainability.

Sumapaz paramo, Colombia
Luis Alejandro Romero

Solution 5

Covered crops with drip irrigation to address heavy rains and frost, Ecuador[10]

Specific location	**Province of Napo**
Implementation period	**2020-2022**
Framework project	"Adaptation to the Impacts of Climate Change on Water Resources in the Andes (AICCA Project). Ministry of Environment, Water, and Ecological Transition (MAATE). CONDESAN
Adaptation at Altitude Portal Solution	Adaptation to the Impacts of Climate Change on Water Resources in the Andes (AICCA), Ecuador
Involved actors	- Ministry of Environment and Water. - CONDESAN. - Beneficiary communities.
Funding agencies	GEF, through the Development Bank of Latin America (CAF).
Compiler of the measure for Adaptation at Altitude	**Diego Quishpe**

[10] https://adaptationataltitude.org/solutions-portal/adaptation-to-the-impacts-of-climate-change-on-water-resources-in-the-andes-aicca-ecuador/

Agricultural produce, Napo, Ecuador
AICCA

Themes

- **Water resources management**
- **Livelihoods (agriculture)**
- **Infrastructure development**
- **Community capacity building/awareness**

Ecosystems

- **Páramos**
- **High Andean Forests**

Timescale of climatic impact — Fast / Slow

Scale — Local

Level of requirements

Technical	★★☆	Infrastructure	★★☆
Technological	★☆☆	Logistic	★★☆
Financial	★☆☆	Politics	★☆☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Altered growth regimes, loss of productivity, crop loss, changes in rainfall patterns, heavy rains, low temperatures

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target B

ODS 5, 13,

The parishes of Cuyuja and Papallacta are located within the Cayambe Coca National Park, an important protected area in Ecuador that faces significant pressures due to the expansion of the agricultural frontier.

According to climate risk and vulnerability studies conducted by the AICCA Project and CC projections, this area also faces hydrometeorological threats due to increased heavy rainfall and the frequency of frost. Therefore, to reduce crop losses caused by these events and alleviate pressure on the protected area, this measure was promoted, aiming to **increase the resilience of the main productive sectors in the province by promoting greenhouse cultivation with drip irrigation systems**.

Covered crops or greenhouse cultivation have become an excellent alternative for addressing issues related to heavy rains and frost. They allow for cultivation in a controlled environment that protects plants from adverse weather conditions, and also, when combined with drip irrigation systems, help optimize water use through more precise application, reducing losses due to runoff and evaporation.

What makes this experience interesting?

This is a progressive adaptation measure accessible to stakeholders with varying implementation capacities, given its low economic and technological requirements. It generates tangible results quickly and offers significant benefits, as it reduces crop losses, increases productivity, and thereby helps alleviate socio-economic pressures on the páramo and high Andean forests.

Its results can be tracked, measured, and evaluated, and it is easy to socialize and replicate. Additionally, its design makes it sustainable and adaptable to diverse and changing situations, and although it includes infrastructure, it is mobile, making it reversible as well.

Greenhouse, Napo, Ecuador
AICCA

Core activities

This initiative was developed through the following stages:

- **Preparatory activities:** conducting working meetings with local actors to understand the gaps and needs of the target population; preparing a climate risk and vulnerability study to identify climate hazards and the vulnerability of the population; discussing with stakeholders the available alternatives to address climate hazards and social vulnerability, and selecting the most viable initiative from a social, economic, environmental, and political perspective.
- **Planning:** defining the criteria for implementing the solution at the farm level; discussing the problems to be addressed and the actions to be developed in the pre- and post-implementation phases; socializing the initiative and signing agreements between beneficiaries, the local government, and the project to promote its sustainability.
- **Implementation:** installation and operation of metal-framed greenhouses and drip irrigation systems, and training of beneficiaries in good agricultural, livestock, and environmental practices.
- **Monitoring:** measuring and tracking indicators related to income, livelihood diversification, and increased family income.

Greenhouse, Napo, Ecuador
AICCA

Benefits

This solution has contributed the following benefits:

Socioeconomic

- Strengthening the livelihoods of 42 families, as covered crops have increased productivity, diversified crops, and reduced risk

Environmental

- Reducing the expansion of the agricultural frontier in the protected area of the Cayambe-Coca National Park.
- Increasing water use efficiency.

Political-institutional

- Strengthening cooperation and coordination between authorities and community-based organizations.
- Establishing conservation agreements with beneficiaries to prevent the expansion of the agricultural frontier and achieve the sustainable development of their economic activities.

Main challenges

The main challenge faced by this solution was ensuring that the signed agreements were fulfilled. To this end, AICCA, together with local partners, conducted monthly follow-ups on their implementation.

Potential for Expansion and Replication

Greenhouses are a valuable alternative for strengthening the agricultural production system and ensuring food supply throughout the year. For the initiative to work, it must be accompanied by a specific socio-environmental analysis and training in good productive and environmental practices to minimize present and future environmental impacts. The measure has the potential to be expanded and replicated, but it is important that the same steps are followed and the necessary funds are allocated when replication is planned in different areas.

Agricultural products, Napo, Ecuador
AICCA

Solution 6

Climate-smart livestock farming, Ecuador[11]

Specific location	**Provinces of Imbabura, Loja, Manabí, Guayas, Santa Elena, Morona-Santiago, and Napo.**
Implementation period	**2016-2020**
Framework project	Climate-Smart Livestock Production (CSLP). Ministry of Agriculture and Livestock (MAG), Ministry of Environment, Water, and Ecological Transition (MAATE), FAO, and GEF.
Adaptation at Altitude Portal Solution	Climate-Smart Livestock Production in Ecuador: climate change adaptation for small and medium-sized livestock producers, with special focus on the Imbabura and Loja
Involved actors	- Ministry of Environment, Water, and Ecological Transition (MAATE), Ministry of Agriculture and Livestock (MAG) (Undersecretariat of Livestock Development and Ecuadorian Agency for Agricultural Quality Assurance, AGROCALIDAD), and decentralized provincial, municipal, and parish governments. - National and regional livestock associations, as well as local organizations of small and medium-sized producers and local farmers. - National University of Loja and State University of the Santa Elena Peninsula (UPSE).
Funding agencies	- GEF, FAO. - Ministry of Environment, Water, and Ecological Transition and Ministry of Agriculture and Livestock. - Decentralized provincial, cantonal, and parish governments. - Beneficiary farmers and producers
Compiler of the measure for Adaptation at Altitude	**Raúl Córdova**

[11] https://adaptationataltitude.org/solutions-portal/climate-smart-livestock-production-in-ecuador-climate-change-adaptation-for-small-and-medium-sized-livestock-producers-with-special-focus-on-the-imbabura-and-loja-provinces/

Imbabura volcano, Ecuador
Sales

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (livestock)
- Financing mechanisms
- Research
- Monitoring
- Community capacity building/awareness
- Technical training of officials and decision-makers

Ecosystems

- High Andean Forests
- Grasslands
- Agricultural land

Timescale of climatic impact

Fast
Slow

Scale

Sub-national

Level of requirements

Technical	★★★	Infrastructure	★★☆
Technological	★★★	Logistic	★★★
Financial	★★★	Politics	★★★

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, heat stress, landslides, loss of productivity, changes in rainfall patterns

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ● Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

N/A

ODS

1, 2 ,3, 5, 6, 8, 9, 11, 12, 13, 15, 16, 17

Small and medium-scale livestock production in the Ecuadorian Andes is an important and expanding productive sector that provides livelihoods for thousands of rural and urban households. However, it is a system facing high climate risk and, moreover, contributes to the reduction of remaining forests and páramos, including their vital ecosystem services, through low-productivity, high greenhouse gas (GHG) emission extensive grazing.

To address this problem, an innovative solution was chosen: Climate-Smart Livestock Farming (CSLF), which seeks to **transform animal production systems to make them more sustainable, productive, and resilient to CC**.

Rather than viewing livestock farming as a problem, CSLF considers it part of the solution. It focuses on increasing productivity by improving animal nutrition and optimizing resource use; on adapting systems to changing climatic conditions (droughts, floods, high temperatures); and on mitigating CC by reducing GHG emissions and increasing carbon sequestration in soils.

What makes this experience interesting?

This is a Nature-based Solution (NbS) that innovates in CC adaptation by combining science and local knowledge to develop 75 climate-smart livestock practices tailored to the natural and cultural context of the target provinces.

It scaled the scope and benefits of the approach by including other technological, financial, and infrastructural solutions. As a result, it also contributed to water security, socioeconomic development, fair resource distribution, and the equitable generation of social benefits.

Finally, in addition to strengthening local governance, it overcame one of the most challenging aspects of adaptation measures: influencing national policy in the country where it was implemented. Consequently, despite being a measure with very high economic, technical, technological, logistical, and political requirements, it serves as a reference for agricultural sector adaptation to CC in the region.

Climate-smart livestock farming, Ecuador
Proyecto GCI

Core activities

The implementation of this solution involved actions in the areas of farm planning and resource optimization; animal feeding, nutrition, management, health, and welfare; genetic improvement and reproduction; conservation and restoration; management to reduce conflicts with wildlife; handling of agrochemicals and veterinary inputs; management of livestock waste; management of organic and inorganic solid waste; and water management and treatment. All of this entailed:

- **Basic studies:** Assessments of local climate vulnerability and climate risk (exposure, sensitivity, and adaptive capacity), and zoning of pasture use.
- **Community training and awareness:** Training livestock producers in CSLF practices.
- **Technical training for public officials and decision-makers:** Formal training of technicians from various government institutions (MAG and MAATE) through universities.
- **Implementation of various CSLF practices:** Through co-execution agreements, beneficiary producers carried out pasture assessments, rotational grazing, electric fencing, pasture management and renewal, forage conservation, herd health and reproductive management, ecosystem conservation and restoration, manure and waste management, plot irrigation, pruning and thinning, record-keeping, organic fertilizers, and good milking practices. Additionally, they established forage banks, water troughs, and feeders, and included forage mixtures, nutritional blocks, and mineral salts in livestock feed.
- **Financing:** Establishment of a green credit line for producers implementing CSLF practices through BanEcuador, and the creation of communal savings funds and agricultural service centers (CSA).
- **Infrastructure:** Provision, co-financed by the producers themselves, of basic productive infrastructure such as stables, reservoirs, and water storage systems, pressurized irrigation systems, electric fences, water troughs, and feeders.
- **Monitoring:** Design and implementation of two mobile tools to monitor and evaluate at the farm level and in real time: 1) CSLF practices, climate risk, and adaptive capacity of agricultural systems, and 2) GHG emissions.

Benefits

The various CSLF practices carried out on 29 pilot farms in Imbabura have allowed for the conservation of 53 hectares of forest remnants (an average of 5 hectares per farm) and reduced pressure on forests and páramos. Additionally, the implementation of live fences with native tree species has increased vegetation cover by up to 40%, representing a significant advance for CC adaptation and mitigation.

In Loja, the CSLF practices implemented on 30 pilot farms have allowed for the planting of improved pastures, pasture improvement, the establishment of energy and protein banks, and the cultivation of maize for forage conservation. Furthermore, they have reported increases in biomass productivity of up to 50% with forage mixtures and higher-quality natural pastures, with protein levels ranging from 14% to 18%. Additionally, they have increased tree cover on farms through the implementation of live fences, which in some cases have increased by up to 80%, contributing to sustaining animal feed, especially during the most critical months (June-December), and conserving natural remnants.

Additionally, this solution has provided benefits including:

Socioeconomic

- Improvement of the living conditions of 1,056 small and medium-sized livestock producers.
- Expansion of access to water.
- Increase in meat and milk productivity, and thus the income of producers.
- Improvement sector equipment and infrastructure.
- Reduction of climate risk and vulnerability.
- Access to CSLF services and technology.
- Training of community organizations in integrated livestock management.
- Broad incorporation of women into decision-making, training, and implementation processes, as well as green financing, agricultural service centers, and communal funds.
- Creating provincial livestock networks (Napo and Manabí) and the Loja Livestock Roundtable.

Environmental

- Improvement of soil and pasture quality.
- Reduction of GHG emissions.
- Conservation and restoration of ecosystems.

Political-institutional

- Incorporating the CSLF approach into public policy instruments, the Nationally Determined Contribution (NDC) as a line of action in the agricultural sector, and local land-use planning and zoning plans.
- Strengthening sector governance through multi-actor, multi-level, and multi-sectoral coordination and cooperation.
- Developing the capacities of local officials from MAG and MAATE, parish, cantonal, and provincial governments, and livestock sector organizations.
- Strengthening of social capital through communal savings funds and agricultural service centers.

Based on the evaluation of its impacts, it was found that agricultural producers wish to continue with the CSLF approach and practices. The reason: it has allowed them to increase productivity, and they have perceived environmental benefits such as improved soil and pasture quality and greater access to water. In fact, the signing of co-execution agreements and the investment of their own resources in creating savings funds and agricultural service centers demonstrate its value within the community.

Main challenges

Among the main barriers faced by this solution was the lack of political support from government actors not involved in the project framework. This particularly affected the process of incorporating the CSLF approach into local government planning instruments and constitutes a barrier that limits its scaling and replicability.

Another obstacle was the lack of access to the national market to ensure the commercialization of surplus milk and meat production. To counteract this, it was necessary to strengthen strategic alliances with the private sector and the social and solidarity economy sector.

Finally, although the mobile applications have great potential for monitoring and evaluating various CSLF practices, their use was affected by the high socioeconomic, connectivity, and educational limitations persistent in rural areas of the country. In this sense, to utilize this technology, it will be necessary to first assess its feasibility in the context of the target communities.

Potential for expansion and replication

While the moderate complexity of the approach is a limitation for its expansion and replication, particularly at the local and community level, according to the actors involved (producers, government and FAO-Ecuador personnel, and FAO officials), it is a model to follow. This motivated the dissemination of lessons, experiences, and tools from this solution through exchanges with other teams and projects in Colombia, Uruguay, Peru, and the Dominican Republic, as well as in Europe and Asia.

Climate-smart livestock farming, Ecuador
Proyecto GCI

Solution 7

Funding conservation of mountain ecosystems and poverty reduction through a community fund, Ecuador[12]

Specific location	**Cities of Ambato, Pelileo, and Tisaleo. Province of Tungurahua**
Implementation period	**Since 2008**
Framework project	**N/A**
Adaptation at Altitude Portal Solution	Funding and implementation of climate change adaptation measures in high mountain indigenous communities through the Fund for the Tungurahua Paramos Management and the Fight Against Poverty, Ecuador
Involved actors	- Indigenous Movement of Tungurahua (MIT-FENOCIN), Movement of Kichwa Peoples and Campesinos of Tungurahua (MIT-CONAIE), and Association of Evangelical Indigenous Peoples of Tungurahua (AIET). Corporation of Campesino Organizations of Pilaguín (COCAP), Corporation of Popular and Campesino Organizations Cristóbal Pajuña (COCP), and Central Ecuadorian Agricultural Services (CESA). - Honorable Provincial Government of Tungurahua (HGPT), Association of Decentralized Autonomous Municipal Governments of the Southwestern Front, hydroelectric companies HIDROAGOYAN S.A. and HIDROPASTAZA S.A. (now known as CELEC E.P. Business Unit Hidroagoyán), Municipal Water and Sewerage Company of Ambato (EMAPA-A), and Ambato Regional North Central Electric Company (EEASA). - National Financial Corporation (legally represents the Trust and manages financial resources under the guidelines of the Fund's Technical Secretariat). - European Union (EU). - Association for Rural Cooperation in Africa and Latin America (ACRA), CONDESAN, The Nature Conservancy (TNC), Pastaza Foundation, Federation of Communes of Patate Canton (FECOPA), Institute for Ecology and Development of Andean Communities (IEDECA), Minga Foundation for Rural Action and Cooperation (MARCO), Open Hands Foundation.
Funding agencies	- The Honorable Provincial Government of Tungurahua (HGPT) together with the hydroelectric companies HIDROAGOYAN S.A. and HIDROPASTAZA S.A., the Municipal Water and Sewerage Company of Ambato (EMAPA-A), and the Ambato Regional North Central Electric Company (EEASA). - The Association for Rural Cooperation in Africa and Latin America. - CONDESAN, UE, TNC.
Compiler of the measure for Adaptation at Altitude	**Raúl Córdova**

[12] https://adaptationataltitude.org/solutions-portal/funding-and-implementation-of-climate-change-adaptation-measures-in-high-mountain-indigenous-communities-through-the-fund-for-the-tungurahua-paramos-management-and-the-fight-against-poverty-ecuador/

Tungurahua, Ecuador
Fondo de Páramos Tungurahua y Lucha contra la Pobreza

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (agriculture, livestock, pisciculture)
- Infrastructure development
- Financing mechanisms
- Research
- Community capacity building/awareness

Ecosystems

- Páramos
- High Andean Forests
- Grasslands
- Wetlands
- Peatlands
- Agricultural land

Timescale of climatic impact

Fast
Slow

Scale

Local

Level of requirements

Technical	★★☆	Infrastructure	★☆☆
Technological	★☆☆	Logistic	★☆☆
Financial	★★★	Politics	★★☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, heat stress, landslides, loss of productivity, crop loss

Progression to safety

- Risk mitigation and preventions
- Contribution to safety and sustainable livelihoods
- Reduction of dynamic pressures
- Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

N/A

ODS

1, 10, 11, 12, 13, 15

This is an adaptation measure that involves the creation of two mechanisms for the sustainable management of páramos and forests at the provincial level. One is a planning mechanism based on Páramo Management Plans (PMP) with an indigenous-peasant vision. The other is a fund to permanently finance these plans, called the Fund for the Management of Tungurahua Páramos and the Fight Against Poverty (FPLPT). The ultimate goal: **to promote and finance initiatives to conserve and protect water sources, páramos, and high Andean forests in Tungurahua, while improving the quality of life and livelihoods of its communities**.

Both mechanisms are part of a provincial governance model led by the Honorable Provincial Government of Tungurahua, called the "New Management Model." Seen as unique at the national level, it constitutes a platform for citizen participation made up of different social groups, which drives local development processes through three parliaments: Water, People, and Work, each integrated by interest groups. Thus, in 2006, the Water Parliament, the Páramos interest group, and the Tungurahua Indigenous Movements Unit proposed the creation of both mechanisms for the management of the province's ecosystems.

Community funds are highly useful financial tools for socioeconomic development. Through a trust entity, they collect donations and invest them to generate income that will then reliably and stably finance projects and programs of common benefit. This is how, since 2008, the FPLPT has mobilized approximately US$5.5 million to implement PMPs and has established agreements with national and international organizations for environmental education, training, research, and restoration.

Tungurahua, Ecuador
Fondo de Páramos Tungurahua y Lucha contra la Pobreza

What makes this experience interesting?

The PMPs, together with the FPLPT, are a progressive adaptation solution that helps counteract external dynamic pressures and root causes of vulnerability. In addition to contributing to climate action and the restoration/conservation of key ecosystems in water provision, it helps overcome social inequality and poverty by facilitating access to financing, entrepreneurship, and the commercialization of local production.

Its management scheme promotes a change in local power relations through the participation of various grassroots community organizations and the inclusion of women in the technical and promoter teams of the PMPs. Thus, although women are not yet the majority, each PMP under the Fund has a team of 54 members, 21 of whom are women, representing a significant step toward achieving gender representation and equality. Additionally, indigenous and peasant organizations, as constituent entities of the Fund, actively participate in decision-making regarding the actions of the PMPs to be financed, ranging from ecological restoration to the promotion of productive initiatives that generate added value.

Although it is a measure with very high financial requirements, it is also sustainable and replicable. In fact, its implementation in other countries demonstrates its effectiveness and flexibility. Moreover, the breadth of actors involved facilitates the joint approach to various themes and the integration of research and innovation.

Tungurahua, Ecuador
Fondo de Páramos Tungurahua y Lucha contra la Pobreza

Core activities

Organized by theme, the main activities are:

- **Ecosystem and biodiversity management**: diseño, planificación, conformación de equipos técnicos/promotores, implementación y evaluación de los PMP.
- **Water resource management**: programa de educación ambiental "Agua para el Futuro de Tungurahua" (FUTURAHUA), con la participación de las escuelas de la provincia y la Fundación Manos Abiertas (FMA).
- **Livelihoods**: fortalecimiento de empresas comunitarias y de canales de comercialización, así como capacitación/asistencia técnica en temas de producción agroecológico-agroforestal.
- **Infrastructure**: dotación y mejoramiento de infraestructuras y equipos de apoyo a la producción (sistemas de abrevaderos para el ganado, tanques y embalses comunitarios, sistemas de captura de nubes, sistemas de riego tecnificados, plantas de alimentación animal y ensilaje, sistemas de piscicultura, centros de acopio y procesamiento de leche y laboratorios para el control de calidad de la leche, entre otros).
- **Community training/awareness**: Training in efficient water management and the creation of educational materials on topics related to values, the environment, páramo and forest ecosystems, watersheds, ancestral knowledge, food sovereignty, and good environmental practices.
- **Research/monitoring**: Periodic ecological assessments of páramos, tracking of land-use changes, and participation in national and international experience-sharing events.

Benefits

The combination of PMPs and FPLPT is a strategic partnership of adaptation mechanisms that has enabled a wide variety of benefits, including:

Socioeconomic

- Financing for 15,000 families for the development of productive and conservation projects.
- Ensuring water security for the inhabitants of the cities of Ambato, Pelileo, and Tisaleo (approximately 600,000 people), who depend on water produced in the páramos managed by indigenous communities.
- Environmental education for over 12,000 children through the FUTURAHUA program.
- Improvement and diversification of the livelihoods of indigenous and peasant populations in the páramos and high Andean forests of the province.

Environmental

- Reduction of pressure on páramos and high Andean forests.
- Conservation and restoration of important páramo and high Andean forest areas, with the consequent preservation/recovery of key ecosystem functions: water regulation and supply, biodiversity, carbon sequestration, and storage. In 2019, an ecological assessment of 10 páramos where conservation and restoration actions had been carried out reported that their health status ranged from good to excellent.

Political-institutional

- Strengthening of participation, coordination, and collaboration among indigenous and peasant organizations, public agencies at different levels of government, NGOs, and private actors. Through the sustained financing of PMPs, the Fund has contributed to the "New Management Model" promoted by the Honorable Provincial Government of Tungurahua.
- Strengthening of women's participation in decision-making processes and in the implementation of PMPs.

Main challenges

Among the greatest challenges for this solution is ensuring the continuity of the Fund in the face of a potential reduction in contributions from supporting institutions, given the widespread economic crisis in the country. Additionally, there is the challenge of studying the specific socioeconomic-environmental impact of the Fund's and PMPs' actions to more deeply evaluate the scope and effectiveness of their interventions, as well as to analyze the benefits of the dialogue of knowledge between indigenous communities and technical-scientific actors.

Potential for expansion and replication

With the support of TNC and the United States Agency for International Development (USAID), the experiences of the Fund have been extended to Peru and Colombia. In Peru, two similar funds have already been created. In 2014, the Quiroz Chira Water Fund (FAQCH) was established to finance the conservation of forests and páramos in the upper Quiroz River basin, and in 2015, the Regional Water Fund (FORASAN) for the Chira-Piura basin. In Colombia, the Chinchiná River Basin Water Fund (VIVO CUENCA) was created in 2018.

It has also influenced the creation of other funds at the national level. Since 2008, two other equivalent initiatives have been developed: the Regional Water Fund (FORAGUA), created in 2009 with contributions from several municipalities in the provinces of Loja, Zamora-Chinchipe, and El Oro, and the Guayaquil Water Fund (FONDAGUA), established in 2015 for the conservation of the Daule River basin. Additionally, two other funds are in the design phase: the Portoviejo River Basin Fund, led by the municipality of Santa Ana, and the Fund for Sustainable Development and Water Conservation in Napo (FODESNA), with the support of the Napo provincial government, FAO, and international cooperation.

Furthermore, this solution has received various international recognitions. In 2019, it was ranked as the best Ecuadorian project among the 22 winners of the prestigious Equator Prize by the United Nations Development Programme (UNDP) in its 10th edition, and in the same year, it won 2nd place in the Latin America Green Awards in the sustainable finance category. At the national level, it won the Ecuador Exemplary Practices Contest 2019 in the ecosystem and biodiversity protection category and was a finalist in the Green Prize of the Development Bank of Ecuador.

Tungurahua, Ecuador
Fondo de Páramos Tungurahua y Lucha contra la Pobreza

Solution 8

Sustainable watershed management in glacial mountain ecosystems, Peru[13]

Specific location	**Departments of Áncash, Cusco, and Lima.**
Implementation period	**2011-2019**
Framework project	Glaciares+. CARE Perú and University of Zurich.
Adaptation at Altitude Portal Solution	Sustainable watershed management in glacial mountain ecosystems in Peru
Involved actors	- CARE Peru. - Glaciology Unit of the National Water Authority, regional governments of Áncash, Cusco, and Lima, Ministry of the Environment, and Ministry of Economy and Finance. - Nor Yauyos Cochas Landscape Reserve, Meteored, and Alpine Environment Research Center (CREALP). - University of Zurich and Swiss Federal Institute of Technology Lausanne (EPFL). - Beneficiary communities and their grassroots organizations.
Funding agencies	SDC
Compiler of the measure for Adaptation at Altitude	**Paul DeMerritt**

[13] https://adaptationataltitude.org/solutions-portal/sustainable-watershed-management-in-glacial-mountain-ecosystems-in-peru/

Laguna Palcacocha, Perú
Alejandra Melfo

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (agriculture, livestock)
- Financing mechanisms
- Research
- Community capacity building/awareness
- Technical training of officials and decision-makers

Ecosystems

- Wet punas
- Wetlands

Timescale of climatic impact

Fast
Slow

Scale

Sub-national

Level of requirements

Technical	★★★	Infrastructure	★★☆
Technological	★★☆	Logistic	★★★
Financial	★★★	Politics	★★★

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Floods, landslides, altered biogeochemical cycles, altered water regulation due to glacial retreat, increases erosion on slopes

Progression to safety

- Risk mitigation and preventions
- Contribution to safety and sustainable livelihoods
- Reduction of dynamic pressures
- Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

B D

ODS

13, 17

In Peru, mountain glaciers are vital sources of freshwater for human consumption, agriculture, and electricity generation. Their retreat has led to high vulnerability in various socio-ecosystems, both in terms of water security and disaster risks.

Over the last 40 years the surface area of glaciers in 18 snow-capped mountain ranges in the country has decreased by 53% due to CC, with significant negative consequences (Hou-Jones et al., 2021). This has created unstable lagoons, increased the risk of natural disasters such as landslides and flash floods, and affected freshwater ecosystems along with their flora and fauna.

To address this problem, the NGO CARE Peru, in partnership with the University of Zurich, implemented this adaptation initiative in the regions of Áncash, Cusco, and Lima. Its goal: **to sustainably manage more than 200 new lakes, combined with the protection/restoration of wetlands, grasslands, and forests, the introduction of sustainable agricultural and livestock practices, and risk management**.

Sustainable watershed management in glacial mountain ecosystems is an option that, in general terms, helps maintain the water regulation of the system, preventing floods, landslides, or severe droughts. At the same time, it helps preserve the habitats of species, often endemic, and keep the overall health of the ecosystem.

Agricultural activities, Peru
Glaciares+

What makes this experience interesting?

This is a unique Nature-based Solution (NbS) among those we have gathered here. While it has very high design and implementation requirements due to its scale and thematic scope, it is also innovative because it makes scientific knowledge about glacier melting and its effects accessible to communities. Additionally, it maximizes the co-benefits of integrating disaster risk reduction, environmental protection, climate adaptation, capacity building, livelihood opportunities for communities, and food security.

Through collective action, institutional strengthening, and the promotion of women's leadership, it also fosters effective governance, changes in power dynamics, and the incorporation of glacier melting and associated disaster risks into various public policy instruments, including plans, public investment projects, and new organizations.

Core activities

For this solution, it was first necessary to strengthen technical and operational capacities in glacier monitoring and research, bring this knowledge closer to communities, and facilitate institutional conditions to implement the actions. Then, it involved creating and strengthening local capacities for CC adaptation and reducing risks associated with glacier retreat.

From a thematic perspective, this entailed:

- Disaster risk reduction: Participatory analysis of climate risk; participatory mapping of flood-prone areas and evacuation routes; formulation and implementation of community adaptation and disaster risk management plans; and creation of early warning systems for landslides.
- Conservation and restoration of ecosystem health and services: Restoration of wetlands through replanting native species; protection of grasslands and forests around wetlands; and fencing of tributaries for natural vegetation regeneration.
- Water resource management: Formulation and implementation of water resource management plans to sustainably manage new lakes. This included strengthening water and sanitation service boards.
- Training: Training small farmers and public employees in CC adaptation, glacier monitoring and research, glacier-related disaster risk management, and integrated water resource management.
- Strengthening livelihoods: Formulation and implementation of communal sustainable grazing plans and training farmers in climate-smart agricultural practices and sustainable water use.
- Research: Monitoring and research on glaciers.
- Infrastructure: Construction of multi-sector hydraulic infrastructure and restoration of periglacial lagoons and rustic dams.

Benefits

This adaptation initiative has brought benefits in various areas, specifically:

Socioeconomic

- Protection of indigenous peoples, poor communities, and livelihoods, from natural disasters.
- Reduction of vulnerability for 70,000 people living downstream of retreating glaciers.
- Improved access to water for communities and increased economic income.
- Enhanced capacities of small farmers in CC adaptation, disaster risk management, integrated water resource management, and good practices in the use of highland water resources, such as periglacial lagoons and micro-reservoirs (cochas).
- Creation of four women-owned enterprises to sustainably produce and market products such as coffee, passion fruit, and honey.
- Promotion of women's leadership in public offices, local organization executive boards, and Water and Sanitation Service Boards (JASS).

Environmental

- Emergence of new watering holes for wildlife and restoration of mountain grasslands.
- Protection and restoration of 143 hectares of wetlands and 11 springs.
- Sustainable management of new lakes and water resources in general.
- Reduction of grassland degradation due to overgrazing.

Political-institutional

- Creation of alliances between the Ministry of the Environment, the National Water Authority, the General Secretariat of Disaster Risk Management of Peru, the Ministry of Economy and Finance, and research institutions such as the University of Zurich and the University of Cusco.
- Establishment of the National Institute of Glaciers and Mountain Ecosystems.
- Incorporation of scientific information on the effects of CC on glaciers and other natural resources, community-based adaptation approaches, and specific themes such as disaster risk reduction and integrated water resource management, into development plans.
- Promotion of multi-purpose projects for environmental protection and management.
- Strengthening of collective management of natural resources and climate risks.
- Strengthening of cooperation and coordination between government authorities, academia, private companies, and grassroots community organizations.
- Promotion of institutional conditions for the sustainability of glacier monitoring and research. This has allowed researchers to use more data to inform the design of NbS and create a virtuous cycle of planning-implementation-information generation.
- Establishment of scientific collaboration networks.
- Integration of risk management options, such as landslide early warning systems, into the priorities of public and civil society partners.

Huascarán National Park, Perú
Alejandra Melfo

Main challenges

One of CARE's main roles was to ensure connections among stakeholders, and to align policies from the local to the national level to create an environment conducive to the sustainability of the solution's various actions. However, the greatest challenges arose in the political-institutional realm due to:

1. The rotation and turnover of personnel in public sector partners, which disrupted stakeholder engagement processes.
2. Difficulties in coordinating multi-sectoral partners, which delayed baseline assessments and monitoring.
3. A lack of familiarity with the approaches used in the solution. This required additional time and resources to justify its actions and to formulate policies and procedures to support its implementation and maintenance.

Potential for expansion and replication

As glaciers continue to retreat at an accelerated pace, NbS alone are not sufficient to manage water resources so that the growing demands of the population are met, while further loss of crucial habitats such as wetlands is also prevented. Thus, their combination with gray infrastructure, such as dams, can help ensure long-term management while addressing immediate needs for irrigation, fishing, and energy generation.

The Glaciares+ project has built capacities for climate adaptation among public sector partners, civil society, and the community, helping to integrate adaptation priorities into the budgets, policies, and procedures of numerous ministries, from the local to the national level. This creates a conducive environment for scaling up and replicating glacier melt management measures in other areas of Peru and in other countries in the region, as Glaciares+ has participated in numerous national and international forums and workshops, sharing lessons learned from its implementation.

Solution 9

Conservation/restoration of Queuña Forests (Polylepis Spp.) and creation of private conservation areas, Peru[14]

Specific location	**Vilcanota-Urubamba Mountain Range.**
Implementation period	**2000-2025**
Framework project	"Andean Action" Program Andean Ecosystems Association (ECOAN).
Adaptation at Altitude Portal Solution	Conservation of Queuña forests (Polylepis spp.) of Vilcanota range, Peru
Involved actors	- Ministry of the Environment (MINAM) and National Service of Natural Protected Areas by the State (SERNANP). - Andean Ecosystems Association (ECOAN), Global Forest Generation, and American Bird Conservancy. - Beneficiary communities. - Local business sector.
Funding agencies	- Global Forest Generation (GFG). Conservation International Trust Fund - Green Climate Fund (CI-GCF). - Green Finance for Latin America and the Caribbean (www.greenfinancelac.org). - Americas Fund for Peru (FONDAM). Since 2018, the measure became part of the Andean Action Project, with Global Forest Generation (GFG) as the main sponsor and donor, in coordination with many other global sponsors.
Compiler of the measure for Adaptation at Altitude	**Cecilia Hegoburu**

[14] https://adaptationataltitude.org/solutions-portal/conservation-of-queuna-forests-polylepis-spp-of-vilcanota-range-peru/

Queñua, Perú
Arthur Chapman

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (agriculture, livestock, ecotourism)
- Community capacity building/awareness

Ecosystems

Wet punas

Timescale of climatic impact

Fast
Slow

Scale

Sub-national, several countries

Level of requirements

Technical	★★★	Infrastructure	★★☆
Technological	★★☆	Logistic	★★☆
Financial	★★★	Politics	★★☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Altered growth regimes, sequía, heat stress , forest fires

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

N/A

ODS

1, 5, 6, 8, 13, 15, 17

The Queuña forests are a unique ecosystem of the Andes. Composed mainly of trees and shrubs of the *Polylepis Spp.* genus, they survive under extreme conditions of altitude, cold, and dryness, forming islands of rich biodiversity. They are distributed from Venezuela and Colombia to northern Chile and central Argentina, and it is estimated that only about 500,000 hectares of this ecosystem remain.

In addition to their intrinsic importance, these forests hold significant cultural value for indigenous peoples and are crucial for addressing the effects of CC Their functions of water regulation and provision benefit numerous Andean and Amazonian communities, and their control of erosive processes reduces the risk of disasters in local communities.

In the Vilcanota-Urubamba mountain range (southeast Peru), these forests have significantly retreated due to human activity. In response to this, the Andean Ecosystems Association (ECOAN) together with local communities decided to implement this measure that integrates conservation, restoration, and ecotourism through an ancestral practice: communal work called Ayni, Minka, or Minga, and the creation of Private Conservation Areas (ACP).

Ayni, or reciprocity, is a fundamental principle in the indigenous cultures of the Andes, especially among the Quechua and Aymara. It is based on reciprocity, collaboration, solidarity, and community responsibility, and permeates various aspects of life: work, emergency response, knowledge transmission, and the exchange of goods.

ACPs, on the other hand, are private initiatives created and managed by individuals or legal entities, in synergy with Peruvian environmental authorities. They constitute a legal means to generate payments for ecosystem services, promote conservation and the reconnection of fragmented ecosystems, encourage ecotourism, and benefit local communities.

Building on these political, legal, and cultural advantages, this solution drove the replanting of eight species of the *Polylepis* genus and other native species, as well as the creation of 9 ACPs where ecotourism routes are developed. This was accompanied by actions to improve local living conditions, train communities in restoration, environmental management, and more sustainable agricultural practices, and monitor reforested areas.

Queñua, Perú
Global Forest Generation F Kaiser

What makes this experience interesting?

This is a Nature-based Solution (NbS) combined with progressive adaptation actions. It leverages local knowledge and traditions around community work and uses them to develop large-scale restoration activities involving beneficiaries throughout the process: from the installation of nurseries to transplantation. A solution of this scale would be impossible to achieve otherwise.

Additionally, it takes advantage of the resources provided by the Peruvian state to stimulate conservation: ACPs and mechanisms for retribution for ecosystem services (MERESE). Thanks to this, communities are directly involved in conservation commitments, receive compensation for their efforts, and promote bio-business schemes such as ecotourism.

Core activities

The main actions of this solution were:

- **In restoration:** creation of maps of the areas to be intervened, their forests, reforestation zones, and conservation zones; establishment of communal nurseries using genetic material from nearby forests; technical training of locals in the management and coordination of seedling production, nursery installation, and transplantation; monitoring of area conditions before and after planting through the "Explorer Land" platform, and creation of the Queuña Raymi festival, a reforestation festival involving the participating communities.
- **In conservation:** creation of ACPs recognized by the Ministry of the Environment (MINAM).
- **In livelihood strengthening:** improvement of pastures by incorporating seeds of more palatable species for livestock; installation of greenhouses or shade structures to enhance vegetable production for domestic consumption, and creation of Vilcanota Trek [http://www.vilcanotatrek.com], a rural tourism network of communities of the Vilcanota mountain range, operating within various ACPs.
- **To improve living conditions:** installation of solar panels and domestic gas in target communities, as well as internet service.

Benefits

The ancestral organization of the community and the culture of working for the common good contributed to the solution achieving a notable impact in the forest restoration process. Additionally, its actions contributed to the following benefits:

Socioeconomic

- Strengthening the livelihoods of 21 rural communities comprising 8,650 Quechua people.
- Improving the living conditions of these communities through the provision of basic services.
- Promoting ancestral practices of social work.
- Creating capacities and transferring knowledge to the communities.

Environmental

- Restoring *Polylepis* forests and their ecosystem services.
- Protecting watershed headwaters.

Political-institutional

- Strengthening cooperation between authorities, the private sector, NGOs, and community-based organizations.
- Creating 9 ACPs recognized by MINAM.

Comunidad Quelcanca, Perú
Gregorio Ferro M

Main challenges

Implementers did not report any challenges or barriers in this case.

Potential for expansion and replication

The *Polylepis* forest reforestation project is already expanding, but it still requires significant efforts because Peru hosts the greatest diversity of trees of this species and, consequently, the needs are very extensive.

To replicate an adaptation measure like this, it is recommended to select social groups and/or communities that practice communal work or have a communal structure, and depending on the scope of the objectives pursued, it will be necessary to have personnel from various specialties, including nursery workers, agronomists, lawyers, biologists, and GIS engineers, among others.

Queñua, Perú
Isidro Reajar

Solution 10

Multipurpose water management in the context of climate change, Bolivia[15]

Specific location	**Provinces of Larecaja, Los Andes, and Pedro Murillo. Department of La Paz.**
Implementation period	**2015-2023**
Framework project	Bolivia's Strategic Program for Climate Resilience (SPCR). Ministry of Environment and Water, and Ministry of Planning.
Adaptation at Altitude Portal Solution	Multipurpose Drinking Water and Irrigation Program for the Municipalities of Batallas, Pucarani, and El Alto, Bolivia
Involved actors	- Water user associations of Batallas and Pucarani. - Ministry of Environment and Water, Environmental and Water Executive Agency, and autonomous municipal governments of Batallas and Pucarani. - IDB.
Funding agencies	- IDB - Strategic Climate Fund. - Nordic Development Fund.
Compiler of the measure for Adaptation at Altitude	**Julia J. Aguilera**

[15] https://adaptationataltitude.org/solutions-portal/multipurpose-drinking-water-and-irrigation-program-for-the-municipalities-of-batallas-pucarani-and-el-alto-bolivia/

Multipurpose water management, Bolivia
EMAGUA

Themes

- Ecosystem and biodiversity management
- Water resources management
- Infrastructure development
- Livelihoods (agriculture, livestock)
- Community capacity building/awareness

Ecosystems

- Wet punas
- Grasslands
- Agricultural land

Timescale of climatic impact: Fast, Slow

Scale: Sub-national

Level of requirements

Technical	★★☆	Infrastructure	★★★
Technological	★★★	Logistic	★★☆
Financial	★★★	Politics	★★☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, heat stress, loss of productivity, diminished food security

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target: B E F

ODS: 1, 2, 3, 5, 6, 8, 9, 11, 12, 13, 15

Since 2014, the water supply for the city of El Alto has been a concern. The Metropolitan Master Plan for Drinking Water and Sanitation of La Paz and El Alto highlighted that, given the expected population growth by 2036, the city will require approximately 54.4 million m³ of water annually; however, by 2012, the two supply systems were already delivering 38.9 million m³, and their sources could not provide more (IDB, n.d.).

To address this issue, 11 different alternatives were studied to increase the water supply for the city. The best option was to capture and transport the surplus water from the Jacha Jahuira and Khullu Cachi river basins (IDB, n.d.). However, in these basins, where the municipalities of Pucaraní and Batallas are located, basic needs of the rural populations were not met, and irrigation systems were outdated and inefficient. In this context, it was decided to **jointly address the water requirements of El Alto and both municipalities by implementing a multipurpose water management scheme that considers CC resilience aspects**.

This approach to water management aims to optimize water use to meet multiple human and environmental needs without compromising its future availability, harmonizing the attention to different demands and providing infrastructure for water capture, transport, and distribution. As an adaptation measure, it promotes water security in the face of CC, ensuring access to water in terms of quality and quantity.

Multipurpose water management, Bolivia
EMAGUA

What makes this experience interesting?

This is a complex option for a complex problem. It constitutes a progressive adaptation measure that, under the watershed management approach, seeks to ensure water access for both a rapidly growing city and several rural communities, combining climate action and sustainable development.

Although it is not entirely reversible due to the infrastructure it involves, it is viable and sustainable. Additionally, it promotes the fair distribution of water resources and contributes to overcoming poverty and generating benefits in the context of CC. It encourages a change in water consumption patterns; involves communities, including youth and children; considers cultural diversity; promotes the role of women; and strengthens local capacities for joint decision-making.

It has high requirements, especially in the technological, economic, and infrastructural realms, and its replication will likely require financial support and the collaboration of various public entities at different levels. In this sense, stakeholders will need to dedicate significant efforts to its design, implementation, and maintenance.

Core activities

After a process of community consultations conducted in indigenous languages and negotiations between the Ministry of Environment and Water (MMAyA) and communities with prior rights to irrigation and direct water consumption in the Jacha Jahuira and Khullu Cachi basins, a set of activities was initiated, including:

- **Basic studies**: environmental and social impact assessments of the water capture and transport works for El Alto, and technical, economic, social, and environmental evaluations of the project.
- **In terms of infrastructure**: construction of water capture and transport works.
- **In the realm of sustainable resource use**: design of various plans (Environmental and Social Management Plan, Compensation and Social Management Plan, Integrated Watershed Management Plan with CC considerations, and Resettlement Plan).
- **To better understand the impacts of CC on the hydrological cycle of the basins**: installation of a hydrometeorological monitoring system.
- **In community training and awareness**: education of women, children, and youth on water use and health-related topics, and training of producers on agricultural productivity with CC adaptation, community organization, and management of new irrigation systems. The latter was done through a Comprehensive Technical Assistance Plan.

In exchange for the diversion of water from the Jacha Jahuira and Khullu Cachi basins, the MMAyA committed to investing in addressing local needs. This involved the development of other infrastructure-related actions: expansion and modernization of irrigation systems, redesign of existing dams, and provision of drinking water to 13 communities in the municipality of Batallas. Irrigation associations took responsibility for operating the irrigation works, and the autonomous municipal governments of Batallas and Pucarani committed to maintaining them. For this, an agreement was signed with the MMAyA.

Benefits

This measure addresses the increase in drought conditions through the use of modern technology in irrigation systems, the creation of dams to capture glacier runoff as their melting accelerates, and a system of plans to harmonize conservation, sustainable water use, and social development. This has resulted in benefits in the following areas:

Socioeconomic

- Increased water access for 185,000 households and for irrigation of farmland and pastures for 6,600 low-income farmers.
- Implementation of productive initiatives for women.

Environmental

- Conservation of watersheds.
- Sustainable management of water resources.

Political-institutional

- Creation of the Multipurpose Program Management Office (MPMO) under the organizational structure of the Environmental and Water Executive Agency (EMAGUA). This is the governmental body responsible for the execution, monitoring, and evaluation of the framework program.
- Strengthening of collaborative work between communities and political actors.

Multipurpose water management, Bolivia
EMAGUA

Main challenges

The environmental and social impact assessment of the solution identified several environmental and social risks, including impacts on habitats and natural resources, economic displacement, and impacts on the livelihoods of several indigenous communities. These risks played a crucial role in the execution of the above mentioned plans, which were formulated and implemented taking them into account.

Potential for expansion and replication

The solution addresses one of the gradual effects of CC: the increase in drought conditions. Although there is no information yet on the possible expansion of this solution, given its status as a pilot experience, for its replication, implementers recommend continuing to study and consider future climate scenarios.

Solution 11

Pastoreo sostenible y manejo de humedales con acciones de restauración, Argentina[16]

Specific location	**Laguna de los Pozuelos Biosphere Reserve. Province of Jujuy.**
Implementation period	**2017-2024**
Framework project	Program "Saving High Andean Wetlands for People and Nature". Wetlands International/Wetlands Foundation
Adaptation at Altitude Portal Solution	Ecosystem Conservation and Restoration in Laguna de Los Pozuelos, Argentina
Involved actors	- Communities of Pozuelos, Rodeo and Pasajes, Ciénaga Grande, and Lagunillas de Pozuelos. - National Parks Administration (APN), Secretariat of Environment, Secretariat of Family Agriculture, and National Institute of Agricultural Technology (INTA). - Wetlands International / Wetlands Foundation
Funding agencies	DOB Ecology
Compiler of the measure for Adaptation at Altitude	**Cecilia Hegoburu, Emilie Dupuits**

[16] https://adaptationataltitude.org/solutions-portal/ecosystem-conservation-and-restoration-in-laguna-de-los-pozuelos-argentina/

Laguna de Pozuelos, Argentina
Wetlands Int

Themes

- **Ecosystem and biodiversity management**
- **Water resources management**
- **Livelihoods (livestock)**
- **Community capacity building/awareness**

Ecosystems

- **Xerophytic puna wetlands**
- **Grasslands**

Timescale of climatic impact

Fast
Slow

Scale

Local

Level of requirements

Technical	★★★	Infrastructure	★☆☆
Technological	★★☆	Logistic	★☆☆
Financial	★★☆	Politics	★☆☆

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, temperature rise, altered growth regimes, loss of productivity, diminished food security

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ○ Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

G

ODS

11, ,12, 13, 17

The high Andean wetlands of Laguna de los Pozuelos are "hydroecosystems" whose water accumulation and regulation services, in an arid zone like the high plateau of the Province of Jujuy, are key for the climate resilience of the region, as well as for the local communities that rely on grazing llamas and sheep. However, they face three degradation factors: drought due to CC, overgrazing, and changes in land use.

With this in mind, local communities, along with government actors and Wetlands International, chose to integrate social development and conservation through the **implementation of more sustainable grazing practices and wetland restoration actions**. For this, they formulated a Livestock Grazing Management Plan as well as a Wetland Management and Restoration Plan. Additionally, they developed technological solutions to counteract water loss problems caused by evaporation and contamination.

Sustainable grazing is a form of livestock management that harmonizes herd rearing with environmental conservation, considering the environmental impact of the activity and the fragility of ecosystems. In general terms, it involves controlling the number of animals per unit area (animal load) to prevent overgrazing and soil degradation; rotating grazing areas and diversifying forage species. Furthermore, its combination with wetland restoration enhances its scope, as it helps improve water retention and distribution.

Laguna de Pozuelos, Argentina
Kimon Berlin

What makes this experience interesting?

This is a Nature-based Solution (NbS) and a progressive adaptation measure that brings together communities and local actors to restore wetlands through the construction of small dams (azudes); a technique that allows for the restoration and increased productivity of wetlands and the recovery of grazing areas. Additionally, it includes actions that transform open artificial watering holes into closed wells with hydraulic pumps, promoting efficient water use. In this way, it contributes to addressing the water stress caused by variability and CC.

On the other hand, its training actions create greater awareness of the importance of wetlands and their ecosystem services, while strengthening the technical knowledge of herders and the community in general on better grazing practices and wetland management/-conservation.

It is a solution with high technical requirements but lower demands in the technological and economic realms. Moreover, thanks to its combination of quick and slow results, implementers and the community will begin to observe simple changes early on, while more complex ones develop over time.

Core activities

The nine communities settled around the lagoon decided to organize and conduct visits to farms with the purposes of understanding water scarcity-related problems; discussing perceptions about precipitation variability and drought caused by CC, and analyzing their impact on pastures and the local economy.

Based on this knowledge and in community assemblies, residents and technicians established priorities and decided to:

- Implement better grazing management practices, such as rotating livestock in paddocks and controlling animal load. This way, part of the forage is conserved for the dry and cold season.
- Manage and restore wetlands through the construction of leveling dams, sediment embankments, fencing of wetlands, and the creation of watering holes for rainwater capture (Sosa et al., 2022).
- Formulate a Biosphere Reserve Management Plan and a Livestock Grazing Management Plan, ensuring their integration.
- Combine scientific studies with ancestral knowledge through the formation of a field network.
- Install solar water pumps to extract groundwater and supply closed wells, and establish commitments with producers to avoid water loss.

Additionally, significant efforts were made to expand community capacities in sustainable livestock and agriculture, as well as to promote the active exchange of experiences and lessons learned at the local and regional levels. Similarly, agreements were signed with those responsible for mining extraction to facilitate water quality studies and community monitoring and control.

Laguna de Pozuelos, Argentina
Ron Knight

Benefits

Socioeconomic

- Strengthening the livelihoods of 150 families through better livestock grazing practices.
- Capacity building and knowledge transfer to communities and local government actors.

Environmental

- Management and restoration of 45 hectares of wetlands, which, in addition to generating vital ecosystem services for life and the local economy, represent invaluable cultural heritage for many rural communities and indigenous peoples.
- Generation of knowledge about wetland ecology, current uses, and the threats they face in the reserve.
- Management and restoration of wetlands.
- More sustainable management of 6,040 hectares of pastures.

Political-institutional

- Empowerment of provincial public authorities in the collaborative formulation of plans with communities.
- Creation of two new management instruments: Biosphere Reserve Management Plan and Livestock Grazing Management Plan.
- Consolidation of strategic alliances and agreements for the development of a regional wetland conservation program across the entire puna.

Laguna de Pozuelos, Argentina
Kimon Berlin

Main challenges

In this solution, the greatest challenge was multisectoral coordination, as it required agreement among stakeholders involved in wetland conservation, agricultural and livestock production activities, and mining.

Potential for expansion and replication

The objectives of Wetlands International and local actors are to scale up the solution through knowledge platforms, to showcase conservation and restoration options. Similarly, to use the experience of binational cooperation between Argentina and Peru in the conservation of high Andean wetlands, with the aim of working in the future with Chile and Bolivia. For this, the Wetlands Foundation participated in 2020 in the launch of the Wetland Restoration Working Group of the 20×20 Initiative, which is promoted by the Bonn Challenge and facilitated by the World Resources Institute (WRI), as an effort by countries to achieve the restoration of 20,000 hectares of wetlands by 2020.

Solution 12

Strengthening municipal environmental governance and promoting good productive practices, Chile[17]

Specific location	**Municipality of San José de Maipo. Metropolitan Region of Santiago.**
Implementation period	**2016-2021**
Framework project	**"Protection of Biodiversity and Multiple Ecosystem Services in the Mountain Biological Corridors of the Mediterranean Ecosystem of Chile" (GEF-Montaña).**
Adaptation at Altitude Portal Solution	Protecting Biodiversity and Multiple Ecosystem Services in Mountain Biological Corridors of the Mediterranean Ecosystem in the Santiago and Valparaíso regions, Chile (GEF-Montaña)
Involved actors	- Association of Rural Municipalities, Cordillera Park Association, and other civil society organizations. - Small, medium, and large forestry, agricultural, livestock, and tourism producers. Owners of non-agricultural lands in mountainous areas, ski resorts, and mining companies. - Provincial and municipal governments of the target area, and local public institutions (Municipal Museum of Natural Sciences and Archaeology of San Antonio). - Ministry of the Environment (MMA; Division of Natural Resources and Biodiversity, Division of Education and Local Environmental Management, Division of Economics and Environmental Studies), Ministry of Agriculture (MINAGRI), National Forestry Corporation of Chile (CONAF; MINAGRI), Clean Production Council (Ministry of Economy), Institute of Agricultural Development (INDAP), Undersecretariat of Regional Development (SUBDERE, Ministry of Public Works), National Production Development Corporation of Chile (CORFO; Ministry of Economy), National Tourism Office of Chile (Ministry of Economy), Office of Agricultural Studies and Policies (ODEPA), and the Regional Ministerial Secretaries (SEREMI). - Sendero de Chile, Sustainable Chile Program, Foundation for Overcoming Poverty "Servicio País," Fundación Chile, Society of Forest Engineers for Native Forests, Adapt-Chile, and the EPIC Program of the Wildlife Conservation Society (WCS) of TNC. - University of Chile (Faculty of Agronomic Sciences, Department of Environmental Sciences, Faculty of Forestry Sciences, Center for Wildlife Studies), Institute of Ecology and Biodiversity (IEB), Universidad Mayor, Center for Research in Natural Resources (OTERRA, Center for Ecotoxicological Research (CIE)), Center for Advanced Research in Arid Zones (CEAZA), Pontifical Catholic University of Chile (Center for Advanced Research in Ecology and Biodiversity (CASEB), and Center for Sustainable Urban Development (CEDEUS, Department of Agricultural Economics)).
Funding agencies	- GEF, through UNEP. - Partner and implementing organizations and institutions of the project.
Compiler of the measure for Adaptation at Altitude	**Emilie Dupuits**

[17] https://adaptationataltitude.org/solutions-portal/protecting-biodiversity-and-multiple-ecosystem-services-in-mountain-biological-corridors-of-the-mediterranean-ecosystem-in-the-santiago-and-valparaiso-regions-chile-gef-montana/

Metropolitan region, Chile
Gef Montaña

Themes

- Ecosystem and biodiversity management
- Water resources management
- Livelihoods (agriculture, livestock, beekeeping)
- Monitoring
- Community capacity building/awareness
- Technical training of officials and decision-makers

Ecosystems

- Sclerophyllous forests
- Wetlands
- Mediterranean scrublands

Timescale of climatic impact

Fast
Slow

Scale

Sub-national

Level of requirements

Technical	★★★	Infrastructure	★☆☆
Technological	★★☆	Logistic	★☆☆
Financial	★★★	Politics	★★★

Social challenge faced

- Adaptation to and mitigation of CC
- Natural disaster risk reduction
- Reversal of ecosystem degradation and biodiversityloss
- Socioeconomic development
- Food safety
- Water security
- Human health

Climatic risk

Droughts, forest fires

Progression to safety

- ○ Risk mitigation and preventions
- ● Contribution to safety and sustainable livelihoods
- ● Reduction of dynamic pressures
- ○ Root causes addressed

Actors involved

- Community
- NGO
- Academic
- Private sector
- Government

Sendai target

B G

ODS

11, 12, 13, 15, 17

In central Chile, where the Metropolitan Region of Santiago is located, there is a network of high biodiversity value sites that are at risk. Although various strategies have been implemented to counteract anthropogenic pressures on the natural environment, institutional responses have often been limited due to lack of resources, coordination problems, insufficient environmental-territorial information for decision-making, limited local concern for biodiversity conservation, inadequate legal protection of ecosystems, and scares political commitment.

To address this issue and contribute to the development of public-private initiatives aimed at conserving biodiversity and protecting or enhancing the benefits provided by mountain ecosystems, it was decided to implement this solution focused on **developing local environmental governance**. For this purpose, the plan included strengthening municipal capacities in biodiversity, water, and soil management and conservation; promoting and implementing better practices in tourism, agriculture, livestock, and forestry activities; and developing a pilot experience of "Integrated Conservation Districts for Soils, Forests, and Waters."

Environmental governance is a decision-making and power-exercising framework in the realm of environmental management, essential for addressing current challenges in ecosystem conservation and their services. Its utility lies in its ability to more effectively tackle increasingly complex environmental problems through integrated solutions involving multiple stakeholders, aiming to ensure long-term sustainability and environmental justice.

However, achieving this requires governmental and non-governmental institutions with the technical and financial capacity to implement environmental policies, interinstitutional cooperation, the generation and use of scientific knowledge for informed decision-making, citizen participation, and monitoring and evaluation. In this sense, its development and consolidation largely depend on the capacities of the relevant public institutions. This solution was proposed to address these issues.

Biodiversity Information and Monitoring System, SIMBIO, Chile
Gef Montaña

What makes this experience interesting?

This is a Nature-based Solution (NbS) and a progressive adaptation measure that stands out within the set we have gathered here, because its focus is on institutional capacities and the promotion of political initiatives to conserve the Mediterranean ecosystem of Chile. Therefore, actions aimed at technical training, the design of good environmental management practices, the formulation of environmental management instruments, monitoring, and the development of pilot experiences in restoration and the creation of conservation figures carry significant weight.

Its technical, economic, and political requirements are high, but logistical and infrastructural ones are low. It is viable thanks to the collaboration of stakeholders from various sectors, replicable and sustainable, and its results can be tracked, measured, and evaluated. Additionally, by promoting more sustainable productive practices, it strengthens agriculture, livestock, and beekeeping, contributing to poverty alleviation and generating benefits within the framework of CC.

Biodiversity Information and Monitoring System, SIMBIO, Chile
Gef Montaña

Core activities

- **Concerning strengthening municipal capacities in biodiversity, water, and soil management and conservation**: preparation of the study *Floristic and Vegetative Survey in the Area of the GEF Mountain Biological Corridors Project*; creation of maps of areas vulnerable to CC, to propose restoration and training for municipal technicians; training of these technicians in Mediterranean ecosystem conservation and reducing vulnerability to CC effects; creation of a diploma program for environmental professionals, and preparation of the manual *Good Municipal Practices for Biodiversity Management*, which compiles environmental management experiences from 18 municipalities in the Valparaíso and Metropolitan regions. This also included the formulation of eco-local plans at a landscape scale in 36 municipalities (including San José de Maipo), which integrate the ecological dimension into the territorial planning of the municipalities and guide the work of various actors toward the protection of biodiversity and ecosystem services in the natural areas of the municipalities. Similarly, it involved the organization of workshops for the formulation of the District Master Conservation Plan for the municipality of San José de Maipo and the creation of a Municipal Natural Reserve (RENAMU), in coordination with a municipal environmental ordinance.
- **In terms of promoting and implementing more sustainable productive practices**: formulation, in collaboration with the community of Las Tórtolas (San José de Maipo municipality), of a Pilot Livestock Plan to promote more sustainable land management and regenerative livestock farming. It also included the design of a series of good productive practices: organic beekeeping, aimed at honey producers who want to produce chemical-free honey; BIO + Forest Management, to recover and restore the natural functionality of altered sclerophyllous forests and degraded soils; new technologies to address the drought affecting central Chile, using crops adapted to arid zones combined with rainwater harvesting systems, and regenerative mountain livestock farming, which seeks to modernize and reconcile livestock production methods with the conservation of mountain ecosystems.
- **In monitoring**: installation of the first long-term monitoring site of the GLORIA-Andes network in the region (Río Clarillo Reserve).

Benefits

De esta solución han derivado beneficios en los siguientes ámbitos:

Socioeconomic

- Strengthening of livelihoods in 30 municipalities in the Metropolitan Region and 6 in the Valparaíso Region, through more sustainable agricultural production.

Environmental

- Protection of forests and ecosystem services in the municipality of San José de Maipo, through the first "Conservation District for Soils, Waters, and Forests."
- Reduction of the negative impact of some productive activities on local biodiversity.

Political-institutional

- Promotion of environmental management as a strategic axis of local policies and good environmental governance practic-es.Strengthening of municipal environmental units, incorporating traditional environmental issues as well as biodiversity, water, and soil management and conservation.
- Strengthening of environmental governance in the 36 target municipalities with wilderness areas.
- Generation of information on flora species and vegetation formations from 9 provinces in the Metropolitan and Valparaíso regions, for the Biodiversity and Ecosystem Services Information and Monitoring System (SIMBIO) of the Metropolitan Region.
- Adoption of environmental policies at the municipal level and adaptation of these policies to local needs.
- Implementation of pilot experiences in sustainable land and forest management, restoration, and conservation.

Sustainable livestock farming, Chile
Gef Montaña

Embalse El Yeso, San Jose de Maipo. Chile
Jamie Tanelo

Main challenges

The most significant challenge in this solution was adapting and articulating subnational coordination spaces for CC adaptation to local needs and realities. This was compounded by difficulties in overcoming local communities' resistance to adopting conservation practices for transitioning to a regenerative livestock model.

Potential for expansion and replication

The results of this solution have led to a positive impact on biodiversity conservation, improved land management, and the restoration of environmental services. Although this is still at the pilot/local level, there is a favorable environment for its replication and scaling up.

Strengthening municipal capacities for environmental governance through the Conservation Districts figure represents an opportunity to influence the national process of intersectoral articulation between the Ministries of Environment and Agriculture, as well as between environmental conservation objectives and productive development.

6.

The current path of adaptation for climate-resilient development in the andes

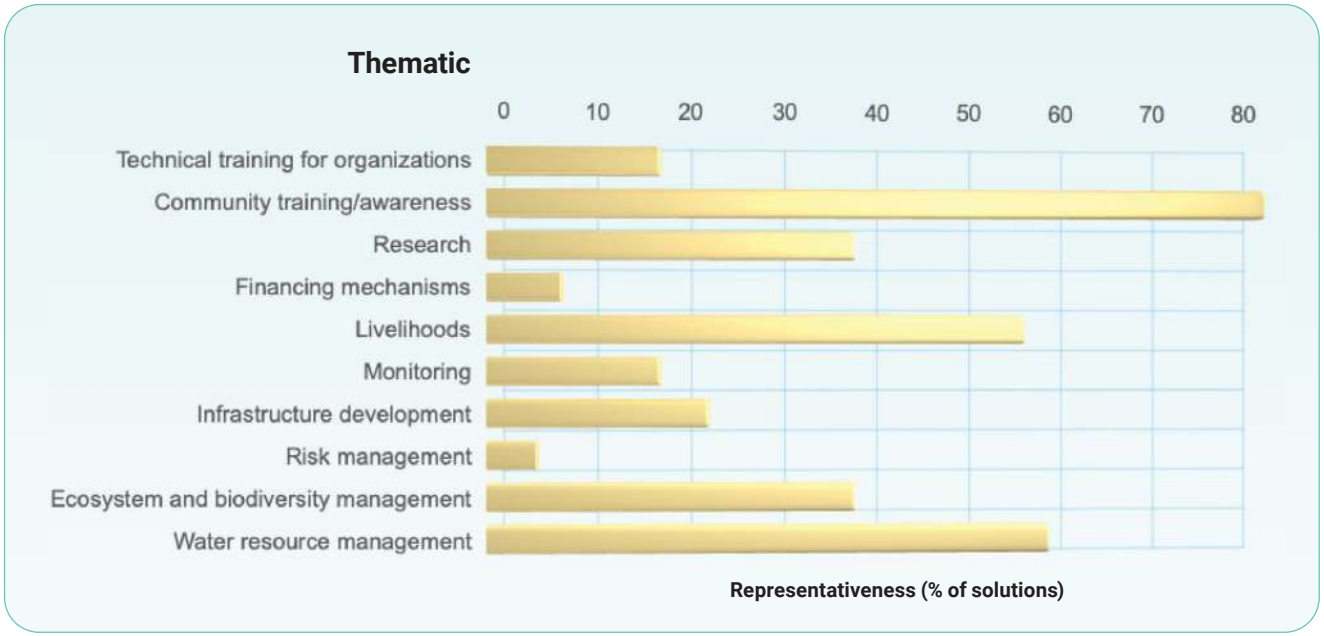


Figure 8. ***Thematic representativeness of the 40 analyzed solutions***

Although we selected 12 out of a total of 40 adaptation measures for this catalog, the selection process led us to a detailed review of all of them and a joint analysis, which allowed us to generate a regional perspective on the current path of CC adaptation in the Andes, its strengths, and challenges for the future.

The measures we present, like the other 28, are characterized in all cases by addressing three or more themes simultaneously, with focus in the preservation of the water regulation capacity of ecosystems. Thus, in order to anticipate a potential reduction in water supply, most solutions include water resource management combined with community training/awareness to reduce their vulnerability to the effects of climate change; strengthening of livelihoods, particularly in agriculture and livestock, to make them more sustainable and resilient to variability in rainfall and temperatures; and management of ecosystems and biodiversity (Figure 8).

Thanks to the experiences described here, such as the Tungurahua Fund and GCI in Ecuador, or the protection of Queuña forests in Peru, it is evident that other topics are also gaining ground in the field of CC adaptation in the Andes. These include strengthening local governance and social capital; the development of various financial mechanisms for conservation/adaptation initiatives; the creation of private conservation areas; and paying for ecosystem services. Other solutions being developed in the region also reflect this, such as those implemented in Peru: payment for ecosystem services in the Cañete River basin; restoration, conservation, and expansion of mountain grasslands and wetlands in Canchayllo; and restoration of ancient water management systems in the high Andes in Miraflores.

General features of adaptation solutions

The 40 analyzed adaptation solutions are geographically distributed throughout the Andes (Figure 9). They share common general features: a local scale of work addressing multiple communities or localities simultaneously; collaborative work with community and governmental actors; a combination of quick-start and slow-start actions that allow for early results while achieving more complex outcomes; and a high heterogeneity in implementation timeframes (Figures 10 to 12).

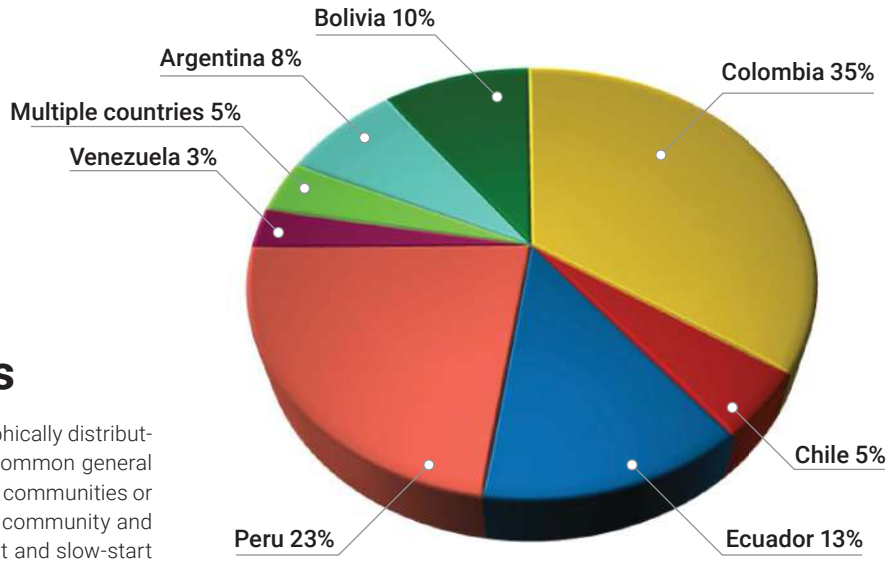


Figure 9. ***Percentage distribution of the 40 analyzed solutions, by country of implementation***

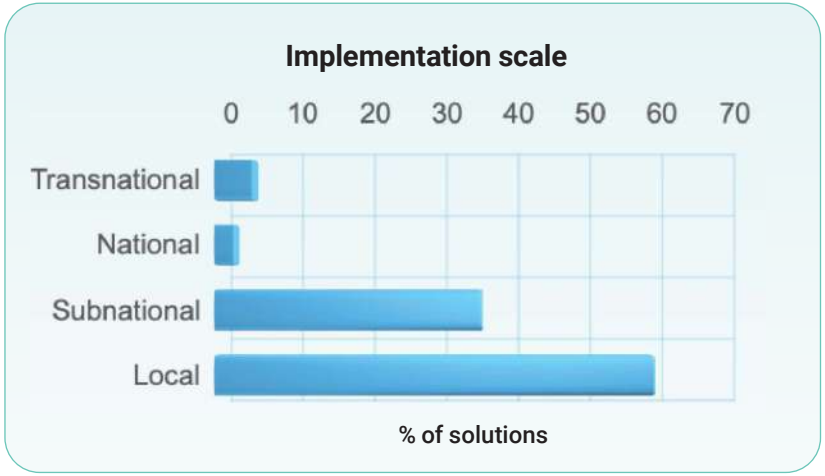


Figure 10. ***Percentage distribution of the 40 analyzed solutions, by implementation scale***

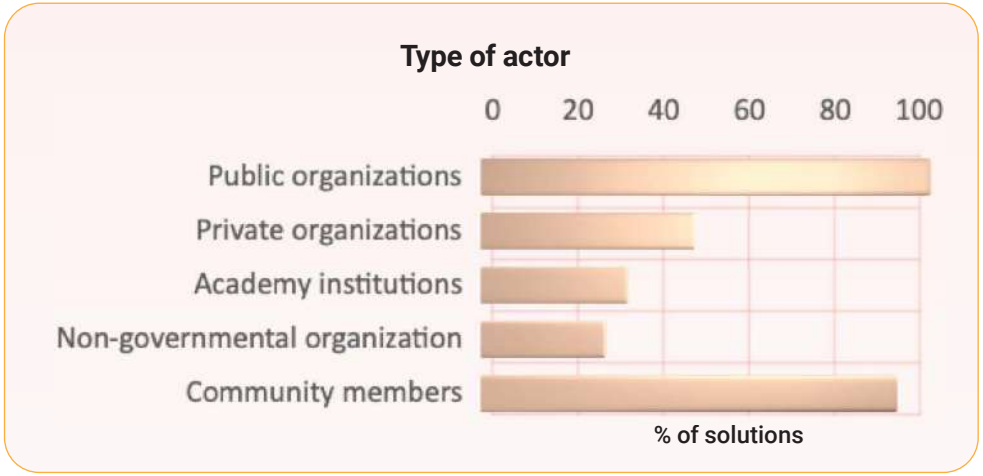


Figure 11. ***Percentage distribution of the 40 analyzed solutions, by type of actor involved***

Additionally, in general, the solutions we analyzed have low to medium level of technical, technological, economic, infrastructural, logistical, and political requirements, making them accessible to various types of actors (Figure 13).

Based on the reports in the systematization sheets of the measures, 28 of the 40 solutions can be implemented with:

- A small number of specialists (which is not the same as a small group of implementers).
- Technologies that can, through training, be managed by community members, like geographic information systems or monitoring equipment.
- Infrastructure that can be built or installed by community members.

Similarly, in most solutions the requirements for mobilization, activity preparation, convening, provisioning, and meeting spaces can be met by the communities themselves. From a political perspective, basic coordination and collaborative work with local government actors are required. This is either because there is national backing through existing public policies and regulatory frameworks, because the number of institutions, sectors, and levels of action to incorporate is low, or because the administrative procedures for their development are not complex.

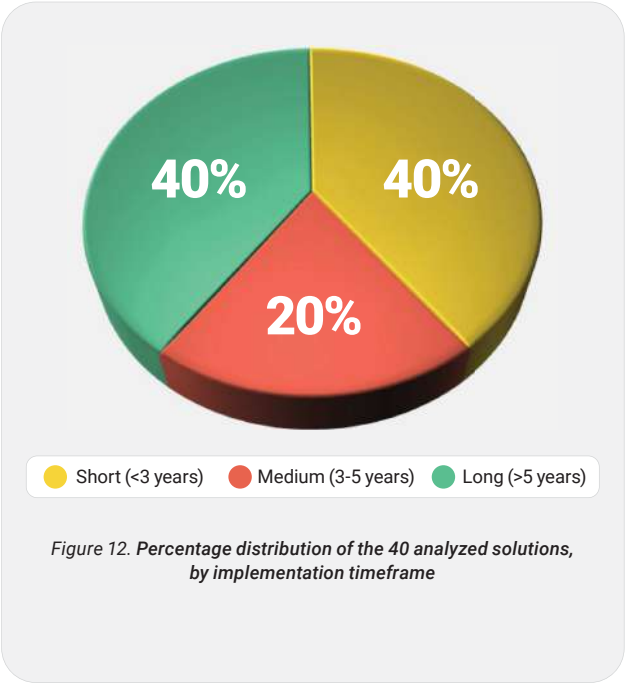


Figure 12. ***Percentage distribution of the 40 analyzed solutions, by implementation timeframe***

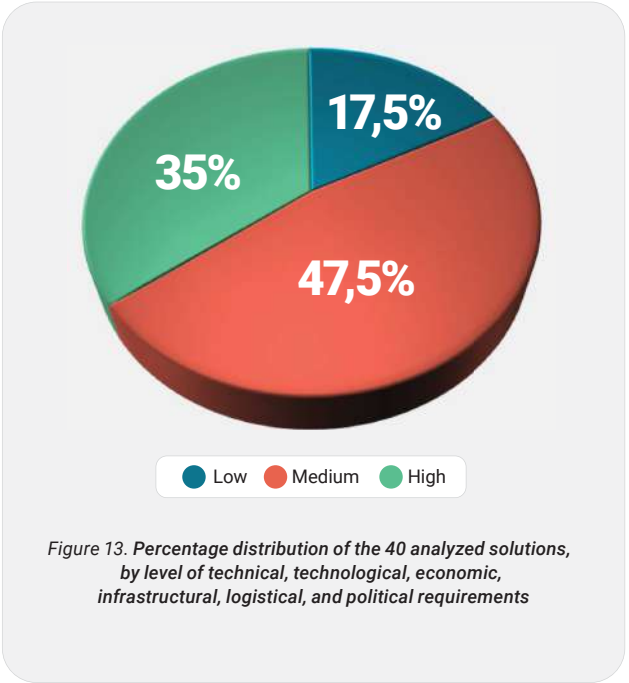


Figure 13. ***Percentage distribution of the 40 analyzed solutions, by level of technical, technological, economic, infrastructural, logistical, and political requirements***

Adaptation solutions and their approaches

The dominant adaptation approaches among the 40 solutions combine NbS (27) and progressive adaptation (13). In the first case, the solutions:

- **Address at least one other social challenge beyond reversing ecosystem degradation and biodiversity loss, such as water security, food security, socioeconomic development, or, to a lesser extent, natural disaster risk reduction. However, it seems necessary to reinforce the focus on human health.**
- **Consider the specific natural and sociocultural context of the sites.**
- **Generate social benefits in a scenario of transparency and broad participation.**
- **Seek to maintain biological and cultural diversity.**
- **Align with national policies and legal frameworks.**

In the second case, progressive adaptation, the solutions aim to:

- **Promote changes in agricultural practices to, among other things, strengthen food security, improve the resilience of agricultural systems to CC, and reduce pressure on ecosystems. This is evidenced by experiences in the Laguna de los Pozuelos Biosphere Reserve in Argentina and the páramos of the Chingaza, Sumapaz, Guerrero, and Cerros Orientales corridor in Colombia.**
- **Stimulate the development of new approaches in predominant economic activities, such as 'birdwatching tourism' in the municipalities of Aquitania, Cuitiva, and Tota in the Boyacá Province (Colombia).**
- **Restore or expand infrastructure for water security, such as water supply and irrigation systems in Pucarani and Batallas (Bolivia), or strengthen local institutional and community capacities to face CC challenges, as was done in Santiago and Valparaíso (Chile).**

Within this group of progressive adaptation measures, we can also include those directed at knowledge generation and monitoring. Although they are not adaptation measures in themselves, they do generate and disseminate essential information for decision-making in adaptation and mitigation. Examples include the phenological bird monitoring network in the Lake Tota basin (Colombia), as well as the International Initiative for Research and Global Monitoring of Alpine Environments (GLORIA) and its Andean chapter, GLORIA-Andes.

From the perspective of progression of safety, we can say that although there was no measure aimed at systematically and progressively countering endogenous and exogenous factors of vulnerability, which is very complex, all 40 measures address some of them. Thus, some contribute to:

- **Secure livelihoods through, for example, the introduction of farming and pasture management practices aligned with expected changes in precipitation, and the promotion of other activities such as beekeeping or traditional gastronomy tourism.**
- **Overcoming unsafe conditions related to water scarcity, ecosystem degradation, and poverty through the combination of NbS and gray infrastructure, modernization of irrigation systems, fencing of wetlands, installation of water capture systems, or hydroclimatic monitoring.**
- **Overcoming endogenous dynamic pressures related to weak local governance through knowledge transfer for informed decision-making, encouraging participation and empowerment, and promoting cooperation and coordination among actors.**

To these qualities, we can add, though in smaller numbers, the achievement of safe places through climate risk management, as in the case of managing new glacial lagoons and early warning systems in Peru. Similarly, overcoming local institutional weaknesses, as promoted by solutions in Argentina, Chile, and Colombia.

San Fernando del Valle de Catamarca, Catamarca, Argentina
Jan Zakelj, Pexels

Adaptation solutions and climate-resilient development

Of the 40 measures analyzed, three-quarters share another common characteristic: they have a high or very high level of alignment with the requirements of CRD. In this sense, the adaptation efforts in the Andes that we have analyzed also include:

- **CC mitigation actions, primarily through the conservation and restoration of carbon reservoirs such as forests, páramos, peatlands, and wetlands, and secondarily through the control and reduction of GHG emissions, as in the case of climate-smart livestock farming in Ecuador.**
- **Sustainable development strategies through agricultural and livestock practices that adapt to their natural environments, reduce pressure on ecosystems, and contribute, among other things, to overcoming poverty.**

The analysis also allowed us to identify various technical, socio-environmental, socioeconomic, and political characteristics in the solutions. From a technical perspective, the reviewed adaptation solutions are replicable; their results can be tracked, measured, and evaluated; they are flexible, viable, sustainable, and, with the exception of reforestation and infrastructure, reversible. They combine traditional and scientific knowledge and anticipate expected climate changes.

More than half of the measures address a wide range of future scenarios, thanks to specific studies on the effects of CC in the target area. Of the 40, 34 promote innovation, while the other 6 focus on rescuing or implementing traditional practices, as in the case of the recovery of traditional production systems and native Andean crops in the Boyacá Province (Colombia).

In the socio-environmental realm, all aim to reduce vulnerability; however, 28 integrate all or most of the aspects we considered in the analysis. In most solutions, the combination of reducing economic vulnerability while also reducing social and political vulnerability predominates, with less attention given to physical vulnerability to CC and exposure.

In terms of restoration, preservation, or improvement of ecosystem health, the results indicate that among the 35 measures that address this:

- **17 solutions combine all three purposes, as in the case of wetland management with restoration actions in the Laguna de los Pozuelos Biosphere Reserve (Argentina), sustainable management of watersheds in glacial mountain ecosystems (Peru), or the conservation of queuña forests (Peru). Other analyzed experiences also reflect this quality, including the germination centers in Lake Tota (Colombia), reforestation in the municipalities of the Cochabamba metropolitan region "Kanata" (Bolivia), and robust ecosystem adaptation measures in the Nor Yauyos-Cochas Landscape Reserve (Peru).**
- **12 solutions specifically address the preservation-improvement combination, as shown by the participatory zoning of páramos and wetland protection in Mixteque (Venezuela) or other solutions such as the improvement of vegas and wetlands through traditional Aymara practices in the northern Altiplano of Chile, and the strengthening and sustainable development of quinoa cultivation in the Anta Province (Peru).**
- **6 solutions focus on preservation, as in the case of improving food security against the adverse effects of CC in the Pichincha Province and the Jubones River basin (Ecuador).**

In the socio-economic realm, all 40 measures generate social benefits in the context of CC, and of these, 39 involve communities, 36 contribute to overcoming poverty, 35 promote community empowerment, 28 include a gender focus, 14 include a generational focus, and 12 maintain or promote cultural diversity.

In this area, we also detected an objective that seems to be gaining relevance: the fair distribution of resources through actions aimed at fostering diverse and innovative financing mechanisms; encouraging the creation of trusts, payment for ecosystem services conservation, and community-benefiting enterprises; and ensuring equitable access to resources. This is reflected in the multipurpose water management in the municipalities of El Alto, Pucarani, and Batallas (Bolivia), the Tungurahua Fund for Páramo Management and Poverty Reduction (Ecuador), CC adaptation in the Sumapaz-Chingaza-Guerrero and Cerros Orientales corridor (Colombia), as well as CC adaptation in the upper Blanco River basin (Ecuador).

Finally, in the political realm, it is noteworthy that 25 measures have specific backing in national policies, plans, and regulatory frameworks, while the others were developed within a more general framework. Additionally, there is a predominance of solutions that promote two of the four components of effective governance we analyzed: cooperation and coordination among civil society groups, private organizations, and public institutions, and transparency with broad, active participation.

7.

Lessons learned, challenges, and recommendations

Although our perspective on the current state of CC adaptation in the Andes is based on the 40 measures analyzed, we were able to identify some strengths, weaknesses, and challenges that allow us to provide recommendations for both those designing adaptation measures, and those with the means to implement them in their living and working environments.

Strengths and weaknesses of adaptation solutions in the Andes

The strengths of the reviewed adaptation measures are numerous and diverse. Among them, the most notable are those stemming from the particular approaches they are based on and their robust nature, as they generate benefits for communities, their livelihoods, and ecosystems, regardless of how the climate changes.

Another strength is their multi-benefit nature across various domains. While each solution targets a specific goal, 25 generate more than two co-benefits simultaneously. As a result, the analyzed solutions, to varying degrees, have contributed to:

- Increase the knowledge of communities and local public officials about CC and its effects.
- Enhance the adaptive capacity and resilience of communities.
- Strengthen leadership, entrepreneurship, and the technical and organizational capacity of communities.
- Restore infrastructure and ancestral techniques.
- Strengthen food security and family economies.
- Diversify community economies and increase the resilience of their productive systems.
- Reduce losses in the agricultural sector and strengthen value chains.
- Promote more sustainable management of ecosystems such as páramos, wetlands and grasslands.
- Restore ecosystems, reducing anthropogenic pressure on them, and conserve areas important for their water regulation and carbon storage functions.
- Create or strengthen links between community, private, and public organizations, as well as between public agencies at different levels.
- Generate and disseminate information useful for designing public policies and decision-making on CC adaptation.

Other strengths include the flexibility of the solutions and the use of local knowledge and experiences. This allowed for adjustments to unforeseen and complex changes, as evidenced by the adaptations made during the COVID-19 pandemic, which involved collaborative participation from various actors. It also facilitated knowledge exchange, learning between communities, public officials, and implementers, and better alignment of actions with the socio-environmental context.

Thanks to the appreciation of cultural diversity, some solutions also promoted the recovery of ancestral knowledge, practices, and traditions at risk of being lost, resulting in a cultural co-benefit as significant as the adaptation itself. Examples include the revival of medicinal and culinary culture around Andean tubers in the Boyacá Province (Colombia), the identification of key milestones that altered culture-ecosystem relationships over the last century in Chingaza, Sumapaz, Guerrero, and Cerros Orientales (Colombia), and the recovery of historical memory and traditions in the Mixteque community (Venezuela).

Finally, other strengths include the fact that more than half of the solutions involve multiple actors, including communities, public officials, and the private sector. Also noteworthy is a trend towards incorporating early warning systems for disasters and hydro-meteorological monitoring equipment, as well as publishing a wide range of educational materials and manuals for the general public and public sector technicians.

However, alongside these strengths, there are also some weaknesses. One is the lack of a strong or explicit monitoring component that allows for the modification or adaptation of actions and their implementation strategies as impacts are detected (see Dupuits et al., 2024). There is a tendency to wait until the completion of the project framework to begin measuring results, and because of this, only 27 solutions report monitoring during implementation. Among other things, this places limits to the possibility of making early adjustments and implementing adaptive management approaches.

Related to this, another weakness is that 18 of the 40 solutions are short-term (<3 years), which limits the assessment of impacts and benefits, as well as the possibility of developing the community identification/ownership needed for their sustainability. This often necessitates establishing agreements with beneficiaries, communities, or public agencies for these purposes.

In some cases, land-use planning or territorial zoning is not considered, which is also a weakness, given its high potential to promote sustainable land use and environmental conservation. Additionally, there is a tendency to focus more on gender than generational inclusion. While significant efforts are made to strengthen the role and participation of women, less attention is given to actively involving members of different age groups, which, for example, misses the opportunity for children and adolescents to drive changes in their community's relationship with the environment and to more effectively integrate the knowledge and perspectives of older adults.

Closing this list of weaknesses is the limited consideration of disaster risk management, which is particularly relevant given the mountainous environment of many target locations, where risks of landslides and flooding are frequent (see Andean Mountain Initiative, 2024).

Challenges for climate change adaptation in the Andes

From these weaknesses, as well as the context of each solution, various challenges for CC adaptation in the region arise. Perhaps the most common challenge for all cases is designing measures in scenarios of high social, political, economic, environmental, and climatic uncertainty. However, there are other challenges we identified in the reviewed measures.

From the perspective of understanding the context and local dynamics, one challenge is to understand the origin and trajectory of socio-environmental conflicts in the implementation sites, as well as the interests of different actors to reach mutually beneficial agreements. Engaging with a community is highly complex and requires time to build the trust and interest that will motivate its members to collaborate. In this sense, the method, the road to this mutual understanding, is a long and complex process.

From a social perspective, another challenge is overcoming resistance to deeply rooted agricultural practices, as well as cultural barriers. In the former case, because modernization processes replaced ancestral practices decades ago, and reviving them may require additional efforts involving more resources and time. In the latter, because the unique worldview of each community may condition the acceptance and adoption of "new ways of doing things," highlighting the importance of understanding the context being intervened.

Fully raising awareness among local populations about climate-related impacts and their effects on livelihoods and quality of life is another social challenge for adaptation. For example, while communities are aware of reduced precipitation, some implementers of the analyzed measures noted that achieving this comprehensive awareness has been a significant challenge, as has mobilizing and organizing communities without a tradition of collaborative work or strong local institutions.

Economic challenges also arise. Among the most significant are countering the intensification of mining, extensive livestock farming, and industrial monoculture. Others include ensuring that measures are maintained over time and space, especially when agroecological practices involve additional time in daily activities, and ensuring generational succession in communities responsible for maintaining solutions, as younger populations are emigrating. Similarly, in the specific case of reforestation measures, convincing landowners to reforest with native species instead of pines or eucalyptus is a challenge.

Finally, in the political-institutional realm, its is a challenge to link locally implemented adaptation strategies with national and subnational adaptation policies and strategies, in an effective way (Dupuits et al., 2022). Other challenges in this area include:

- Incorporating adaptation measures into local development plans.
- Adapting to staff turnover in participating public agencies.
- Countering institutional weaknesses such as limited financial management capacity and the ability to implement certain actions and practices associated with the measures.
- Adapting to national crises.
- Achieving effective multisectoral coordination.

Woman harvesting maize, Huaraz, Peru
AICCA

Recommendations for adaptation solution designers

Challenges like these highlight multidimensional requirements, which could greatly benefit from incorporating a prospective territorial approach. This approach is characterized by being simultaneously multi-sectoral, multi-actor, and multi-scale, considering the future not only from a climatic and environmental perspective but also from the social, economic, and political past and present of the locations (see Dupuits et al., 2022).

It is multi-sectoral because it considers the relationships and influences between various factors involved in the problem being addressed, such as infrastructure, livelihoods, disaster risks, social capital, education/awareness, institutional capacity, public policies, and land-use conflicts. It is multi-actor because it involves and addresses the interests, capacities, and limitations of the different actors involved and their conflicts. It is multi-scale or multi-level because it considers the favorable or unfavorable influence of the subnational or national context on the problem's configuration. Finally, it is prospective because it seeks to anticipate, through participatory and future-oriented scenarios, possible changes and their trajectories, as well as the key factors, processes, and actors involved (Dupuits et al., 2022; Salas-Bourgoin, 2013).

In terms of public policies, it could also be beneficial to thoroughly understand and systematize the management instruments and legal frameworks that could serve as opportunities or barriers for the solution. Similarly, analyzing the institutional structure to be involved, including competent public agencies, their mandates, and decision-making capacity, would help strengthen the measures from a political-institutional perspective and maximize the possibilities offered by the system.

This can be complemented by reinforcing actions aimed at:

- **Strengthening local institutional capacities. Key topics include climate change, designing and implementing adaptation measures tailored to local contexts, environmental governance, securing and managing resources for adaptation financing, and decision-making under uncertainty.**
- **Strengthening social capital and grassroots community organizations.**
- **More broadly integrating the private sector into the design, implementation, and monitoring of solutions.**
- **Promoting changes in local power dynamics.**

Incorporating land-use planning into solutions could also make them more comprehensive, as it jointly addresses: protection of natural areas, allocation of land uses based on their carrying capacity, promotion of economic activities aligned with available resources and potential, territorial infrastructure, and disaster risk prevention, mitigation, and control. This integration could be achieved through:

1. **Analyzing the strengths and weaknesses of the territorial planning plan corresponding to the target location, in light of CC adaptation requirements, and promoting its adjustment for these purposes.**
2. **Participatory updating of land-use regulation schemes.**
3. **Strengthening institutional means and capacities to control land use and occupation.**

Similarly, the participation of children, youth, and older adults could be expanded. This could be done through formal and informal education systems. Additionally, fostering community ownership of actions through collaborative adaptive management strategies would help overcome resistance to change through experimentation, knowledge expansion, and the "demonstration effect."

Concerning adaptation approaches, it seems necessary to continue advancing towards security, transformational adaptation, and adaptive management. For the first case, it would be beneficial to expand actions aimed at addressing contextual dynamic pressures such as weak markets, scarce financing, weak production chains, deficient institutions, or insufficient infrastructure. A SWOT (Strengths, Weaknesses, Opportunities, Threats) analysis of the solution would be useful here, as it would provide a comprehensive overview of its possibilities, advantages, challenges, and barriers at different scales.

For the second case, transformational adaptation, it would be beneficial to extend the timeframes of project frameworks and, consequently, the solutions. This would allow for greater depth and scope in terms of transition, long-term measurement and tracking of impacts to compile evidence on good adaptation, and the consolidation or strengthening of permanent learning (and monitoring) sites across the Andes (Carilla et al., 2023; Peralvo et al., 2024).

Finally, in adaptive management, it seems crucial to initiate monitoring processes early. From the outset, systematic and documented tracking of actions, as well as their successes and failures, will facilitate learning, reduce uncertainty, and provide the feedback that this approach promotes.

Recommendations for decision-makers

1

When selecting or opting for an adaptation measure, we believe decision-makers should consider:

- The technical, technological, economic, infrastructural, logistical, and political requirements of the alternatives, and evaluate them based on the capacities and resources available. During the implementation of the measure, capacities can be developed or expanded, and financial resources can be managed and obtained, but a minimum level must be available to ensure the initiation and continuity of actions in the short term.
- The level of community organization, social capital, and tradition of collaborative work. If these are weak or nonexistent, greater efforts to motivate and mobilize the community will be necessary.
- The expectations and interests of different groups in the target territory regarding adaptation.
- Expert opinions and recommendations, in conjunction with those derived from the community.

2

On the other hand, **when designing measures**, decision-makers could also consider:

- Involving a wide diversity of actors, which is different from incorporating a large number of actors. Representatives from the private sector, academia, non-governmental organizations, and other stakeholders broaden the range of perspectives and will allow for understanding present and future objectives and interests that may favor or hinder solutions, establishing mutually beneficial agreements, and incorporating ongoing actions to leverage synergies.
- Understanding and considering the regulatory and administrative requirements for implementing the measures, and the agencies with which coordination will be necessary.
- Analyzing the advantages and disadvantages of including a large number of actions in the measures, versus focusing efforts on those with the greatest potential for success, sustainability, and benefits across various domains. Too many actions can dilute efforts over time and space.
- Maximizing the resources provided by political and legal instruments, as well as the competencies and autonomy of local agencies, to strengthen their role within the solutions and reduce dependence on centralized or concentrated structures.
- Including in the design of solutions a monitoring and evaluation plan with specific indicators, responsibilities for their measurement, and an implementation timeline. Similarly, creating a tool to document the contributions of ancestral/traditional community knowledge to highlight their benefits for the solution.

3

Finally, **for implementing the measures**, it is advisable to:

- Systematically and thoroughly document the execution of actions, successes, failures, and barriers, as well as adjustments and their effects, to reduce uncertainty in future decisions and report best practices.
- Avoid, as much as possible, changes in personnel directly responsible for the implementation/supervision of the solutions.
- Rigorously execute the monitoring and evaluation plans.
- Periodically disseminate the results of monitoring and evaluation to maintain engagement with all actors and the community at large and strengthen transparency.

As demonstrated by the implementers of the analyzed adaptation measures, **much of their success and continuity depends on the level of community involvement**. Additionally, rigorous but flexible planning and well-documented execution are crucial. This, along with monitoring and evaluation, will generate useful information for subsequent stages, replication in similar contexts, and studies on CC adaptation processes and their outcomes.

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Click on each solution to expand the information

9. Annex

Climate change adaptation solutions in the Andes

	Solutions from the "Adaptation at Altitude" portal	Country
1	Wetland management and conservation in the Pozuelos Biosphere Reserve	**Argentina**
2	Ecosystem conservation and restoration in Laguna de Los Pozuelos	**Argentina**
3	Management of vegas and swamps with traditional techniques by the Kolla community of Lagunillas del Farallón, in the Jujuy Puna	**Argentina**
4	Multipurpose Drinking water and irrigation Program for the municipalities of Batallas, Pucarani and El Alto	**Bolivia**
5	Climate Resilience – Integrated Basin Management in the Rio Grande river basin	**Bolivia**
6	Adaptation to the Impacts of Climate Change on Water Resources in the Andes (AICCA), Bolivia	**Bolivia**
7	The Bioculture and Climate Change Project in Cochabamba	**Bolivia**
8	Adaptation to Climate Impacts in Water Regulation and Supply for the Area of Chingaza – Sumapaz – Guerrero	**Colombia**
9	Adaptation experiences to climate change with peasant communities in the Sumapaz – Chingaza – Guerrero and Cerros Orientales Paramo Corridor	**Colombia**
10	Adaptation to the Impacts of Climate Change on Water Resources in the Andes (AICCA), Colombia	**Colombia**
11	Reconversion of conventional production systems to traditional – agroecological systems, with emphasis on in situ conservation of Andean tubers as a climate change adaptation strategy for small producers in Boyacá	**Colombia**

	Solutions from the "Adaptation at Altitude" portal	Country
12	Strategy for Integrated Monitoring of High Mountain Ecosystems in Colombia (EMA)	**Colombia**
13	Implementation of a sustainable tourism proposal in the Tota Lake basin – Colombia	**Colombia**
14	Agroforestry germination center for the recovery and germination of native seeds in the Tota Lake basin, Colombia	**Colombia**
15	Network for phenological monitoring of birds as bioindicators of the effects of Climate Change in the Tota Lake basin, Colombia	**Colombia**
16	Protecting Biodiversity and Multiple Ecosystem Services in Mountain Biological Corridors of the Mediterranean Ecosystem in the Santiago and Valparaíso regions (GEF-Montaña)	**Chile**
17	Improvement of vegas and bofedales through traditional Aymara practices in the highlands of northern Chile	**Chile**
18	Increasing the adaptive capacity of local communities, ecosystems and hydroelectric systems in the Río Blanco upper watershed with a focus on Ecosystem and Community Based Adaptation and Integrated Adaptive Watershed Management	**Ecuador**
19	Funding and implementation of climate change adaptation measures in high mountain indigenous communities through the Fund for the Tungurahua Paramos Management and the Fight Against Poverty	**Ecuador**
20	Climate-Smart Livestock Production in Ecuador: climate change adaptation for small and medium-sized livestock producers, with special focus on the Imbabura and Loja	**Ecuador**
21	Enhancing resilience of communities to the adverse effects of climate change on food security, in Pichincha Province and the Jubones River basin	**Ecuador**
22	Adaptation to the Impacts of Climate Change on Water Resources in the Andes (AICCA), Ecuador	**Ecuador**
23	Improvement of 3 irrigation channels incorporating climate change adaptation measures in Andean ecosystems	**Perú**
24	Mechanisms for ecosystem services retribution in the Cañete river basin, Peru (MERESE)	**Perú**
25	Strengthening and sustainable development of quinoa cultivation in the province of Anta	**Perú**
26	Restoring, conserving and expanding mountain pastures and wetlands and improving communal management in Canchayllo	**Perú**
27	Sustainable watershed management in glacial mountain ecosystems in Peru	**Perú**

Click on each solution to expand the information

	Solutions from the "Adaptation at Altitude" portal	Country
28	Robust ecosystem-based adaptation measures in Miraflores, in the Nor Yauyos Cochas Landscape Reserve	**Perú**
29	Restoring ancient water management systems in the high Andes as an adaptation to climate change – Miraflores	**Perú**
30	Conservation of Queuña forests (Polylepis spp.) of Vilcanota range	**Perú**
31	Promotion of local adaptation initiatives to strengthen and improve the availability of water for irrigation in Peru	**Perú**
32	Management and conservation of wetlands and paramos in Venezuela: Successful experiences of adaptation to climate change in the Mixteque – Mérida paramo	**Venezuela**
33	Global Observation Research Initiative in Alpine Environments (GLORIA) – Andes Network	**Andes**

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	Solutions in the AICCA project portal	Country
34	Organic fertilizer (biofertilizer) production module in the Tota Lake basin	**Colombia**
35	Gardens of life: sustainable livelihood strategy to increase resilience, in terms of food security, in the Tota Lake basin	**Colombia**
36	Beekeeping production systems in the Tota Lake basin	**Colombia**
37	Restoration, recovery and rehabilitation with a participatory approach. Tota Lake Basin	**Colombia**
38	Formation of knowledge communities to reduce vulnerability, increase governance and resilience. Tota Lake basin	**Colombia**
39	Rainwater harvesting and irrigation in the Tota Lake basin	**Colombia**
40	TENDHIS web application, “Historical precipitation and temperature trends” from SENAMHI	**Perú**