EXECUTIVE REPORT

Regenerative Agriculture & Resilient Food Systems

NOVEMBER 2025

Perspectives from the Global South on the Anthropocene

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ABOUT US

The Perspectives from the Global South on the Anthropocene Initiative

The Perspectives from the Global South on the Anthropocene Initiative was established in 2023 by a team of scholars at the Max Planck Institute of Geoanthropology. The initiative focuses on integrating insights from palaeoecology, archaeology, and traditional knowledge to address the urgent challenges of the Anthropocene.

Together, the group forms ECHOES: *Exploring Climate and Human Observations from the Global South* working group. The group currently has members from across Eurasia, the Americas, and Africa, and continues to expand its network.

The ECHOES working group believes that recognizing the importance of archaeological, historical, and ancestral perspectives from the Global South is essential for developing a truly comprehensive understanding of the Anthropocene crisis. These viewpoints shed light on the long-term dynamics of human–environment interactions and their enduring impacts.

Further information about the initiative is available on our webpage:
https://gs-anthropocene.org/

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Foreword and Acknowledgements

This executive report is part of the initiative *Perspectives from the Global South on the Anthropocene*, developed by researchers from the Max Planck Institute of Geoanthropology (MPI-GEA) in Jena, Germany together with colleagues and partners across the Americas, Africa, and Asia. The idea for this series of reports took shape after our conference "Voices of the Global South", held at the MPI-GEA in 2024, where participants from different regions of the Global South shared experiences on how archaeological, paleoecological, and historical evidence can inform today's climate and biodiversity agendas. All members of this group share a common commitment to rethink global environmental policies through the lens of long-term, place-based knowledge.

This first volume brings together that exchange of ideas through a set of case studies showing how ancestral agricultural systems continue to sustain resilient landscapes. Originally conceived for presentation at the 2025 United Nations Climate Change Conference (COP30, Brazil), it aims to contribute to the global conversation on climate and food systems. We hope it will also find its way into other arenas of decision-making, encouraging dialogue between science, policy and the communities that care for the world's ecosystems.

At a moment when international policy forums increasingly recognize the role of food systems in both driving and mitigating climate change, this report contributes to the growing acknowledgment that the Global South should not be viewed merely as a site of vulnerability, but rather a source of innovation and leadership. The historical and scientific evidence presented here demonstrates that regenerative and resilient agricultural practices have deep roots in Indigenous Peoples Knowledge and Local Communities' traditions, and that these practices offer viable, low-cost, and sustainable pathways for socio-ecological restoration and climate adaptation.

This piece also acknowledges the inequalities of the Anthropocene crisis regarding the disparity between actors holding major responsibilities for climate and environmental changes and those suffering its consequences. Including these actors in governance structures must also recognise that territorial security, food security and climatic security are deeply connected to Heritage Management. Indigenous Peoples and Local Communities' heritages extrapolate the boundaries between nature and culture, and reinforces the importance to recognise distinct ontological realities for conservation.

The editors wish to express our deep appreciation to all the authors who contributed their research and time to this collective effort, and to the Indigenous Peoples and Local Communities whose knowledge, practices, and generosity of dialogue made this work possible. Their voices remind us that climate solutions must be rooted in respect, reciprocity, and justice.

This report is also indebted to the institutional and logistical support provided by the MPI-GEA, particularly directors Prof. Dr. Patrick Roberts, Prof. Dr. Ricarda Winkelmann and Prof. Dr. Jürgen Renn. We are also grateful to the ECHOES team who participated in different stages of this publication and the invaluable design support and input for scientific communication by Hans Sell and Michelle O'Reilly from the Outreach, Policy and Sustainability unit at the institute.

We express our sincere gratitude to Edson Krenak, Uraan Anderson Suruí, Candelaria Trejo, and Concepción Trejo for generously sharing their time, experiences, and expertise as Indigenous Knowledge holders. We value these contributions with respect and in alignment with the principles of the United Nations Declaration on the Rights of Indigenous Peoples (UNDRIP) and the UNFCCC's recognition of Indigenous Peoples as vital holders of knowledge, custodians of biodiversity, and key actors in climate action. We also extend our deep appreciation to Vanuza Cardoso, spiritual and political leadership from Quilombo Abacatal, and Marivaldo Gomes Torres, from Quilombo Baixo Itacuruçá, for contributing invaluable perspectives from local knowledge and quilombola inspiration. We are especially grateful to Edson Krenak for his thoughtful and patient dialogue with us on the ethical ways of engaging with members of Indigenous Peoples, which has deeply informed our approach throughout this work. Their insights have greatly enriched this report. We dedicate this volume to all communities working daily to sustain their lands, foods, and ecosystems, and to those striving to ensure that the wisdom of the past becomes a foundation for equitable futures.

1. Introduction

"Regenerative Agriculture and Resilient Food Systems", addresses how long-term land-use practices documented through archaeology, history, paleoecology, and traditional knowledge can contribute to climate restoration and mitigation strategies, in alignment with United Nations Framework Convention on Climate Change (UNFCCC) priorities.

Indigenous Peoples' territories, though not always recognized for their vital role, harbor approximately 80% of the world's remaining biodiversity, underscoring their centrality to global environmental resilience. Focusing on systems that restore degraded lands, enhance ecosystem services, and act as carbon sinks, this chapter highlights the relevance of Indigenous Peoples and Local Communities' practices—such as soil and biodiversity enrichment, forest management, water harvesting, and resilient crop systems—for achieving climate and food security.

During the COP16 biodiversity summit in 2024, it was established that Food Systems are the leading driver of land conversion, deforestation, and biodiversity loss (UNCCD and COP16). Land degradation not only increases the risk of declining human health and the emergence of new diseases, but also drives forced migration and conflicts over scarce resources. Moreover, sustainable land use accounts for 30% of the mitigation potential required to keep global temperature rise below the 1.5°C threshold by 2050. As a result, COP16 called on countries to pursue collective actions to restore degraded lands, boost biodiversity, and scale up nature-positive food production by 2030 (Figure 1):

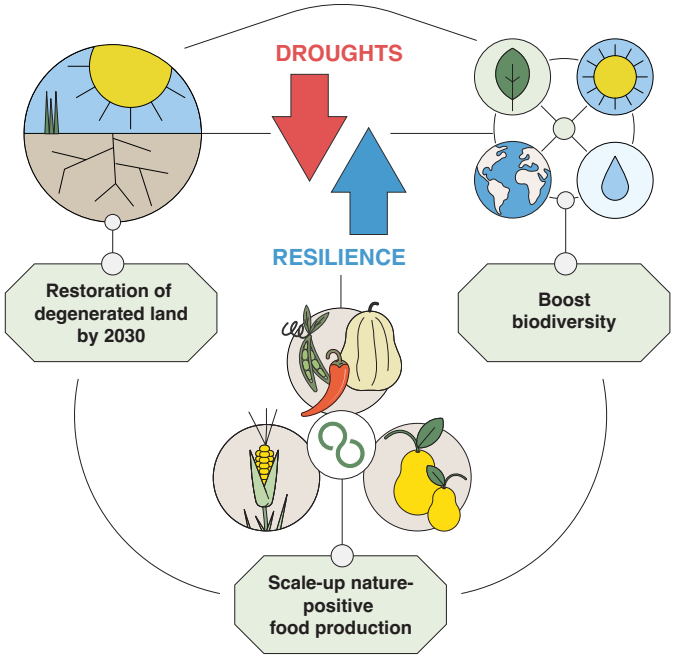

Figure 1. Key actions to reduce droughts and enhance resilience.

Regions managed by local communities tend to experience lower rates of deforestation and land degradation. Preserving and revitalizing traditional and local food systems and landscapes is therefore essential, as it plays a critical role in land restoration and ecosystem resilience. By bringing together case studies from across the Global South, this report mobilizes evidence of long-term human landscape management and adaptation. We argue that understanding historical land-use trajectories—particularly the disruptions and reorganizations caused by colonialism and extractivist projects—offers crucial insights for shaping adaptation and mitigation policies in line with the latest outcomes of the Conference of the Parties.

The long-term perspective offered by eco-cultural knowledge is essential for advancing climate adaptation goals. Past and present human landscapes are a powerful potential asset to address those goals: 1. To make adjustments in natural or human systems in response to current or expected climatic changes. 2. To reduce the negative effects of climate change

while taking advantage of potential new opportunities.
3. To pursue adaptation measures such as building resilient infrastructure, developing early warning systems for extreme weather events, and, central to this volume, modifying agricultural practices. On the mitigation front, resilient food systems can address the root causes of climate change by reducing greenhouse gas emissions and enhancing natural carbon sinks.

Diverse environments and biomes are approaching tipping points at unprecedented rates, leading to increasing damage to land and biodiversity, especially in countries of the Global South, where most conservation areas and sustainable use reserves are located. In recent years, interdisciplinary research in archaeology, paleoecology, and history has documented the existence of natural and cultural landscapes that have supported resilient food systems for millennia. These systems include secondary and enriched forests, land and water management techniques, soil enhancement practices, and the construction of earthworks and stone infrastructures.

Far from being relics of the past, these landscapes represent innovative strategies developed by past societies to adapt to new environmental, climatic, and social conditions. Many of them are still in use today by descendant communities and other local populations. We emphasize that these enduring landscapes and foodscapes are vital heritage for present and future food security as they contribute to resilient food systems and offer co-benefits for climate regulation.

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In order to better understand the resilient food systems within these heritage spots, we utilize interdisciplinary data as a way to explore the time frame and resilience of these enduring landscapes, emphasising their longevity and resistance to past and present changes. Besides the recognition of their relevance in tackling adaptation and mitigation goals, we gather information on their chronology, cultural aspects of their construction and uses across single or multiple phases of modification, climatic and ecological conditions implied in these periods, and their effect on environmental assets in the present.

The case studies in this volume integrate diverse lines of evidence, including: Paleoclimate research and proxies (e.g., isotopic analyses, vegetation, lake and sediment cores); Paleoecology, including vegetation and biodiversity reconstruction; Archaeology and history, (such as earthmoving technologies, biodiversity management, foodways, cultural transitions); and Heritage studies, addressing the restoration of ancient landscapes, reuse of past infrastructure, and the continuity of cultural practices that underpin resilient food systems.

2. Case studies

2.1 Amazonia

The Amazon Basin is the most biodiverse region of the globe, with diversified ecosystems that play crucial roles in climate regulation, such as evergreen forests, savannahs, seasonally flooded fields and regional *campinaranas*. With around 13,000 arboreal species, its modern environmental structure is influenced by long term Indigenous peoples' populations, interactions and management.

This involved the domestication of plants (e.g., manioc), landscapes (e.g., Brazil nut stands) and waterscapes (e.g., canals and ponds), and also the enrichment of soils (i.e., Amazonian Dark Earths; ADE) and the construction of earthworks for house holding and agroforestry cultivation, among other strategies. These archaeological places (summing more than 16,000 sites) are ancestral places cared for, visited, used and narrated by local dwellers, responsible for their conservation, updating and for entangling past and present heritages.

Indigenous Peoples have occupied the Amazon since circa 13,500 years before present, and have developed different food systems based on diversification of cultivars adapted to the regional socioenvironmental conditions and historical periods of cultural and climatic-driven changes.

Palms and roots appear to have played an important role in the first millennia of occupation, and controlled fire was likely an important management strategy already around 10, 000 years ago, in dwelling areas such as rock shelters, forest islands in seasonally flooded savannahs and waterfall plateaus. During the Middle Holocene, since circa 6,500 years ago, people were also building shellmounds and developing food resilience strategies in changing environments during drier than present conditions, including diversification on fish acquisition areas. Important food plants such as manioc were probably domesticated during this period in Southwestern Amazon, when human management also began to reshape soil and create the first ADEs, with more organic matter, higher Ph and nitrogen rates than the basin's natural latosoils. With increased humidity around 3,5k B.P. and forest spreading, places previously occupied continued flourishing, and new areas were occupied. ADE soils spread throughout the basin, and diversified food systems followed an equally diversified culture asset, with a growing population whose management practices have never reached environmental carrying capacity .

Overall food systems were based in constantly increasing biodiversity use rather than food specialisation or

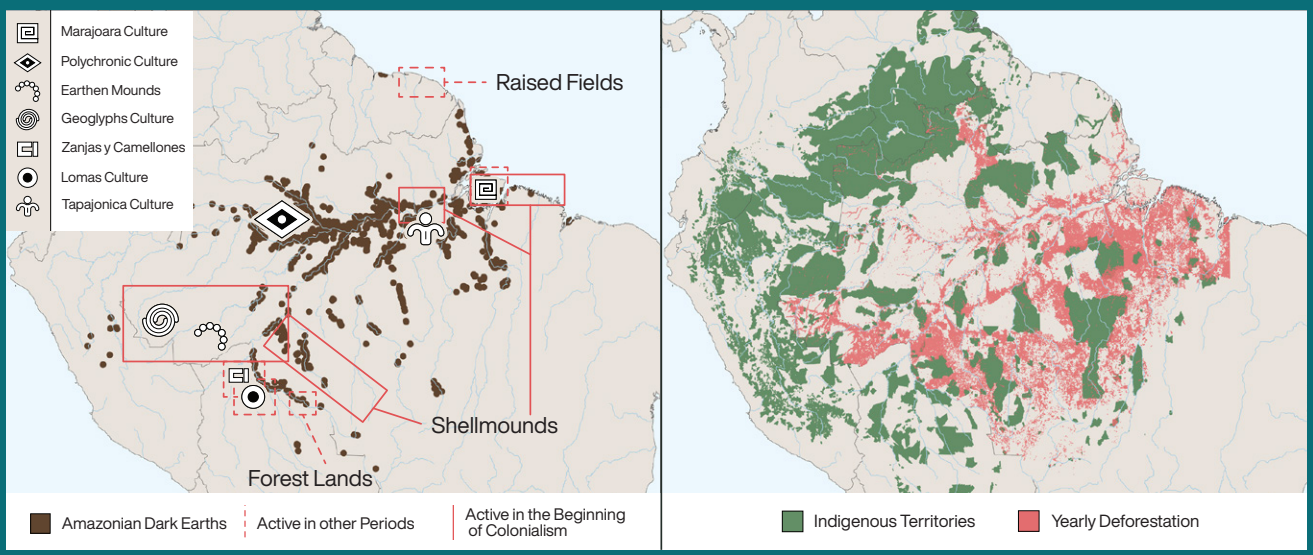

Fig 1: Spatial distribution of evidence of Indigenous landscape management across the Amazon since 13,500 years before present (left). Lower rates of deforestation are observed within Indigenous territories since 2008 (source: Amazon Network of Georeferenced Socio-Environmental Information, RAISG)

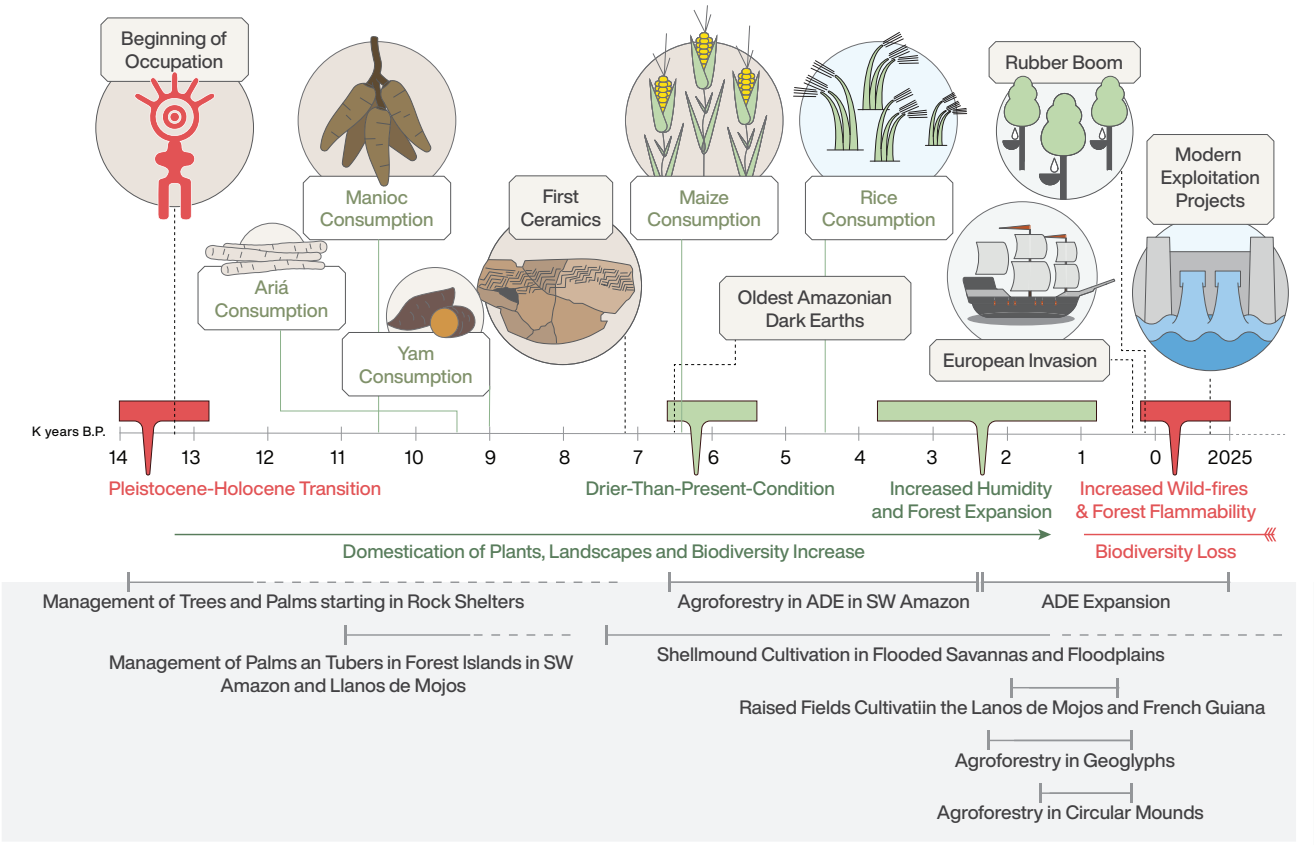

Figure 2. Amazon Basin Timeline in K years B.P. (thousand years Before Present). The events in the top and the Food Systems periods in the botton are based in Archaeological and Historical evidence. Environmental periods highlighted are based in Paleoecological data in soil and lake cores. Biodiversity Increase and Loss are based in archaeobotanical and botanical databases.

monocultures, while food systems resilience were linked to an extensive social network involving food and species exchanges based on decentralized governance, and on the extensification of the cultivated area and/or earthmoving constructions that improved nutrients accumulation and incorporation.

After 1492, the colonial clash drastically changed cultural networks and access to the ancestral territories that sustained such practices, yet it did not erase Indigenous Peoples and Local Communities' knowledge about their lands and food systems. Besides resulting in biodiversity loss and massive landscape damages, including the modification of fire regimes and the commodification of some crops, Traditional Ecological Knowledge sustains an important part of the Amazon's food production in family systems, and ancestral modified soils allow for their use in the present. Far from representing resources for new cycles of exploitation, many of these sites and territories are part of ontological landscapes, whose management continuation depends on the relationship between local inhabitants—humans, non humans (animals and plants) and more than human (masters, owners and spirits)—which have a deep relationship in the negotiation of territorial uses and conservation. Resulting from centuries of violence and forced labour by Europeans and emerging colonial elites, Indigenous Peoples, Quilombolas and Riverine (caboclo) Local Communities resist not only with their cultures, but with their crops, their fields, their forests, their ontologies, and the imbricated networks they developed with the environment.

In this section, we gather discussions and case studies that bring together and bridge past and present food systems in order to demonstrate the importance of taking Local Communities Knowledge seriously. We highlight that ADE soils play an important role in carbon sinks, that Anthropic forests such as Brazil nut stands are a form of ancestral heritage that need local people's governance to be sustained, and that Indigenous Peoples', *Quilombolas*' and Riverine Local Communities' cosmoperceptions and ontologies must be acknowledged and incorporated into management and conservation practices along with their traditional practices of cultivation.

Ancient Knowledge and Modern Conservation: The Brazil Nut as a Pathway to COP30 Climate Actions

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The Brazil nut (*Bertholletia excelsa* Humb. & Bonpl.) is a keystone species native to the Amazon rainforest, reaching over 50 meters in height and exceeding three meters in diameter. Its large, woody fruits contain 10 to 25 nutrient-rich seeds, highly valued worldwide for their flavour and health benefits.

As a long-lived, light-demanding pioneer, ancient and current Brazil nut populations have supported and been supported by a rich biodiversity, including key seed dispersers like the native rodent, agouti (*Dasyprocta* sp.), and human communities. It ranks as the 178th most common out of approximately 200 dominant species that make up 50% of the Amazon's trees, contributing significantly to the forest's biomass and carbon sequestration. These trees thrive in upland *terra-firme* forests, with some living over 500 years, representing a vital long-term resource that intertwines ecological and cultural heritage (Shepard & Ramirez, 2011). Archaeological findings from Monte Alegre, Brazil, indicate human manipulation of the Brazil nut dating back 13,000 years, illustrating a continuous relationship centred on biodiversity conservation and resource use. Recent decades have seen a resurgence in Indigenous People's land stewardship (Levis *et al.*, 2024), with research increasingly highlighting the ongoing importance of traditional management practices.

Figure 1. Exemplary Brazil Nut tree in the Amazon Basin© MPI-GEA / Victor Caetano-Andrade

The first example illustrates how multidisciplinary dendrochronology—the scientific study of tree-rings—applied to Brazil nut trees at the Purururu Lake site in the Central Amazon, revealed a long-standing relationship between Indigenous People's land use and the persistence of Brazil nut populations (Caetano-Andrade *et al.*, 2019). Located just a few kilometers from Manaus, an area with colonial presence dating back to the early 17th century, the region exhibits extensive Amazonian Dark Earth (ADE) soils predominantly dated between 2,500 and 500 years calBP (calibrated years before present). These soils serve as evidence of

long-term Indigenous People's presence and soil enrichment practices, such as controlled burning and organic matter input. Historical records indicate that the site was occupied by Mura Indigenous groups at the time of European contact, and tree-ring analyses demonstrate that active management practices—likely including trail opening, selective species removal, harvesting, and fire use—have sustained high recruitment rates and enhanced growth performance of Brazil nut trees over centuries (Caetano-Andrade *et al.*, 2019). Intriguingly, these Indigenous Peoples' management strategies appear to have been carried forward by subsequent riverine communities in recurrence of migratory movements driven by the 19th-century rubber economy. Tree-ring data reveal that peaks in recruitment and growth often align with periods of documented human presence, while declines correlate with reduced human activity, underscoring the intrinsic link between Brazil nut dynamics and traditional forest management (Caetano-Andrade *et al.*, 2019). This evidence indicates that forest management continued and intensified, with new settlers adopting similar agroforestry techniques to sustain resources like the Brazil nut—highlighting that Indigenous Peoples and Local Communities' Knowledge of local ecology remains resilient and adaptable, continuously shaping forest composition and resilience over history and changing contexts. Conversely, in stands not reoccupied by riverine communities, ring-width series and stand structure typically show aging cohorts and suppressed recruitment as trail maintenance, selective thinning, and low-intensity burning cease.

Comparing areas with continued and discontinued management shows that cultural stewardship helps maintain high genetic diversity, promoting resilience and adaptability. The second example uses genomic research to trace the evolutionary history of the Brazil nut: demographic reconstructions indicate a steady population decline since the Last Glacial Maximum (~20,000 years ago), likely driven by the extinction of large seed dispersers (Wang *et al.*, 2025), contributing to low genetic diversity in many Amazonian sites today. In Jaú National Park and Tapirapé-Aquirí Forest, despite archaeological evidence of millennia of Indigenous People's management, periods of social upheaval and post-Rubber-Boom abandonment reduced human presence; these sites show population decline, reduced genetic variability, and predominance of natural, non-human-mediated regeneration (Wang *et al.*, 2025). By contrast, Tefé National Forest has maintained uninterrupted management from the pre-colonial period to the present, with sustained soil enrichment and stewardship over the past 3,000 years, and contemporary communities continue to actively manage the landscape. Genetic data confirm that Tefé's Brazil nut populations have the highest diversity, attributable to practices such as transporting and planting seeds, which bolster resilience and adaptive capacity. Together, these findings underscore that long-term, active forest management rooted in tradition is essential for conserving the Brazil nut amid ongoing environmental change (Wang *et al.*, 2025).

Supporting community-led management and land tenure in National Adaptation Plans (NAPs)—especially Indigenous Peoples and Local Communities' Knowledge—can enhance forest recovery, buffer socio-economic pressures, and align with global efforts like REDD+. A key aspect, however, in the above-mentioned approach is that human-rights and previous informed consultation is thoroughly respected. Recognizing and scaling these long-standing, adaptive systems empowers local communities as active stewards of climate action. Integrating traditional land-use wisdom into policies offers a powerful pathway to achieve climate goals, biodiversity, and climate justice—transforming centuries of Indigenous People's stewardship into key drivers of a resilient, low-carbon future.

Recommendations

- **Promote Indigenous Peoples led Brazil nut management** through agroforestry systems that integrate nut harvesting with the mobile maintenance of dynamic forest succession.
- **Enhance regional and basin-wide genetic diversity** to counteract declining genetic variation while maintaining the Brazil nut's economic and ecological importance in the Amazon.
- **Support interdisciplinary research** that combines archaeological and genomic approaches to explore the long-term genetic and anthropogenic histories of key tropical tree species.
- **Expand similar studies** to Brazil nut populations in different regions and to related species to better understand human impacts on tree genetics through time
- **Incorporate historical and genetic insights** into contemporary forest management strategies to promote resilience, sustainability, and biodiversity conservation.

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Quilombo Do Abacatal And Quilombo Baixo Itacuruçá: Land Use And Resilience Strategies Through Smallholder-Family Farming in the Amazon (Pará, Brazil)

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Throughout the twentieth century, extractive activities spread across the Amazon to supply global commodities markets, intersecting with Latin American nationalist and regionalist agendas. These activities and projects drew on past colonial legacies—such as resource extraction and environmental degradation—and expanded at an unprecedented pace and scale contributing decisively to the deterioration of the global environmental and climate crisis.

In this context, people recognized the Amazon as both highly vulnerable and essential for global climate stability. At the same time, international environmental debates intensified local and regional disputes over land tenure and land use. Large-scale extractive projects exposed the tension between global capitalism and the social and ecological resilience of traditional communities and forest ecosystems.

Bearing this tension in the background of our analysis, we situate the pathways of Quilombo do Abacatal and Quilombo Baixo Itacuruçá—both in the eastern Brazilian Amazon, in Pará—within the intersection of past, present, and future projects for the Amazon (Figure 1). These quilombos illustrate the critical role of smallholder-family farming and agroecological practices in mitigating climate change, preserving cultural identities, and promoting territorial justice.

QUILOMBO DO ABACATAL

Quilombo do Abacatal represents resistance, memory, and ancestral heritage. Its origins trace back to 1710; descendants of enslaved people established the territory, inheriting land from Count Coma Mello, who lived in the eighteenth-century and possessed land rights under the Portuguese colonial rule near the Uriboquinha stream. Coma Mello had three daughters with the enslaved woman Olímpia- known as the “Three Marias” - who became the rightful heirs to the lands of the Engenho do Uriboca lands.

Quilombo do Abacatal lies in the municipality of Ananindeua in the Belém Metropolitan Region of Pará, Brazil. The community stretches along the Uriboquinha stream, a tributary of the Guamá River, in a periurban area. It sits about 12 kilometers from downtown Ananindeua and 16 kilometers from Belém, the capital of the northern Brazilian federal state Pará.

The Fundação Cultural Palmares officially recognized the Quilombo as a remnant *quilombola* community in 2012. Until this federal recognition, some previous steps had to be done. Legal land titling secured the community’s territorial rights in two stages: the first granted 317.9366

hectares on May 13, 1999, and the second added 265.3472 hectares on December 2, 2008, totaling 583.2838 hectares[1]. Before official recognition, the community experienced a long history of territorial disputes and violence. In the 1950s, part of their original lands was sold to the Pirelli company for the cultivation of rubber trees in what is now the city of Marituba. In the following decades, particularly throughout the 1970s and 1980s, residents faced violent conflicts, protracted legal disputes, unpaid labor, house demolitions, evictions, illegal land sales, and numerous legal contests.

Figure 1. Quilombo do Abacatal, Pará, Brazil.

Historically, the Abacatal community ensured its food security through smallholder-family farming, through collection of açaí, cupuaçu, and pupunha, alongside the cultivation of staple crops such as manioc, corn, beans, regional fruits, and medicinal plants. The community also raises small livestock, including pigs and chickens. Generations shared down traditional shifting cultivation techniques, forming a system of ecological knowledge that values (agro-)biodiversity and harmony with nature. Today, residents sell horticultural and agricultural products through internal exchanges and at markets in Ananindeua.

The Quilombo of Abacatal maintains a profound connection to its land, traditional knowledge, and natural environment. Smallholder-family farming forms the backbone of the local economy. Abacatal currently hosts approximately 500 residents across 162 families. However, climate crises and global environmental changes increasingly threaten food security, directly affecting the livelihoods of *quilombola* families and their autonomy over traditional production, cultivation, and sustenance practices.

Despite these adversities, Quilombo do Abacatal has responded with resilience and innovation.

Recently the community has experienced severe climatic and territorial transformations. Deforestation in surrounding areas, pollution of local streams, and unplanned urban expansion have altered environmental dynamics. Rainfall, once predictable, has become irregular; intense heat hinders crop growth, and fertile soil suffers from fires and erosion.

Rising temperatures, erratic rainfall, and environmental degradation disrupt ecological balance and reduce productivity in traditional fields and agroforestry systems (SAFs). To ensure food security in Quilombo do Abacatal also requires securing territorial rights, rights to water and access to healthy food, as well as the possibility for continuation of ancestral ways of life—key elements of *quilombola* resistance and climate justice. The ongoing threats, for instance, directly affect food security. Declining agricultural productivity increases dependence on processed foods, raises living costs, and undermines community autonomy. Additionally, small-scale *quilombola* food production faces marginalization as commercial enterprises expand and public policies rarely recognize traditional practices as part of climate solutions.

Despite these adversities, Quilombo do Abacatal has responded with resilience and innovation. Quilombola women lead reforestation projects, community gardens, and environmental education initiatives. Strengthening solidarity-based markets and reviving

[1] According to lands titled by the Pará State Land Institute (Iterpa).

heirloom seeds demonstrate that food security goes beyond mere availability; it encompasses sovereignty, autonomy, and recognition of traditional knowledge. Agroecological practices and productive home gardens confront climate crises while honoring ancestry and reaffirming the community's spiritual and cultural connection to the land.

Food security in Quilombo do Abacatal extends beyond agricultural production. It serves as a political act and a form of resistance against climate and social injustices. Climate crises disproportionately affect traditional territories, which contribute little to global emissions, but endure the most severe impacts. Ironically, these territories hold some of the most sustainable solutions for living in harmony with the environment.

QUILOMBO BAIXO ITACURUÇÁ

The *quilombola* communities of the Abaetetuba Islands in Pará pursued recognition and land titling through the Instituto de Terras do Pará (ITERPA), reflecting a collective push for the assertion of their land rights, nourishment of ancestral memory, and the affirmation of *quilombola* identity.

Black populations arrived in Abaetetuba during the 18th and 19th centuries, fleeing sugar mills and plantations in the Lower Tocantins river basin. Seeking freedom and new ways of life, they settled on islands and riverbanks, forming self-sufficient villages. These communities developed livelihoods based on artisanal fishing, subsistence agriculture, açaí collection, and cassava flour production. Solidarity, religious celebrations, traditional knowledge, and community organization sustained *quilombola* identity despite centuries of invisibility and social exclusion. Over time, residents developed strong territorial consciousness, perceiving land as a space of memory, culture, and ancestry rather than a mere economic resource.

As public policies supporting traditional peoples have strengthened in the last twenty years, the Abaetetuba communities organized to claim legal recognition. ARQUIA—the Association of Quilombola Communities of the Abaetetuba Islands—represents their collective interests. ARQUIA secured the Collective Land Ownership Recognition Title from ITERPA on June 5, 2002, officially recognizing 11,458.5320 hectares in Abaetetuba along the PA-151 highway toward Igarapé-Mirim. Subsequent technical studies and geographic surveys led ITERPA to issue a Rectification Term on December 16, 2010, reducing the area to 9.076.1909 hectares and updating the perimeter to 66.336.75 meters, forming an irregular polygon with 151 sides. This adjustment ensured precise territorial delimitation while fully preserving collective ownership and reaffirming historic *quilombola* rights.

Recognition and titling extend beyond legal formalities, symbolizing the resilience and agency of families who preserve African and Amazonian heritage across generations.

Recognition and titling extend beyond legal formalities, symbolizing the resilience and agency of families who preserve African and Amazonian heritage across generations. Traditional sustainable forest and water management practices illustrate that quilombolas serve as biodiversity guardians and defenders of ecological balance. Many practices draw from agroecology. The Rio Baixo Itacuruçá community relies on traditional cultivation, artisanal fishing, and home gardens to sustain daily life, preserve ancestral heritage, and maintain a respectful relationship with nature.

Key agricultural products include communal cassava flour and derivatives — manioc flour,

beiju, tapioca, starch, flour porridge, rice, and croeira (residual cassava reused for food). Residents also cultivate corn, pupunha, cupuaçu, cocoa, medicinal and aromatic herbs (e.g., lemongrass tea), and regional fruits like tucumã, inajá, mango, bacuri, and coconut. Açaí cultivation, in both floodplain and upland areas, supports food security alongside small livestock such as chickens, ducks, and pigs. Açaí plays a pivotal role in subsistence, culture, and monetary income.

Figure 3. Comunidade do rio baixo Itacuruçá, Pará, Brazil.

Recently, climate change has affected the Rio Baixo Itacuruçá community. Excessive heat and drought dry the soil and hinder plant growth, reducing yields. Intense rains inundate fields and destroy crops. Açaí production has declined, some trees are dying, and livestock face water and pasture scarcity. Springs and creeks that once supplied the community now dry or suffer pollution from deforestation, impacting domestic water use and food production.

These changes directly affect nutrition and health. Reduced crop yields limit access to fresh fruits and vegetables, forcing families to buy external food, raising costs, and diminishing dietary quality. Heat and stagnant water also encourage disease and insect proliferation.

Climate change severely affects açaí palms, essential for local diets and income: leaves wither, fruit clusters fall prematurely, and many trees die or fail to produce. Soil erosion and water scarcity exacerbate the situation, creating chronic problems. Other regional fruits have suffered as well, reducing agrobiodiversity and food security. Environmental challenges also include river pollution. Runoff from neighboring farms contaminates the Rio Baixo Itacuruçá, killing fish and shrimp, reducing water quality, and making springs unsafe for human use. Deforestation drives wildlife away from remaining forests, directly affecting traditional diets and local ecological balance.

Despite these challenges, the community demonstrates resilience. Residents unite to protect nature, restore degraded areas, and preserve springs. They combine ancestral knowledge with sustainable practices to confront climate change and secure a balanced future for coming generations. Medicinal herbs play a fundamental role in community life. They embody ancestral wisdom, cultural resilience, and a deep connection with nature. Residents use herbs for curative and preventive purposes, addressing ailments from digestive issues to spiritual concerns. Herbs complement modern medicine while highlighting local biodiversity as a vital source of life and well-being. Beyond medicinal uses, many herbs enrich cuisine, contributing flavor, aroma, and nutrients to traditional dishes.

Conscious, sustainable use of plants promotes food security and strengthens cultural identity. The community preserves resistance and ancestral knowledge, reinforcing the importance of environmental preservation, smallholder-family farming, and cultural practices for survival and dignity.

Conscious, sustainable use of plants promotes food security and strengthens cultural identity.

CONCLUDING THOUGHTS

The Quilombos of Abaetetuba and Abacatal demonstrate historical resilience and cultural preservation in the Amazon. Descendants of enslaved Africans consolidated distinct ways of life, sustained by harmonious relationships with rivers, creeks, and forests. Preserving this knowledge remains essential. In times of climate change and biodiversity loss, valuing and documenting community knowledge ensures these practices continue to inspire care for health, land, and collective memory.

Ensuring food security in these communities means protecting land, clean water, and recognizing *quilombola* ways of life in public policies addressing climate change. Food sovereignty and agroecology provide practical and viable strategies to maintain the Quilombos of Abacatal and Abaetetuba as a home of living memories, where food symbolizes identity, culture, and resistance.

Finally, the latest official data by the INPE (Brazilian Institute for Space Research) deforestation rates from 2008 to 2021 from the Legal Amazon Deforestation Monitoring Project (Prodes) demonstrate that 99% of these *quilombola* territories have preserved vegetation, creating preservation shields in the Amazon). In Pará, where 7,236 *quilombola* families live, there has been 474,000 km^2 of deforestation outside of the 10 km radius of their territories. However, within these territories, conservation reaches 99%. Therefore, enhancing the quilombolas projects has further positive feedbacks that exceed food security and sovereignty but also biodiversity in Amazonia and other endangered biomes where these communities settle, such as the caatingas and Atlantic forests.

Key Messages

- **Protecting and empowering *quilombola* communities** simultaneously strengthens food security, preserves cultural heritage, and supports climate-resilient landscapes in the Amazon and other vulnerable biomes.
- **Full legal recognition and protection of *quilombola* territories must be ensured**, including waterways and forests, to safeguard food production and ecosystem services.

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A World Where Many Worlds Fit? Taking Indigenous Peoples and Local Communities' Knowledge Seriously at the COP

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The case studies in this chapter shed light on how traditional and Indigenous Peoples and Local Communities' Knowledge has been fundamental to building, sustaining, and restoring present-day ecosystems over the long term. Although these case studies show strategies developed by past societies, it is stated throughout this chapter that they are far from being relics of the past and are often used and meaningful to the population of Indigenous Peoples and Local Communities. Their knowledge systems show many continuities with those of ancient societies, despite the brutal process of colonization in many parts of the Global South / Majority World and the inherent dynamics of knowledge transformation. This essay aims, insofar as is possible within the limits of a brief text and given the complexity of the subject, to reflect on what it would mean to take Indigenous Peoples and Local Communities' Knowledge seriously in the context of COP. This is the supreme decision-making body of the UNFCCC, which brings together all signatory countries to negotiate and advance climate action. We argue that while it is essential to recognize the crucial role of Indigenous Peoples and Local Communities in developing strategies to curb the climate and environmental crisis, a further step is fundamental. One must truly acknowledge that the ontological foundation of their knowledge production is different from Western ones. Recognizing this is a fundamental basis for engaging in legitimate interontological dialogues.

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Indigenous People's participation in spaces such as the COPs leads to encounters between radically different conceptual worlds. Although Indigenous Peoples are formally acknowledged in various outcomes of these processes—ranging from IPCC reports to the Paris Agreement's recognition of Indigenous Peoples and Local Communities' Knowledge, and the establishment of the Local Communities and Indigenous Peoples Platform (LCIPP)—their contributions often remain framed within categories predefined by dominant institutions.

To ground this, we draw on an example from a climate policy workshop organized by the Federation of Indigenous Organizations of the Rio Negro (Foirn) in partnership with the Socioenvironmental Institute (ISA), a Brazilian NGO. At one point, a facilitator (one of the authors of this essay) asked a group of Tukano Indigenous Peoples' participants what the

terms “biodiversity” and “governance”—both central concepts within international climate negotiations—meant to them.

Their responses situated these notions within an ontological frame distinct from the Western one: they defined biodiversity as encompassing both visible and invisible beings, as active agents part of environmental management. Similarly, they framed governance as a practice of care, inseparable from shamanistic interactions with these same invisible beings—a process mediated by shamans through, among other things, bahsese.

To elaborate, *bahsese*—a term Tukano speakers often translate into Portuguese as *benzimentos*, or “acts of blessing”—refers to a repertoire of words, expressions, and discourses. It enables communication and negotiation between a human expert and invisible beings, functioning as a fundamental technology of care and healing. Relationships with “sacred places,” or *wametise* (literally “named places”), are also central to this form of governance. These sites are intrinsically linked to the origin of the world and humans (Barreto *et al.*, 2018).

Drawing from grounded examples like these, what would it mean to take seriously forms of knowledge that emerge from non-dominant worlds—worlds whose ontologies acknowledge beings, entities, and practices not recognized by the dominant order of nation-states, international treaties, and the Western sciences that guide climate diplomacy? Is it possible to engage the knowledge systems of both the COP and Indigenous Peoples in a way that aligns with Indigenous reflexive pragmatics (Viveiros de Castro, 2012), thereby avoiding unilateral explanations? And ultimately, could the very conceptual architecture of the COP be transformed through such an encounter, if these knowledges were taken seriously as equivalent interlocutors?

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To address these concerns, a crucial starting point is to underscore that treating different knowledge systems on an equal footing requires refusing to frame Indigenous Peoples and Local Communities’ Knowledge as a system of beliefs. The problem with this label is that it often serves to disqualify “other” knowledges, rather than recognizing them as coherent systems with their own internal logic and requirements. For instance, when an Indigenous person states that biodiversity encompasses invisible beings with whom shamans interact, the task at a negotiation table—where what matters and what exists is ontologically different for each party (Stengers, 2018)—is not the job of the Western side to dismiss this by stating that “invisible beings do not exist”. From the standpoint of Eurocentric modern science, the existence of such beings may be considered false, but this is to miss the point entirely. As anthropologist Viveiros de Castro (2013) argues, doing so is equivalent to wondering “whether the number two is tall or green” (p. 494)—it is simply the wrong category of question! Indigenous Peoples and Local Communities’ Knowledge is based on a system of concepts that, like those in any other knowledge system (including the scientific), are intellectual tools for thinking about, understanding, and engaging with reality (Viveiros de Castro, 2013). Therefore, taking Indigenous Peoples and Local Communities’ Knowledge seriously requires putting Indigenous Peoples’ concepts on the negotiation table.

From a pragmatic standpoint, the ability to respond satisfactorily to a problem is inherent to any system of knowledge—each produces facts with pragmatic consequences. The “truth” of

scientific facts, for instance, stems not from a supposedly unquestionable authority, but from their capacity to offer reliable solutions to the problems they set out to solve (Costa, 2021).

Let us take as an example the relationship of Indigenous Peoples with the most biodiverse forest on the planet. Their management practices, embedded in their own knowledge systems, have profoundly transformed the Amazonian landscape over millennia without destroying it, leaving behind fertile soils, geoglyphs, earthworks, and forests rich in food (Heckenberger *et al.* 2003; Watling *et al.*, 2017; Levis *et al.*, 2017). These practices have actively enhanced ecosystem diversity and biodiversity. It follows, then, that the successful conservation of the Amazon rainforest is fundamentally dependent on these very relationships, which are rooted in knowledge systems developed over millennia of interaction with the forest. This was a system fully capable of sustaining the *buen vivir*—the "living well"—of Indigenous Peoples and the beings (both visible and invisible) who co-inhabit the forest with them, right up until the colonial encounter with the world of white people, the "People of Merchandise" (Kopenawa & Albert, 2013). And it still is—as long as Indigenous Peoples' rights are guaranteed and their territories officially recognized.

In this sense, struggles for the defence of fundamental territories for biodiversity and climate regulation—where Indigenous Peoples and Local Communities' Knowledge or ways of knowing, acting, and relating to the world are entangled with the environment—are also ontological struggles (Escobar, 2016). Given that the threats in this context originate from non-Indigenous worlds, it is a matter of ontological justice that Indigenous Peoples participate in climate policy decision-making with their concepts taken into account, without trying to force a mismatch into a single dominant worldview defined by modernity.

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It is important to emphasize that seeking common ground is not about fulfilling a "liberal desire to understand everyone" (Blaser, 2013, p.559) by brushing off conflicts and differences. It is both possible and necessary for irreducible disagreements to coexist (Stengers, 2018), just as a world where many worlds fit should be possible, as the famous Zapatista motto states.

This is not about reaching the same conclusions, using the same language, or creating a project to encompass all worlds. It is about co-producing the conditions for a shared articulation—a rearrangement of what is not yet known and what will be built jointly by these multiple, divergent worlds (Stengers, 2005).

Philosopher Isabelle Stengers emphasises the need to slow down the construction of the common and to create room for hesitation as a way of resisting the dismissal of what matters to one's world. In many conflicts or negotiations between non-Indigenous and Indigenous peoples, the latter are often expected to renounce their worlds. As one might put it, the unspoken condition often seems to be that Indigenous concepts of governance are welcome—so long as they exclude acts of blessing, invisible beings, and sacred places.

While at COPs it is possible to see Indigenous participants begin their speeches with acts of blessing and prayers, having their concepts and what matters to them included as legitimate pieces at the negotiation and decision-making table is a significant step forward.

Considering an unpredictable and dynamic world, there is no single narrative capable of

encompassing everything that can be said about it (Costa, 2021). The "truth" would then be that which produces pragmatic convergences without flattening ontological divergences—a truth forged through engagement with the world and the beings that take part in it (Costa, 2021).

If negotiations are necessary, they should happen through dialogue—an encounter between people through which they collectively name and make sense of the world. However, a true dialogue cannot occur between those who wish to impose their naming of the world and those who are denied the right to speak their own word. For those whose voices have been silenced, the first step is to reclaim that right to speak and to resist the continuation of this dehumanizing denial. To speak a true word is to perform praxis—the unity of reflection and action—which transforms the world and, in doing so, humanizes it (Freire, 2005).

What Indigenous scholars and leaders and non-indigenous anthropologists have been claiming is that recognizing and valuing the ontological differences is essential for fostering a fair and balanced dialogue and negotiation between different worlds per se (Andrade & Vieira, 2012; Barreto *et al.*, 2018; Blaser, 2013; Krenak, 2022). A shared common ground can only be imagined and constructed by fully acknowledging these singularities. This requires, above all, thinking *with* Indigenous Peoples (Viveiros de Castro, 2012).

In this short essay, we do not aim to present solutions to the challenges and questions we initially raised, since these are part of an ongoing and long-standing philosophical, ethical, political, and onto-epistemological open debate. Rather, we seek to emphasize the importance of keeping these questions in mind when striving to engage in fair and symmetrical dialogue with Indigenous Peoples and Local Communities' Knowledges.

Recommendations

- Recognize that ontological differences are not mere beliefs, but truths about worlds that matter.
- Not disqualify "non-Western" knowledge when it conflicts with Western knowledge.
- Value differences as fertile opportunities for producing joint solutions.
- Refrain from imposing Western terminology and logic as the default consensus in interepistemological dialogues.
- Acknowledge the limitations of Western thought and its role in the current climate and ecological crisis.
- Remain open to revising their convictions, including the presumed universalism of Western knowledge.

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2.2 Andes

The Andean Highlands are among the most challenging environments for human settlement on Earth. From arid high plateaus above 3,500 meters to steep mountain valleys and glaciated peaks, communities have long adapted to extreme cold, thin soils, and irregular rainfall. Rather than imposing dominance over nature, Andean societies developed food and water systems grounded in a relational worldview. In this perspective, mountains (apus), water (yaku), soils (allpa), plants, animals, and humans are all part of a single community, where every being has life, agency, and kinship ties.

Highlighting Peru and the location of the case study in this section

Central to this worldview is the idea of *Uyway/Uywaña*, often translated as "mutual nurturing". This concept goes far beyond the Western notion of "domestication". To "nurture" means to care for and be cared for by soils, crops, animals, and waters. Agricultural work is thus framed as a dialogue with the environment, rather than an act of exploitation. Over centuries, these principles were materialized in landscapes of terraces, irrigation canals, and wetlands. In the Andean highlands, terracing technologies have been in use since around 4,300 BP, allowing communities to create flat surfaces for cultivation on steep slopes, to build deep and fertile soils, and to retain moisture in otherwise arid environments. Hydraulic systems are designed to guide water rather than force it, with reservoirs, canals, dams and *q'ochas* (shallow basins) enhancing infiltration and storage. Wetlands or vegas are "raised" and cared for as part of this reciprocal relationship, supporting both biodiversity and herding economies.

Agriculture in the Andes has always been a collective endeavor. Families operate within networks of labor exchange (*ayni, minka, yanapa*), where planting and harvesting are shared responsibilities, embedded in cycles of reciprocity. Soils (*allpas*) are classified and "raised" according to their qualities—warm, cold, fertile, or tired—and matched

Andean Highlands
Credit: Bepa/stock.adobe.com

with specific crops or rotations. By planting in multiple ecological zones, staggering sowing dates, and intercropping, farmers spread the risks of frost, drought, or pests, ensuring continuity even in adverse years.

This mode of production has endured because it is sustainable at its core: it maintains soil fertility, conserves water, reduces climate risks, and ensures biodiversity. It also sustains cultural and spiritual values, as cultivation is inseparable from honoring *Pachamama*, the Mother Earth who gives life. For centuries, these practices have safeguarded an extraordinary diversity of crops, including quinoa, potatoes, maize, and tubers adapted to different ecological niches. Rather than seeking uniformity, Andean farmers have historically valued and actively fostered genetic variability. Long before European colonization, thousands of local landraces and ecotypes coexisted, reflecting a deep understanding of ecological diversity and coevolution with the landscape— and, to this day, despite post-colonial genetic erosion, more than 4,000 native potato varieties are still preserved in the Andes.

Throughout history, Andean communities have continually adapted their food and water systems to climatic fluctuations, from prolonged droughts to intense rainfall. Farmers developed flexible strategies, such as checkdams, to slow down and retain water, reducing erosion and enhancing soil moisture. Terraces were built not only to create cultivable land but also to stabilize slopes and buffer the effects of frost or sudden storms. Crop diversification, multi-altitude planting, and staggered sowing further minimized risks, ensuring that at least part of the harvest survived under adverse conditions. These strategies, tested for centuries in one of the world's most climate-sensitive regions, highlight the Andes as a living laboratory of resilience.

In an era of climate crisis, Andean systems demonstrate that it is possible to live, farm, and thrive in fragile, high-altitude environments. Their success lies not only in technical ingenuity but in the relational worldview that places reciprocity, respect, and balance at the center of human–nature relations. These landscapes are living archives of adaptation, offering insights highly relevant for today's climate challenges.

In an era of climate crisis, Andean systems demonstrate that it is possible to live, farm, and thrive in fragile, high-altitude environments.

Past Water Futures: Rehabilitating Ancient Dams for Present-day Use in the Peruvian Andes

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Peru is at the forefront of climate change and concomitant water insecurity due to increasingly unstable rainfall regimes, retreating glaciers and new socioeconomic pressures on water use (Drenkhan *et al.*, 2015). Yet, climate change is not a modern phenomenon, human populations have suffered, mitigated and overcome the effects of adverse weather and environmental conditions for millennia. One such event was the Medieval Climate Anomaly (abbreviated as the MCA, see also, Lüning *et al.*, 2019). Occurring between *c.* AD 750-1350, with a core period during AD 1000-1200, the MCA in South America generally brought a drier and warmer climate (Figure 1).

It is likely that the MCA triggered the almost complete disappearance of glacier cover from the Pacific-facing western mountain range, precipitating a situation in which rainfall became the only annually reliable source of water. To offset this increased unpredictability of water availability, Late Prehispanic period (AD 1000-1532) communities in these highland zones adapted to the new climate regime through sustained building of hydraulic infrastructure, especially water dams, along the upper watershed basins. These features were what are known as *gravity dams*, constructed of stone and clay in which the weight and bulk of their construction is what held them in place, usually anchored onto bedrock for further stability.

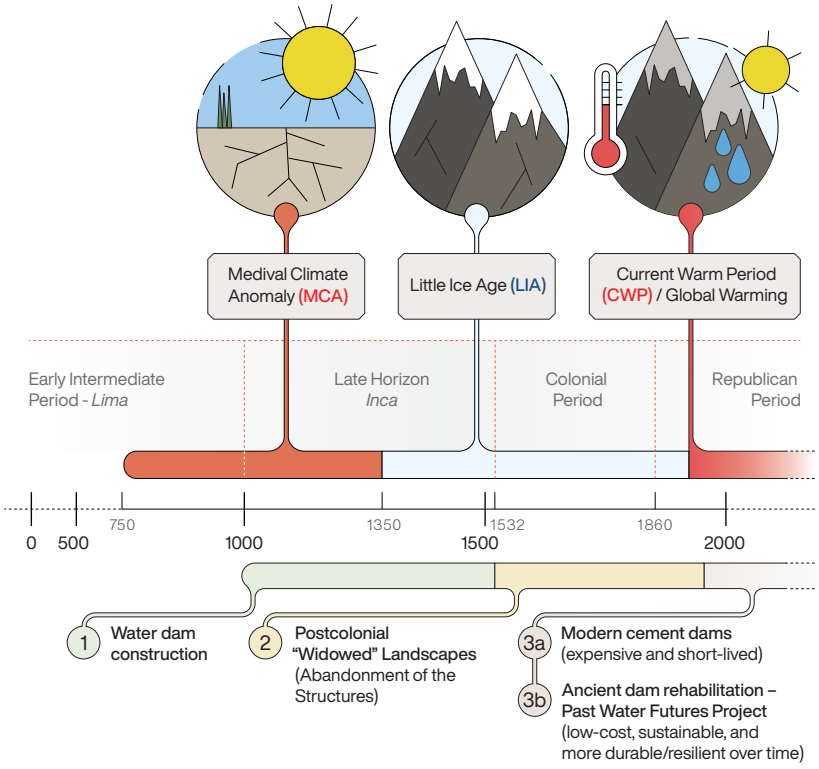

Figure 1. Timeline

This investment was considerable. Across the Cordillera Negra, covering a stretch of c. 130 km, over 290 ancient water dams have recently been identified (Pey *et al.* 2025). A limiting factor seems to have been the availability of clay near to the proposed dam: during this period the dam was invariably built where rock—ubiquitous to the highest areas of the Andes—and clay was present. In turn, this strong investment in water security led to a population explosion in the highlands, representing the highest such increase until the establishment of Spanish

imperialism across the Andes (post-AD 1532). Following this formative event, a catastrophic decline in the Indigenous People's population during the 16th and 17th Century led to the almost wholesale abandonment of these structures, heralding the establishment of *widowed landscapes* and ecologies, including derelict hydraulic infrastructure such as dams, reservoirs, *amunas*, and even terraces, among others. Nowadays, these abandoned infrastructures represent an important *installed capacity* of water-capture potential, especially as the Peruvian Andes face renewed pressure from climate induced water scarcity.

Figure 2. Ricococha Baja: pre-Hispanic dam rebuilt in 2008, failed within six months.

In these present-day circumstances where water insecurity is on the rise, the go-to solution has been the construction of modern micro-dams throughout Peru (Autoridad Nacional del Agua 2016). Invariably, in the highlands these constructions are often placed directly upon the older Prehispanic structure irrevocably destroying any record or function associated with them. While it is known that modern micro-dams are a tried-and-tested and widely accepted form of grey infrastructure that can ameliorate water scarcity, it does come with problems especially within the complex context of the Peruvian highlands.

Modern micro-dams are built from concrete and steel, and while they can hold much greater quantities of water than their more rustic Prehispanic cousins, they are also considerably more rigid and inflexible in a region where seismic events are a common occurrence. Furthermore, modern micro-dams require expert engineering knowhow both at the design and construction level. Once the initial cost outlay has been expended in their construction few of these structures are maintained regularly, especially by rural highland communities that lack the expertise to assess a dam's condition or the financial means to redress any necessary repairs.

Another major problem is the potential for malfeasance in the modern construction of these dams. There are numerous cases of substandard materials and less quantity than the required (especially of cement bags) being employed in the construction of new micro-dams, such that the life-expectancy of these structures declines precipitously from the standard 50 years (Wieland 2010) to on average 20-30 years, in some cases considerably less so. By way of comparison, Prehispanic dams show incredible resilience, in many cases even after 500-years of negligible maintenance many of these ancient gravity dams still partially function, retaining and distributing water. The construction of the modern Ricococha Baja dam in 2008 ably demonstrated this (Figure 2). This dam functioned for just six months before it was rendered almost completely inoperable due to seismic activity compounded by bad planning and the use of limited and substandard materials (Llosa Larrabure, 2008).

Even so, state agents, NGO's, and critically, highland communities view modern micro-dams as paragons of rural development, acknowledging the use of cement and steel as progress, going so far as to term these 'noble material'. In contrast, the Prehispanic stone and clay dams are seen as defunct and inherently 'ignoble', even when in certain cases over 500 years of abandonment and negligible maintenance have not stopped these structures from still retaining and distributing water.

The *Past Water Futures* project advocates for the rehabilitation of Prehispanic dams, thereby providing a heritage-based solution grounded in the recovery of Traditional Ecological

Knowledge (TEK) and technical knowhow rooted in strong community engagement. Local buy-in is critical to these projects, as it ensures that the restored structures are effectively adopted by the target communities and maintained as an integral component of their yearlong activities (*faenas*). In essence, the restoration of ancient water dams represents a technically complex, yet low-carbon solution to water scarcity in the Andes. Additionally, there are important cost-saving implications; while a modern micro-dam budgets at a minimum of one million USD, the rehabilitation of a Prehispanic dam ranges between 100,000 and 150,000 USD apiece.

Figure 3. Weetacocha: pre-Hispanic dam rehabilitated in 2024.

To date, the two Prehispanic dams, Ricococha Alta and the Weetacocha (Figure 2 and 3) dams, have been rehabilitated, and are both located in the Pamparomás District of the Cordillera Negra. While respecting the original construction of the dams, these rehabilitation projects incorporate certain modern materials, such as geomembrane, geotextiles and a modern sluice mechanism, thereby increasing the efficiency of the restored structures. Respectively, these two dams have a basin capacity of 18,750 m3 and 24,000 m3. Furthermore, in the first rainy season (November-April) both dams filled up at least twice, greatly boosting the available water. Some of this water then infiltrates via crack porosity through the dense Andesite geology replenishing underground aquifers that emerge as springs further downslope, creating a virtuous circle of water availability throughout the watershed. Additionally, the provision of new water at the head of the basin has incentivised the recovery of localised ecology, especially of birds which now frequent the new lakes. We have termed this positive hydraulic feedback loop with benefits to both water availability and environmental renewal a *recovered ecology*.

In regards to human benefits, the rehabilitation of these Prehispanic dams has led directly to three main outputs alongside heritage preservation of these structures, including; water provision which leads to increased water security and resilience among local communities; the growth of local economies, directly impacting monetary activity and output; and finally, protection of the environment, given that dam rehabilitation not only restores the dam itself but also protects important high-altitude wetlands which are crucial for preserving wildlife and plant environments. Of the identified 290 ancient dams in the Cordillera Negra, a conservative estimate could see at least a third of these rehabilitated. The skills honed by our research team through this process of rehabilitation can be applied on similar structures throughout the Andes and further afield. For instance, analogous technology has been observed in Africa (including the sand dams of Kenya, see Lasage *et al.*, 2008), Asia (such as the gabarbands in Pakistan and India, see Possehl, 1975) and Europe (for instance the anthropogenic fish ponds of central and eastern Europe, see Pokorný & Hauser, 2002).

Nevertheless, going forwards with this program of ancient hydraulic technology rehabilitation will require a significant paradigm shift from the current one of disregard and even contempt, towards one that embraces and promotes the restoration of these structures intimately embedded within rural communities. To this end, our research team is currently working towards deliverable policy directives at the local and state level which enshrine the rehabilitation of past hydraulic infrastructure for present-day use. We contend

that in future, a hybrid approach will be best. Where old hydraulic infrastructure already exists (*installed capacity*), then these should be protected and restored; where no such infrastructure is present, then modern solutions, with the right safeguards against malpractice, should be implemented. Only by harnessing both the past and present—a combined approach—can we mitigate the risk of climate-induced water scarcity, providing resilience and reassurance to increasingly water-stressed communities throughout Andes and the world.

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Recommendations

- Recognize ancient hydraulic infrastructures as strategic climate assets, offering resilient, low-cost, and sustainable alternatives for contemporary water management and adaptation planning.
- Integrate heritage-based restoration into national water policies, promoting the rehabilitation of pre-Hispanic dams as community-driven solutions to water scarcity.
- Implement modern solutions only where such ancestral systems are absent, ensuring safeguards against unsustainable or extractive practices.
- Strengthen local capacities and community engagement through participatory restoration programs that ensure long-term maintenance and social ownership of rehabilitated dams.

Supplementary Materials

https://gs-anthropocene.org/publications/

2.3 Africa

Africa is among the world's regions most vulnerable to the impacts of climate change. Average temperatures across much of the continent have already increased by about 0.7°C, and projections indicate further warming accompanied by more frequent droughts, floods, and biodiversity loss (UNFCCC Factsheet Africa, 2007).

These climatic pressures are compounding pre-existing challenges related to food security, water scarcity, and land degradation. As the UNFCCC highlights, addressing these issues requires locally grounded adaptation strategies that integrate ecological conservation, sustainable land management, and community resilience. Archaeological research across eastern and sub-Saharan Africa further reveals how past farming and herding communities adapted to environmental variability through flexible land-use systems, nutrient management, and mobility. These long-term perspectives demonstrate how traditional knowledge and landscape stewardship can inform current policies on adaptation, restoration, and nature-based solutions.

Savannah in Kenya
Credit: Tomas/stock.adobe.com

Integrating Indigenous Peoples and Local Communities' Knowledge of Agriculture In The Pursuit of Sustainable Farming Practices

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Small scale farmers – under 2 ha – play an important role in the world food production systems with a contribution of about 35% of global food production (Ricciardi *et al.*, 2018; Lowder *et al.*, 2016) while improving local economies and livelihoods for over decades despite environmental and climatic challenges that lowers their production level (Kirina *et al.*, 2025; Dubois *et al.*, 2024; Olayide & Alabi, 2013; Morton, 2007). The global focus is aligned with Sustainable Development Goal 2 (SDG 2: Zero Hunger), which aims to end hunger and promote sustainable food systems through affordable technologies, information sharing, and resource mobilization to help small-scale farmers adapt to climatic and economic challenges (Restrepo *et al.*, 2023; Ricciardi *et al.*, 2021; Chasek *et al.*, 2016). In the East African region, for instance, extreme climate events such as floods and droughts will increase significantly by the end of the century (Ayugi *et al.*, 2022; Gebrechorkos *et al.*, 2023; Muheki *et al.*,2024; Demissie *et al.*, 2025).

Improving farming systems requires approaches that conserve soil, protect biodiversity, and adapt to climatic change. Practices such as regenerative agriculture, agroforestry and conservation agriculture improves production while preventing soil degradation and building resilient food systems (Dummu *et al.*, 2013). Lessons from historical Indigenous Peoples' land use practices can guide the adoption of these methods in modern small-scale farming (Figure 1).

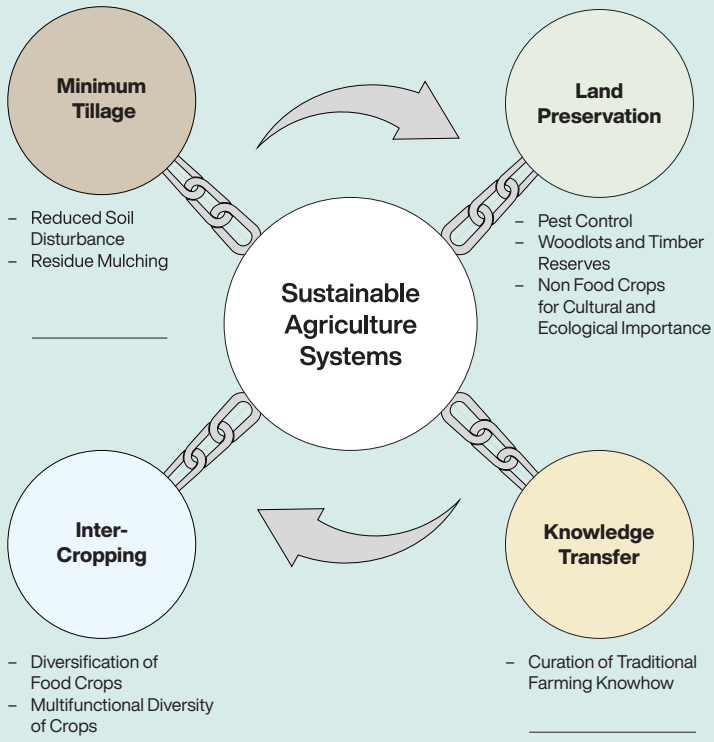


Figure 1. Core components of East Africa Indigenous Peoples' sustainable agriculture systems linking soil, land, biodiversity, and knowledge.

Historical and contemporary discussion of Indigenous land use and farming systems globally are mostly associated with wide scale landscape destruction of forest ecosystems (Crawshay, 1902; Hutchins, 1909; Baker, 1931; Aleman, 2018). In East Africa, Indigenous agricultural communities are highly linked to montane forest destruction over the past five centuries (Crawshay 1902; Castro, 1991; Leakey, 1977). In hindsight, this biased or misinterpreted context ignores the ingenuity, resilience and sustainability aspects embedded in native farming practices (Allan, 1965; Castro, 1991).

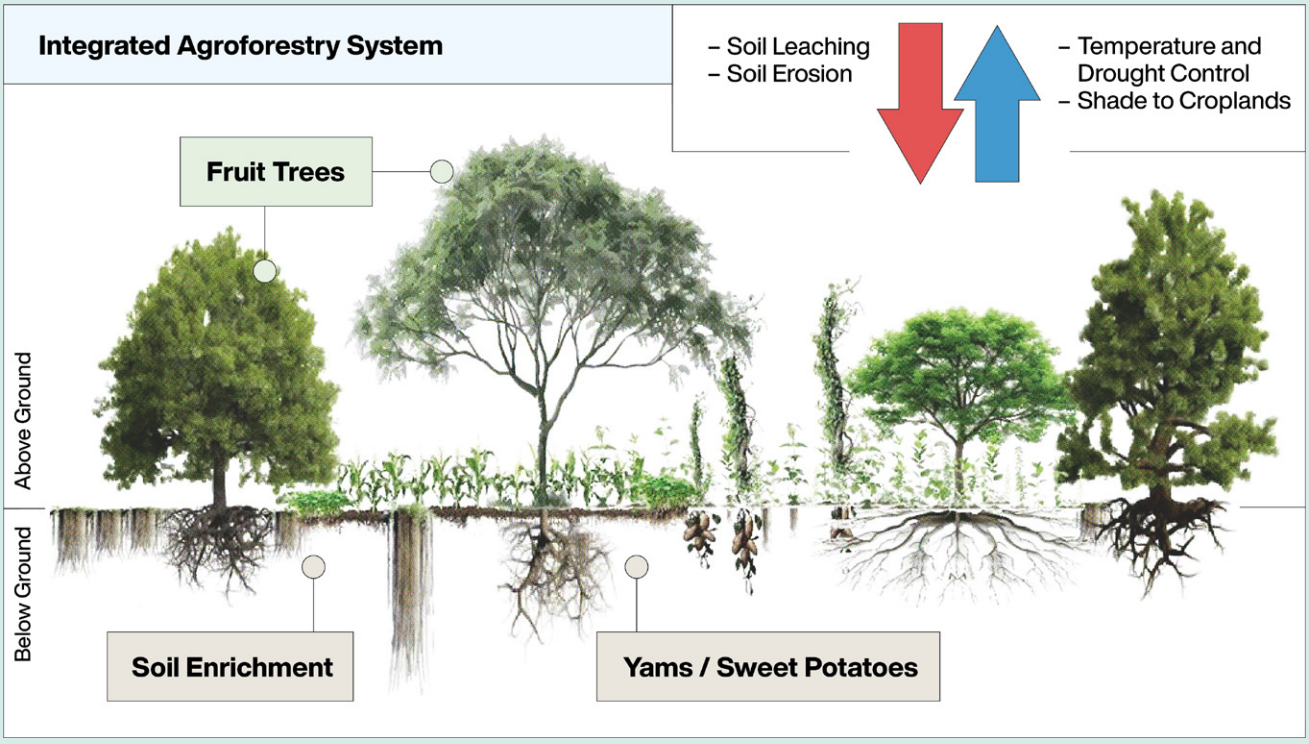
Indigenous farming communities developed and maintained adaptive practices, tools and knowledge over centuries to sustain productivity amid changing climates and food demands (Melash *et al.*, 2023; Atleo, 2011). It has been shown that during the major climatic shifts during the Holocene period, which include the African Humid Period estimated to have occurred between 11000-5000 Yrs BP (Tierney *et al.*, 2011, Kuper & Kröpelin, 2006) and the subsequent arid period (deMenocal & Tierney, 2012), communities adopted strategies that helped them prevail against the changing climate shifts (Phelps *et al.*, 2025). Through inter-cropping, agro-forestry, biological pest control and irrigation practices suited to local environments, they maintained resilient farming systems. Their reliance on fertile landscapes supported not only food production, but also essential resources like fodder, medicine, fibers, timber, fuelwood, security fencing, tools and weapons (Castro, 1991; Jessen *et al.*, 2021).

African agriculture is dominated by cash crops introduced and expanded during colonialism, promoting monocropping for export. In the mid-1950s, small-scale farmers adopted these practices including synthetic fertilizers use, resulting in extensive ecological impacts.

ENCOURAGING MINIMUM TILLAGE AND SOIL DISTURBANCE

In Indigenous farming systems where practices like minimal tillage and crop diversity was integral, annual and perennial species—such as tubers and plantains served as natural organic mulching. Therefore, nutrients recycled and preserved soil health and biodiversity (Leakey, 1977) (Figure 2). Unlike modern monocultures, ecologically healthy methods, such as intercropping, offer valuable lessons for regenerative agriculture and climate resilience.

Figure 2. Illustration depicting an integrated farming setup consisting of grain, vegetables, tubers, fruit trees and non-food crops to maximize sustainable farming opportunities for both above ground and below ground soil conservation.



In modern-day small-scale farming practices, the majority of farmers have adopted farming monocultures of staple crops that have in turn greatly reduced the diversity of crops and their associated benefits to the soil profiles. This is in contrast to the minimum tilling efforts that were employed to sow cereals using basic tools with minimal soil disturbance (Leakey, 1977). In addition, the incorporation and dependency on annual and perennial food crops such as tubers, plantains acted as cover crops and minimal tillage was required at the end of every season. Controlled burning and use of crop residue and application as mulch was extensively used with homestead organic pits commonplace within homesteads.

ADOPTION OF SPATIAL AND TEMPORAL CROP ROTATION

Indigenous farming systems in Kenya's highlands utilize crop rotation and fallowing to restore soil nutrients, enhance biodiversity, and reduce dependence on synthetic fertilizers- offering sustainable practices modern agriculture can adapt. Indigenous intercropping systems integrated food and non-food plants with indigenous trees such as *Commiphora zimmermanni* (African myrrh)*, Ricinus communis* (castor bean)*, Cordia abyssinica* (grey-leaved cordia or Sudan teak)*, Croton megalocarpus* (Kenya croton or musine)*, and Albizia sp.* (silk tree) to boost yields, enhance biodiversity, and provide cultural and ecological (Castro, 1991). Unlike modern monocultures with exotic species such as *Grevillea robusta* (silky oak) *and Eucalyptus sp.* (eucalyptus or gum tree) of low habitat value (Castro, 1983; Brokensha *et al.*, 1983), these multifunctional landscapes combined agriculture with community needs and environmental stewardship (Leakey, 1977; Castro 1991).

... these multifunctional landscapes combined agriculture with community needs and environmental stewardship.

LAND PRESERVATION

Indigenous land-use systems balanced private and communal ownership, protecting tree resources through woodlots and reserves—a model that suggests modern farming should retain tree plots instead of clear-cutting for ecological sustainability.

Indigenous farming systems sustained both food and non-food production through selective crop choices, biological pest control, and integration of indigenous species. These practices promoted soil and water conservation, biodiversity including pollinators and resilience-offering lessons for modern small-scale farmers facing and pressures and environmental challenges (Kiboi *et al.*, 2017, 2021; Okeyo *et al.*, 2014; Jessen *et al.*, 2022; Melash *et al.*, 2023).

TRANSFER OF FARMING KNOWLEDGE

Indigenous farming relied on conserving diverse plant species and generational knowledge transfer that included but not limited to weather, crops, and cultural practices ensuring sustainability (Castro, 1991; Melash *et al.*, 2023; Malapane *et al.*, 2024). Today, this knowledge transfer has weakened, with modern agriculture mostly driven by economic demands rather than cultural values leading to reliance on quick, less sustainable practices.

Indigenous farming systems provide policy lessons on sustainability, biodiversity, and cultural knowledge. By fostering community-based knowledge transfer, gender-specific expertise, mixed cropping and prioritizing local food security, modern policies can strengthen ecological resilience, soil health, and long-term stability against climate change.

Recommendations

- **Promote community-based knowledge exchange and capacity building**. Support participatory platforms where Indigenous Peoples and Local Communities of farmers can share adaptive techniques—such as intercropping, soil conservation, and biological pest control—to strengthen climate resilience.
- **Integrate Indigenous land-use models into national agricultural policies**. Encourage mixed land-use systems that retain woodlots, promote agroforestry, and balance private and communal land management to enhance ecosystem services and food security.
- **Revitalize crop diversity and rotation practices.** Incentivize the use of diverse annual and perennial species, crop rotation, and minimal tillage to restore soil fertility, reduce dependence on synthetic inputs, and foster biodiversity.
- **Align agricultural incentives with ecological and cultural sustainability.** Redirect subsidies and extension programs toward practices that value long-term soil health, traditional ecological knowledge, and local food systems rather than short-term market gains.

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Sustaining Livelihoods and Ecosystems: The Role of Regenerative Pastoralism and Indigenous Peoples' Knowledge and Traditional Ecological Knowledge in African Food Security

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Since the colonial period, Indigenous herding practices have been repeatedly mischaracterized as environmentally destructive and economically backward (Hardin, 1968; Lamprey, 1983; Fratkin, 2001). These assessments, grounded in limited ecological understanding, conflated mobility with mismanagement and justified restrictive land policies (Anderson, 2002; Galaty, 2021). These interventions caused pastoralists to lose nearly half of the most productive grazing lands, leading to fragmentation of both livestock and wildlife populations (Whittlesey, 1953; Coldham, 1979). Contemporary sedentarization and industrial agriculture further erode biodiversity and increase vulnerability to drought and disease (Kirkbride & Grahn, 2008; Lind *et al.*, 2020).Yet archaeological and ethnographic evidence from East Africa reveals that pastoralist mobility, rather than degrading the land, has long played a regenerative role in sustaining soil fertility and biodiversity (Lane, 2013; Marshall *et al.*, 2018).

Traditional pastoralism in eastern Africa—characterized by mobility across arid and semi-arid lands—ensures a cyclical redistribution of nutrients across diverse habitats. This mobility promotes ecosystem connectivity and resilience by maintaining wildlife corridors and preventing overgrazing (Muchiru *et al.*, 2008; Boles & Lane, 2016). Far from being ecologically destructive, these practices represent a form of regenerative land management comparable to ecological "bioengineering" (Ventresca Miller *et al.*, 2020; Branch *et al.*, 2023).

Archaeological studies show that historical anthropogenic "hotspots" created by mobile herding communities have enriched African savannah ecosystems for thousands of years. At Pastoral Neolithic sites in southern Kenya (3,700–1,550 cal. BP), chemical and isotopic analyses reveal high nutrient and δ15N enrichment in ancient dung deposits, with fertility levels persisting for over 3,000 years (Marshall *et al.*, 2018). These nutrient-rich patches formed through repeated livestock enclosures have become grassy glades that attract wildlife and increase savannah heterogeneity (Porensky & Veblen, 2015). Across areas such as the Maasai Plains and the Laikipia Plateau, pastoral glades are broadly distributed, typically spanning 15 to 45 hectares, highlighting the long-term spatial impact of traditional herding practices (Marshall *et al.* 2018)

Traditional pastoralism in eastern Africa—characterized by mobility across arid and semi-arid lands—ensures a cyclical redistribution of nutrients across diverse habitats.

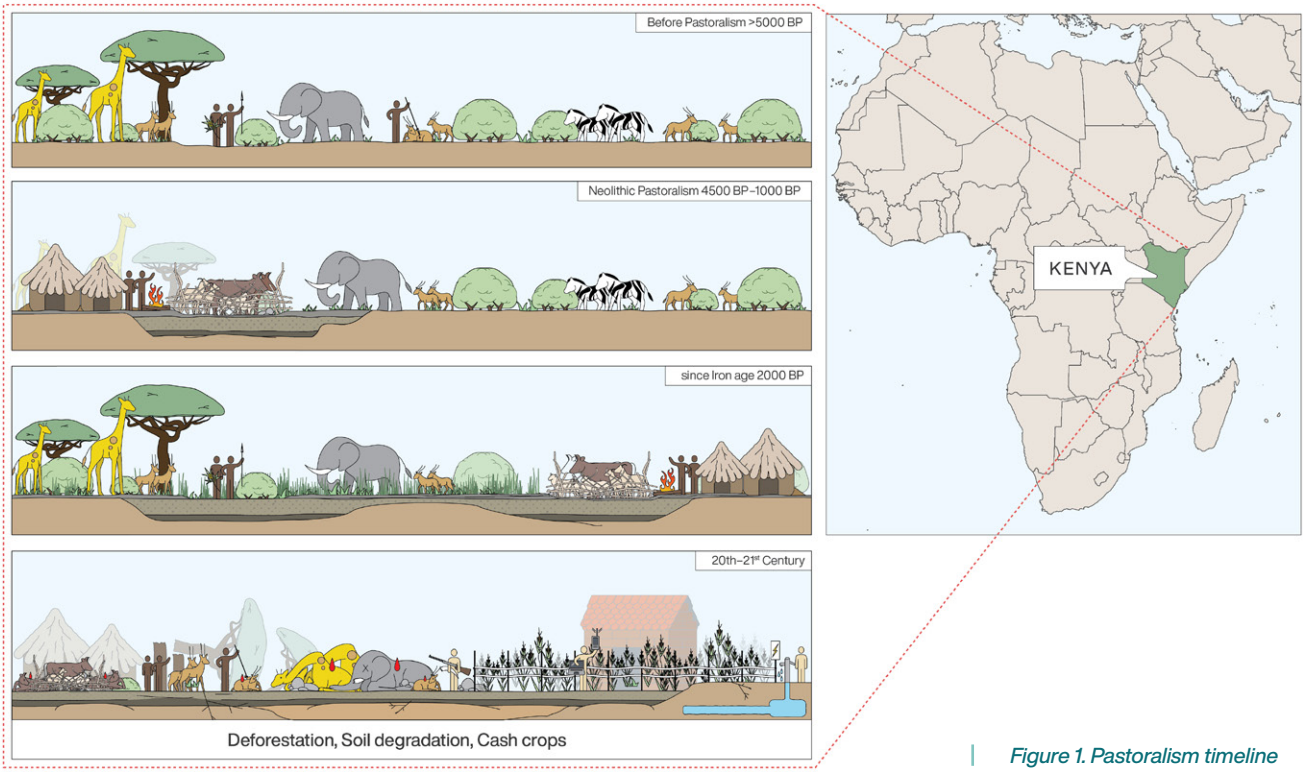
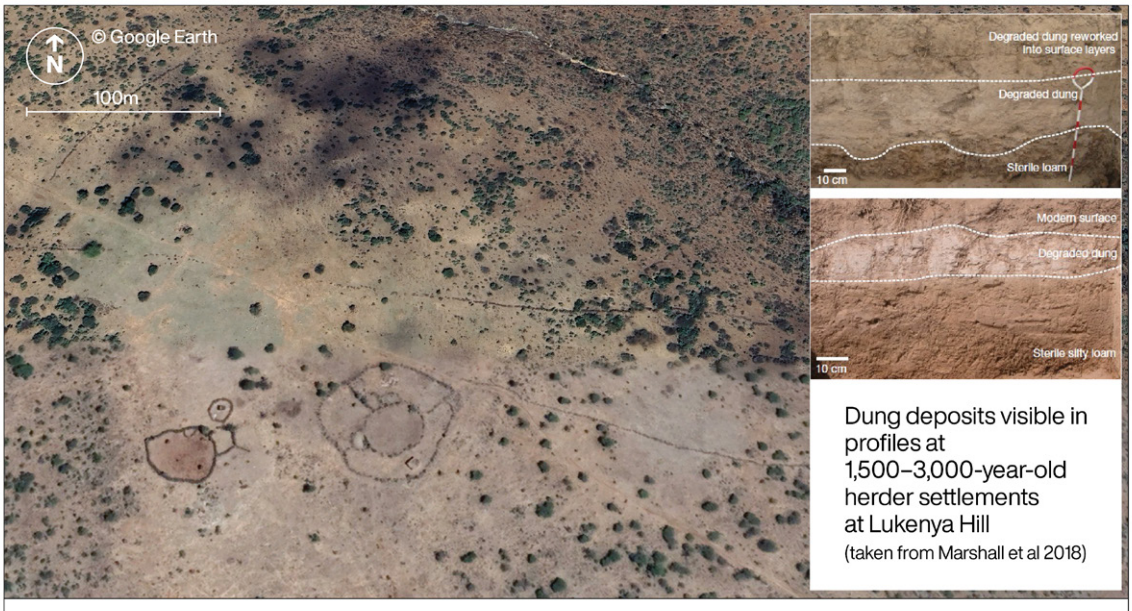


Figure 1. Pastoralism timeline

Moreover, traditional pastoralist practices that include grazing strategies to enhance carbon sequestration and support soil health. Integrating a variety of land cover types, including tree mosaics, is also crucial for boosting organic carbon inputs and minimizing soil erosion influence vegetation, which in turn affects the storage and circulation of nutrients in terrestrial ecosystems (Gitau *et al.*, 2025). Comparative studies show that while forest soils have higher organic carbon at shallow depths, grasslands accumulate more soil organic carbon at greater depths, highlighting that ecological restoration is a long-term process (Bai *et al.*, 2022). Grasslands, including those sustained by traditional pastoralism, can therefore enhance short-term soil carbon accumulation, while forest succession promotes long-term soil organic carbon stability and sequestration. Together, these vegetation systems contribute to maintaining terrestrial carbon pools and enhancing climate resilience.



High nutrient legacies encourage open grassy plant succession relative to bushy off-site vegetation at Ntuka (adapted from Marshall et al 2018)

Recommendations

- **Integrate Indigenous knowledge into agricultural policy.** Position Indigenous Peoples' Knowledge of farming systems as models of sustainability that blend biodiversity, soil fertility, and cultural heritage. Mainstream these systems within agricultural and climate policies at national and regional levels.
- **Foster community-based knowledge exchange**. Strengthen local extension networks and farmer-to-farmer and pastoralists learning platforms that promote adaptive knowledge on weather, soils, and crops. Integrating traditional and scientific expertise enhances resilience to climate variability, and also inter-community exchange of knowledge and experiences.
- **Promote biodiversity through mixed and multipurpose cropping.** Encourage mixed cropping and the cultivation of multipurpose species for food, fodder, and cultural use. This reduces dependence on monocultures, enriches soils, and supports pollinator diversity.
- **Recognize gender-specific agricultural expertise.** Embed gender equity into agricultural planning by acknowledging women's and men's distinct contributions to crop management, soil care, and seed conservation.
- **Prioritize local food security over export expansion.** Design agricultural policies that first ensure local food sovereignty and nutritional security before focusing on export production, reducing pressures for unsustainable intensification.
- **Embed cultural and social values in land stewardship.** Incorporate local belief systems and cultural values into land restoration and soil management programs to strengthen community ownership and long-term ecological stewardship.
- **Create incentives for agroecological and low-input practices.** Provide financial and technical incentives for farmers who adopt regenerative and agroecological methods that enhance biodiversity and carbon sequestration, supporting NDCs targets.
- **Strengthen climate information services for farmers**. Develop localized early warning systems and seasonal forecasts tailored to Indigenous Peoples and smallholder Local Communities to support proactive adaptation.
- **Recognize pastoral glades as long-term ecological assets:** Acknowledge areas with pastoral glades are widely distributed, as enduring products of traditional herding systems. These glades enhance soil fertility, vegetation diversity, and wildlife abundance, representing key nature-based solutions for dryland restoration.

- **Integrate archaeological and ecological evidence into land-use planning.** Use archaeological and geochemical data from Pastoral Neolithic and Iron Age sites to guide regional conservation and rangeland management. This evidence shows millennia-long nutrient enrichment and ecological stability created by herding practices — valuable for contemporary adaptation planning.
- **Secure land tenure and mobility rights for pastoral communities:** Strengthen legal frameworks that protect communal and transboundary grazing rights, enabling adaptive mobility that sustains nutrient cycling and reduces land degradation.
- **Incorporate pastoral glades into carbon and biodiversity accounting:** Include nutrient-enriched glades and rangeland mosaics in national greenhouse gas inventories and biodiversity indicators. Recognizing their role in soil carbon sequestration can align local practices with Nationally Determined Contributions (NDCs) and National Adaptation Plans (NAPs).
- **Enhance landscape monitoring and data integration** : Develop satellite-based and participatory monitoring systems to map and track pastoral glades, soil fertility, and vegetation cover changes. Combining remote sensing with community knowledge can improve evidence-based policy and adaptive management.

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3. Resistant crops, resilient foodsystems

3.1 Introduction

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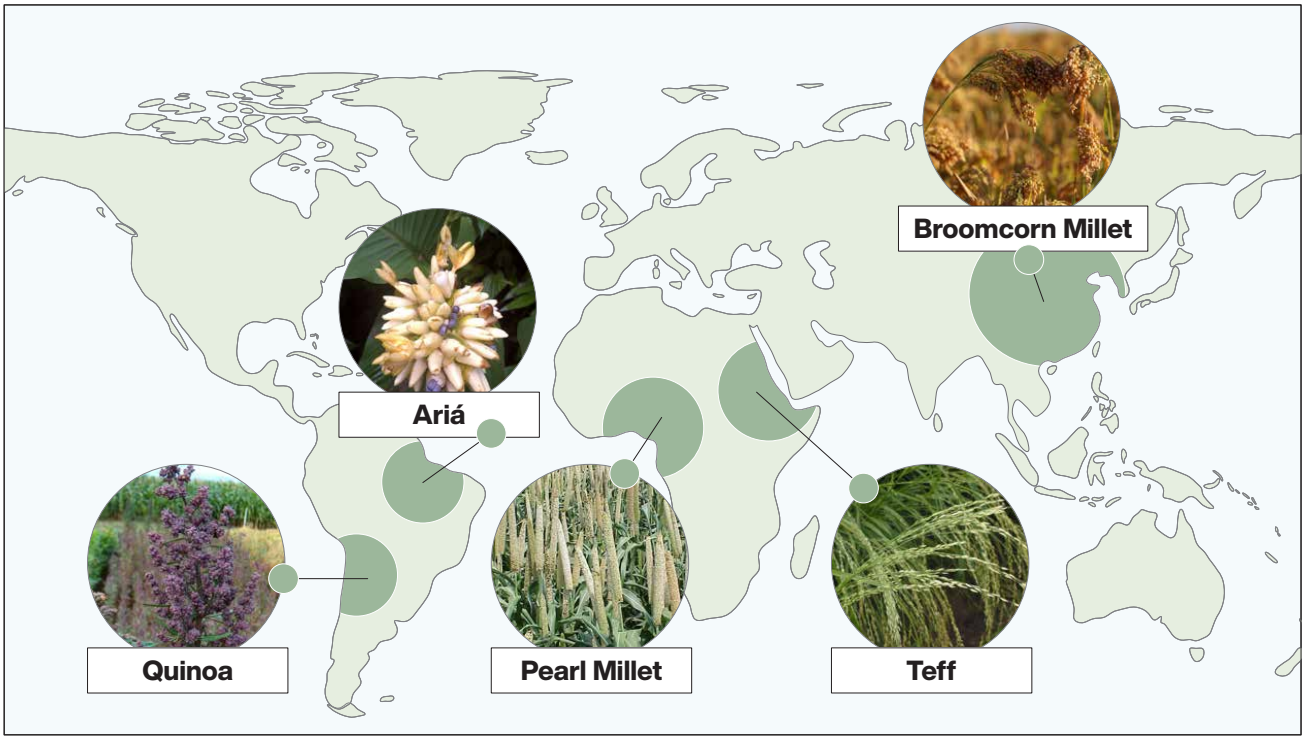
Traditional food systems involve not only food production, but also the entanglement of management and nurturing practices whereby foodways are a means of sustaining a relationship among people, plants, animals and landscapes, in intricate socioecological networks. In the long-term Indigenous histories across the globe, different peoples have developed different strategies for climate and environmental changes, adapting their food systems by both creating improved landscapes and food webs. Some of the plants consumed by Indigenous Peoples have crossed these transformations and inspired the adaptation of resilient food systems, where crops resistant to climatic and environmental changes play an essential role.

Traditional and resistant crops are not only superfoods, but living heritage conserved on farm, that embodies sustainable coexistence between humans and ecosystems.

In this section, we bring together resistant crops from the Andes, the Amazon, Africa and Asia highlighting the importance of TEK for the development and maintenance of human settlements in the past and present. In addition to their cultural resilience, the crops, the Andean quinoa, the Amazonian ariá, the African pearl millet and teff; and the Asian broomcorn millet,are plants important for food security. We also highlight the importance of maintaining territorial security and autonomy in regions of traditional cultivation of those crops, aiming to guarantee local management strategies responsible for their resilience, including genetic diversity and cultural practices of selection. Finally, we call for caution when transforming these crops into broader staple foods without the inclusion of their knowledge keepers into dialogues for promoting resilient practices of cultivation that do not risk their traditional and ancestral diversity.

3.2 Resistant crops from traditional/ Indigenous People's agriculture and its potential for food security



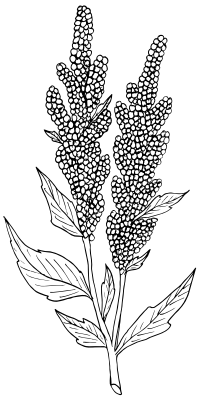
WHY "RESISTANT," BUT ALSO TOOLS OF RESISTANCE?

These crops do more than withstand droughts, floods, or poor soils . They embody the endurance of the peoples who have cared for them across generations. By valuing and supporting traditional food systems, we not only preserve biodiversity but also strengthen local autonomy and food security. In a world facing growing environmental challenges, Indigenous crops remind us that the future of sustainable agriculture is deeply rooted in ancestral wisdom. Their survival stands against the homogenizing forces of industrial agriculture, revealing the power of traditional knowledge to sustain productive, diverse, and regenerative landscapes. Supporting their cultivation is therefore both an ecological and political commitment — one that protects food security, preserves cultural memory, and reaffirms the intertwined futures of people and the environments they nurture.

Their survival stands against the homogenizing forces of industrial agriculture ...

Quinoa (*Chenopodium quinoa* Willd.)

Quinoa has been cultivated in the Andean highlands for millennia, with archaeological and paleobotanical evidence tracing its use to early Holocene hunter-gatherers (8000–3000 BC).



Although its exact center of domestication remains debated, current evidence points to the south-central Andes before 3000 BC. Revered in the Inka world as *chisiya mama* ("mother of all grains"), quinoa held both nutritional and sacred significance (National Research Council, 1989). Colonial expansion marginalized its cultivation, yet it persisted in traditional farming systems until the twentieth century, when imported cereals began to displace it from regional diets. Since the early 2000s, quinoa has undergone a global revival—symbolized by the UN International Year of Quinoa (2013)—and is now cultivated in more than 60 countries (Bazile *et al.*, 2015).

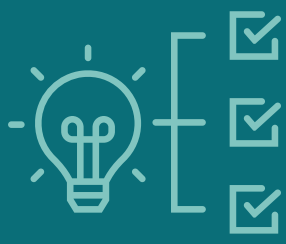
The agronomic resilience of quinoa is remarkable as it can tolerate frost (down to −4 °C), high temperatures (up to 35 °C), and soil salinities up to 51.5 dS/m, maintaining growth and yield under moderate saline irrigation (~17 dS/m) (Jacobsen *et al.*, 2012). It thrives from sea level to over 4,000 m and performs well in nutrient-poor or degraded soils, making it one of the most adaptable crops for climate-stressed regions. Nutritionally, quinoa provides a complete amino-acid profile, essential micronutrients, and gluten-free carbohydrates, positioning it as a strategic crop for food security and nutrition (Ruiz *et al.*, 2013).

Quinoa is genetically diverse. It comprises a broad range of ecotypes—highland, inter-Andean, *salares*, and lowland groups—each adapted to specific climatic and soil conditions (Jarvis *et al.*, 2017). Recent genomic studies confirm its extensive allelic variation, reflecting millennia of local selection across distinct agroecological niches. Today, around 16,400 accessions of quinoa and its wild relatives are conserved in 59 institutions across 30 countries, with 88 % safeguarded in the Andean region (Bazile *et al.*, 2022). This genetic reservoir is vital for future adaptation, but its protection depends on policies that ensure fair access, benefit-sharing, and the active participation of Indigenous custodians.

Quinoa's resilience is not only biological, but it is relational asts cultivation is embedded within an ecological and cultural system that links soils, water, animals, and humans in mutual care (*crianza mutua*). Techniques such as rotational cropping, sectoral fallowing, and multi-altitude planting sustain soil fertility, reduce pests, and buffer climate variability (Valladolid Rivera, 1994). These practices represent a long-standing form of adaptive ecological engineering rooted in TEK and continuous environmental observation. Global expansion, however, brings new challenges. When cultivated outside its ancestral landscapes without safeguarding Andean genetic resources and knowledge systems, quinoa risks decontextualization—becoming a commodity detached from its ecological and cultural fabric. Policy frameworks promoting its global use must therefore include mechanisms for seed sovereignty, benefit-sharing, and the recognition of Indigenous custodianship.

Quinoa's resilience is not only biological, but it is relational asts cultivation is embedded within an ecological and cultural system that links soils, water, animals, and humans in mutual care (crianza mutua).

Recognizing quinoa as both a crop and cultural heritage is an important step to advance the Sustainable Development Goals (SDGs 2, 12 and 13). Its integration into climate-adaptation strategies demonstrates how biodiversity conservation, traditional knowledge, and food sovereignty can work together to strengthen resilient food systems worldwide.



Key Messages

- **Beyond biology:** Quinoa is not only a superfood, it is a living heritage that embodies sustainable coexistence between humans and ecosystems. Quinoa's resilience is ecological and cultural. Its balanced cultivation depends on conserving Andean genetic, water, and soil resources alongside ancestral knowledge.
- **Sustainable practices:** Techniques such as rotational cropping, sectoral fallowing, and multi-altitude planting protect soils, reduce pests, and buffer climate shocks.
- **Risk of decontextualization:** Expanding quinoa globally (>60 producing countries) must avoid reducing it to a mere commodity, ensuring that Andean communities and their worldviews remain central.

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Ariá (*Calathea allouia*)

Ariá is a plant of the Marantacea family endemic to the Amazon forests and produces a small root used for food supply.

Similar to quinoa, it is one of the few plants with all the essential amino acids, making it a highly nutritious food. It has been cultivated in the Amazon since circa 9,000 years ago, in distinct habitats including seasonally flooded savannas and evergreen forests. It is also a bioindicator of Amazonian Dark Earths (ADE), especially in southwestern Amazon where its consumption dates back to the beginning of local occupations.

The ariá plant integrated into the early food systems of the Amazon along with palms and other roots such as manioc (*Manihot esculenta*). Differing from manioc, the ariá was not transformed into a commodity during colonial times and its consumption largely vanished from local food webs. Even so, many Indigenous groups maintain ariá cultivation in their gardens or manage spontaneous ariá concentrations growing in their territories, and it is recognized as a plant that binds the connections between ancestral lands and modern territories.

THE MANIOC IMPACT AFTER DROUGHTS AND THE ARIÁ ALTERNATIVE IN THE AMAZON

In recent times, due to the impact of climatic changes in manioc cultivation, researchers and stakeholders are in dialogue for promoting ariá gardens for sustaining food security in the Amazon.Traditional manioc gardens represent the staple food for many Indigenous Peoples and Local Communities in the Amazon basin, and familiar production is responsible for 85% of the national production (around 19,13 million tons for 2023) in Brazil. As a result of recent extreme climatic fluctuations in this region, the production of manioc has been severely impacted by the draughting and heating of the soil, causing food insecurity for entire communities. In face of these events, ariá has been proposed as an alternative crop, being more drought tolerant than manioc.

Key Messages

- **Biodiversity hotspot:** Ariá is important due to its drought tolerance benefits for climatic change periods, but also for the maintenance of biodiverse food webs, which are essential for the food system's resilience.
- **Memory crop:** Nowadays, ariá is a time connector between past and present, bringing together ancestral roots to new solutions of sustainability. This reinforces the connection between land security and food security, once TEK involving food plant biodiversity is deeply rooted in landscapes and memories.
- **Caution in expanding crop exploitation:** As many other previous experiences, the use of traditional food crops as staple foods can include risking its ecological security by diminishing genetic diversity (ex. the rubber tree). Keeping a familiar agriculture base, informed by TEK, is a best practice for sustaining expanded ariá cultivation.

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Pearl millet (*Pennisetum glaucum*)

Globally, pearl millet is one of the most resilient cereal crops due to its high adaptability to arid and semi-arid environments and is increasingly recognized for its potential in climate change adaptation.

Domesticated in the western Sahelian zone of sub-Saharan Africa, pearl millet has a long history of cultivation, with its use spreading across Africa and later to Asia, where it became established as a traditional crop in regions such as India between 4,000 and 3,500 years ago (Fuller & Boivin, 2009). Africa is both a center of origin and diversity for millets, such as fonio, black fonio, and guinea millet, pearl millet represents a cornerstone of agrobiodiversity and food security for millions of small-scale farmers across Sub-Saharan Africa. Its drought tolerance, short growing season, and ability to thrive in nutrient-poor soils (*i.e.* sandy and calcareous) underscores its relevance as a climate-smart crop in both traditional farming systems and contemporary agricultural strategies. Cultivated on marginal and drought-prone lands, it thrives where few other crops can grow, requiring minimal external inputs while delivering high nutritional value, superior protein quality, and essential micronutrients.

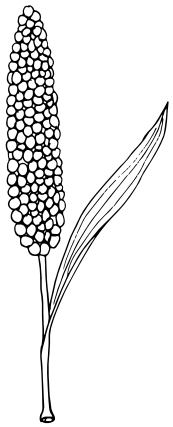
Beyond its agronomic importance, pearl millet cultivation embodies a rich cultural and ecological heritage, maintained through Indigenous Peoples and Local Communities' Knowledge, local seed management systems, and community-based food traditions. Each farming community preserves distinct local cultivars, finely tuned to specific agroecological and livelihood contexts, making farmers the primary custodians of genetic diversity. Despite its ecological and nutritional advantages, millet agriculture remains largely neglected in research and policy frameworks, underscoring the need for integrated strategies that link biodiversity conservation, food security, and rural empowerment. Strengthening this interface is crucial for enhancing climate resilience and cultural continuity across Africa's dryland farming systems.

Pearl millet survives and maintains yield under water stress through a combination of short-term physiological adjustments and long-term structural adaptations. In the short term, the plant reduces water loss through stomatal closure while maintaining photosynthesis, adjusts cell osmotic potential to preserve water content, and produces antioxidants to protect tissues from damage. Over the long term, pearl millet develops deep and extensive root systems, with rapidly elongating primary roots and dense lateral roots that access moisture from deep soil layers, even penetrating compacted soils. Its leaves adapt by rolling, folding, or temporarily withering to reduce water loss during drought, yet they recover after rainfall. The plant also exhibits asynchronous tillering, where secondary shoots develop at different times to compensate for drought-affected growth and maintain grain production. Additionally, flexible flowering, either early or delayed, allows grain maturation to align with rainfall patterns, helping the crop escape terminal drought (Shrestha *et al.*, 2023).

Pearl millet is exceptionally tolerant of heat and drought, and as global temperatures rise and rainfall becomes more unpredictable, its resilience is likely to restore its prominence.

Pearl millet has long been invaluable to millions of rural communities across eastern and southern Africa. Yet over the decades, many farmers—particularly in southern Africa—have gradually shifted to maize. Several factors have driven this transition: international research has improved maize productivity relative to pearl millet; government incentives have made maize financially more attractive; and maize is easier to process, making it more convenient for daily use. As a result, maize has increasingly been introduced into regions traditionally suited to pearl millet, where it often struggles to perform reliably.

However, a new opportunity is emerging. Pearl millet is exceptionally tolerant of heat and drought, and as global temperatures rise and rainfall becomes more unpredictable, its resilience is likely to restore its prominence. Among grains that support livelihoods under harsh environmental conditions, pearl millet stands out for its ability to thrive where other crops fail. Today, roughly one-third of the world's millet is cultivated in Africa, with about 70 percent of this production concentrated in West Africa (National Academies of Sciences, Engineering and Medicine, 1996). Key pearl millet–producing countries in the region include Nigeria,



Policy Implications

- Pearl millet's resilience makes it a key climate-smart crop for adaptation strategies in Sub-Saharan Africa, South Asia, and other arid regions. Supporting the cultivation of pearl millet and integrating it into national adaptation plans can:
- Enhance food security under increasingly unpredictable rainfall patterns.
- Reduce vulnerability of smallholder farmers to droughts and crop failure.
- Promote sustainable land use in marginal, degraded, or semi-arid soils

Niger, Burkina Faso, Chad, Mali, Mauritania, and Senegal, while Sudan and Uganda are major producers in East Africa. In southern Africa, the expansion and commercialization of agriculture have led to maize partially or entirely replacing this traditional staple. The second place where pearl millet is widely produced is India, where 4,000 years ago it crossed the Indian Ocean and became an important staple in South Asia, where it is known as bajra. Today, it ranks as India's fourth most important cereal, after rice, wheat, and sorghum, covering nearly 10 percent of the country's food-grain area and contributing roughly 5 percent of total cereal production. The states of Rajasthan, Maharashtra, Gujarat, and Uttar Pradesh account for around 80 percent of the 14 million hectares planted and 70 percent of the annual 5 million tons of pearl millet grain.

While some farmers grow pearl millet under irrigation during hot, dry months—reaching yields of 3–4 tons per hectare—the majority cultivate it in arid, low-fertility regions where rainfall is insufficient for sorghum or maize, sometimes receiving as little as 150 mm per year. Even under these harsh conditions, pearl millet survives and provides a reliable food source.

Finally, to strengthen resilience and sustainability, it is critical that scientific research, agricultural programs, and rural development policies actively support the implementation of ethno-ecological approaches in Sub-Saharan African communities and beyond.

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Teff (*Eragrostis tef*)

Teff is an ancient cereal native to Ethiopia and one of the oldest domesticated grains in Africa. It remains a cornerstone of Ethiopian food systems, providing the flour for *injera*, the fermented flatbread that is a national staple. Culturally, teff defines daily meals and identity. Cultivated across highly diverse agroecological zones—from semi-arid lowlands to highlands above 3,000 m—teff shows remarkable plasticity to climatic and edaphic variation (Bayable *et al.*, 2021).

This grain tolerates both drought and temporary waterlogging better than many cereals, owing to rapid phenological development and a high capacity for recovery after rehydration (Gebremedhin *et al.*, 2025). Field trials indicate yield reductions between 25 % and 50 % under drought stress, depending on its timing and severity. Molecular analyses reveal complex regulatory networks that enable drought adaptation, including abscisic acid–dependent and –independent pathways, antioxidant responses, and genes controlling osmotic adjustment and stomatal conductance (Ramírez-Gonzales *et al.*, 2024). Efforts to test teff in other dryland contexts, such as the Mediterranean Basin, show promising results for dual use as grain and forage under climate-change scenarios (Ruggieri *et al.*, 2024).

Despite its adaptive traits, teff productivity remains modest—averaging 1.5–2 t ha^{-1} under smallholder conditions (Bayable *et al.*, 2021). Lodging and nutrient depletion in highly weathered soils are major constraints, alongside uneven rainfall and limited access to improved varieties. For these reasons, teff represents both a cultural keystone and a research priority for sustainable intensification. Given its centrality in food and economy, the intensification or expansion of teff is not a neutral agronomic shift: it engages issues of seed sovereignty, market power, and land tenure in Ethiopian communities.

Teff is not only agronomically resilient but also deeply rooted in Ethiopia's social, cultural, and economic fabric. It is grown by smallholder farmers—some 6.5 million households—and functions as both a subsistence staple and a cash crop (Adepoju *et al.*, 2024). In fact, 43 % of Ethiopian farmers cultivate teff, and its commercial surplus has economic value comparable to that of all other cereals combined (Minten *et al.*, 2018). In traditional systems, teff is sown by broadcasting seed by hand on lightly prepared soil, often after the onset of rains. Because its seeds are extremely small, farmers sometimes increase seeding density to outcompete weeds. It is intercropped or rotated with pulses or cereals to maintain soil fertility and reduce pest pressures. Harvesting is done manually, usually with sickles, followed by threshing by trampling or other traditional methods. Farmers also value the straw as fodder—teff straw is preferred over many other cereal straws for livestock feed.

Beyond agronomy, its success in Ethiopia is sustained by the co-evolution of knowledge and practice—rotations, varietal mixtures, and local scheduling systems that anticipate rainfall variability. Supporting these knowledge systems through participatory breeding and fair access to germplasm will be key to enhancing resilience.

Policy-notes

- **Promote participatory breeding for drought tolerance**, lodging resistance, and nutrient-use efficiency.
- **Integrate teff into dryland diversification strategies** as a low-input, climate-resilient crop.
- **Protect native landraces and local seed systems** as living reservoirs of adaptive potential.

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Broomcorn Millet (*Panicum miliaceum L.*)

Broomcorn millet is one of the earliest domesticated cereals in Asia, cultivated in northern China at least 10,000 years ago and later diffused across Eurasia (Lu *et al.*, 2009).

Archaeological evidence from ancient Chinese sites such as Cishan suggests that millet's storage and use became ritualized, embedded in early agrarian transition as communities moved from foraging to farming (Cishan Culture, ~8,000 years ago). Its short growing season (60–90 days), low water requirements, and tolerance to poor soils make it a model crop for dryland agriculture. In traditional agricultural systems, it is often part of mixed cropping or intercropping schemes: planted alongside other grains or legumes to diversify risk, buffer climatic variability, and enhance total system yield. Its cultivation is closely tied to local seed exchange networks, where farmers conserve landraces adapted to microclimates. Because its yield does not demand high inputs, it is often favored in resource-poor farming systems.

Broomcorn millet's drought resilience helped stabilize agrarian communities facing erratic rain. As climate stress intensifies, its role as a "security crop" is regaining relevance. But scaling its cultivation must protect the integrity of traditional practices and seed systems, so that diversity is not lost under commercial uniform varieties. Recent genomic and physiological studies underscore its remarkable resilience, indicating broad genetic diversity for stress adaptation (Yuan *et al.*, 2022). It also shows adaptive responses to salinity. Beyond physiology, its ecological robustness is complemented by complex plant–microbe interactions: soil rewetting after drought triggers shifts in the rhizosphere bacterial community, contributing to post-stress recovery (Liu *et al.*, 2024).

Beyond its agronomic and microbial resilience, broomcorn millet carries deep cultural and symbolic weight across Eurasian societies. In the Pontic region, for instance, historical sources such as Pliny the Elder praise broomcorn millet as a revered staple, reflecting its symbolic status within agricultural identity (Dal Corso *et al.*, 2022). Recipes like *kulesh* (nutritive porridge) further grounded millet in daily life and survival narratives across Slavic and steppe societies. Today, traditional dishes like *chatang* in northern Chinese cuisine, made with broomcorn millet flour, preserve that gastronomic link — a living cultural thread that connects rural agricultural memory with modern urban life.

Policy-notes

- **Integrate broomcorn millet into regional adaptation plans** as a short-cycle, low-input grain for semi-arid regions.
- **Support participatory selection** of locally adapted landraces and maintain genetic diversity through community seed networks.
- **Leverage new genomic resources** to develop multi-stress-tolerant varieties while avoiding genetic homogenization.

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3.3 Case Study: Enhancing the Importance of Traditional Foodways

When the *Chagra* Guides Time: Eco-Cultural Calendars and Climate Resilience in Vaupés, Colombia

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The *Derecho Humano a la Alimentación y Nutrición Adecuadas* (DHANA, or Human Right to Adequate Food and Nutrition) emerged in 1948 as a response to global hunger and food insecurity, guaranteeing everyone access to sufficient and dignified food at all times (FIAN, 2020). More than seven decades later, the COVID-19 pandemic deepened this crisis: between 2019 and 2021, hunger increased by 150 million people worldwide, reaching 768 million, while 2.3 billion experienced moderate or severe food insecurity (GNR, 2022). In Latin America and the Caribbean, 13.2 million more people suffered from hunger, and malnutrition now coexists with overweight and obesity, affecting both children and adults. In Colombia, where 54% of the population faces some level of food insecurity and chronic undernutrition affects 10.8% of children under five (FIAN, 2024), these problems—rooted in social determinants such as poverty, education, and access to clean water—underscore the urgency of systemic change in public health and food systems.

In Vaupés, one of Colombia's 32 departments located in the Amazon region, food insecurity, iron deficiency, and the erosion of food sovereignty remain pressing challenges. With a population of about 44,700 inhabitants—71% of whom live in rural areas and 82% self-identify as Indigenous Peoples—Vaupés is among the country's most culturally diverse yet sparsely populated territories (0.8 inhabitants/km^2). Nearly 88% of its land is designated as Indigenous reserves, home to Cubeo, Desano, Tucano, Wanano, Siriano, Tuyuca, Yuruti, Bara, Carapana, Tatuyo, Barasano, and Piratapuyo peoples (DANE, 2018). Despite this, many communities

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still lack formal land recognition or sufficient territory, while others face conflicts due to overlapping jurisdictions with national parks or municipal boundaries. Even in extensive reserves, resource control and protection are difficult, and extractive pressures persist. These conditions have contributed to the loss of traditional crops and a growing dependence on purchased foods, weakening both food security and cultural identity (Peña *et al.*, 2009).

At the same time, Indigenous Peoples continue to be viewed through a pathological lens that equates ancestry with vulnerability. Public health and nutrition policies, grounded in Western biomedical paradigms, often impose standardized diets and interventions that disregard Indigenous Peoples and Local Communities' Knowledge of food systems and cosmologies. This approach reproduces colonial dynamics in which external actors—missionaries, settlers, and now institutions—undermine ancestral knowledge, food practices, and locally grounded notions of wellbeing (Figure 1).

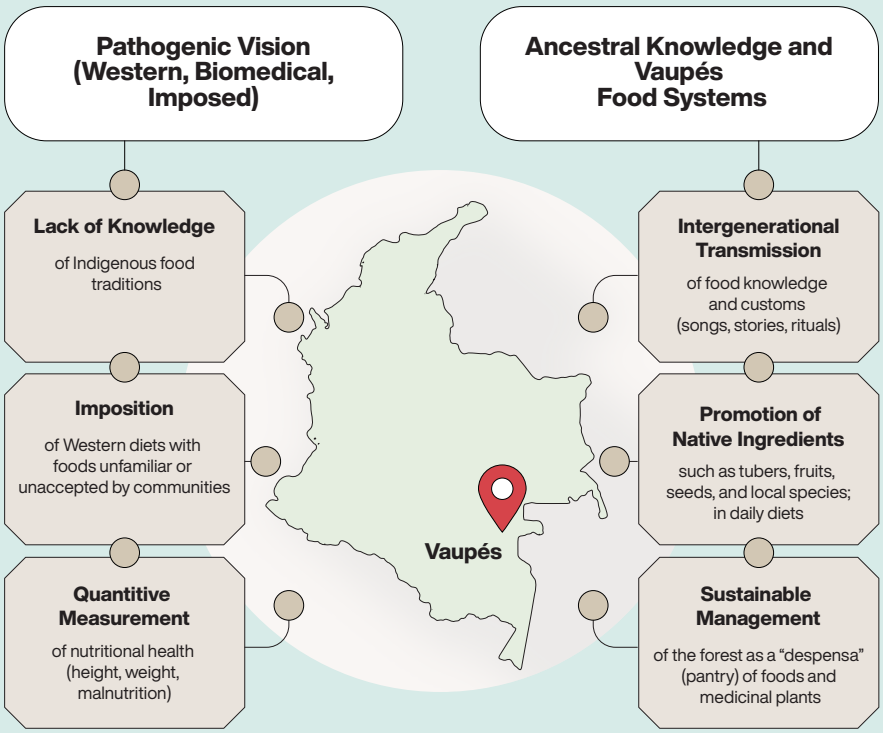

Figure 1. Map of Colombia highlighting the Vaupés region, alongside a comparison between the 'Pathogenic' and the 'Ancestrality-Centered' perspectives.

Despite these challenges, Indigenous Peoples and Local Communities in Vaupés continue to develop strategies that allow them to resist the pressures of globalization, market dependency, and rapid—often forced—acculturation. One of the most enduring forms of resilience lies in the application of traditional knowledge to food preparation and social organization around production. A striking example is *yuca brava* (bitter cassava), the region's staple crop and a symbol of both subsistence and identity. Though toxic in its raw form, it is transformed through ancestral techniques into casabe (a flat cassava bread) and *fariña* (cassava flour). These practices embody a sophisticated understanding of ecology, toxicity, and transformation that has been transmitted across generations, reaffirming the communities' deep relationship with the forest and the spiritual power of food—to heal, to sustain, and to connect with the divine (Arango-Ruda, 2021; Sinergias, 2022).

The peoples of Vaupés also face profound environmental changes: unpredictable river levels, prolonged droughts or rains, and declining fish and game populations (Sánchez, 2024). Yet alongside these disruptions, new forms of resistance emerge, grounded in a kinship relation between humans and the forest. The forest is recognized as mother or sister—an entity that gives and receives, alive and sentient. This worldview sustains practices of reciprocity, care, and protection that contrast sharply with Western extractivist logics. Within this living cosmology, two key expressions of resilience stand out: *the chagra*—a traditional agroforestry garden system—and the ecological-cultural calendars that embody the memory of the forest's cycles.

THE CHAGRA AS A PRACTICE OF RESISTANCE

The *chagra* is the traditional cultivation space where Indigenous Peoples grow most of the foods they consume, including those essential for rituals—such as cassava, coca leaves, chili peppers, and pineapples. Work in the *chagra* forms the foundation of women's cultural and traditional labor, a practice transmitted and adapted through generations.

Its organization reflects a clear gendered division of labor: men clear and burn the fields, while women are responsible for planting, harvesting, and overall management. The *chagra* is therefore under women's stewardship, and household food security largely depends on their work. Although often undervalued, their role is crucial (Andoque & Castro, 2013). Through exchange networks with other communities—selling some products to obtain and plant others—women sustain and diversify production. The *chagra* also grants authority to knowledgeable women, guardians of medicinal plants and healing practices. It is both *despensa* (pantry) and pharmacy, a space that nourishes and heals body and spirit. Yet, many medicinal species once common are no longer cultivated.

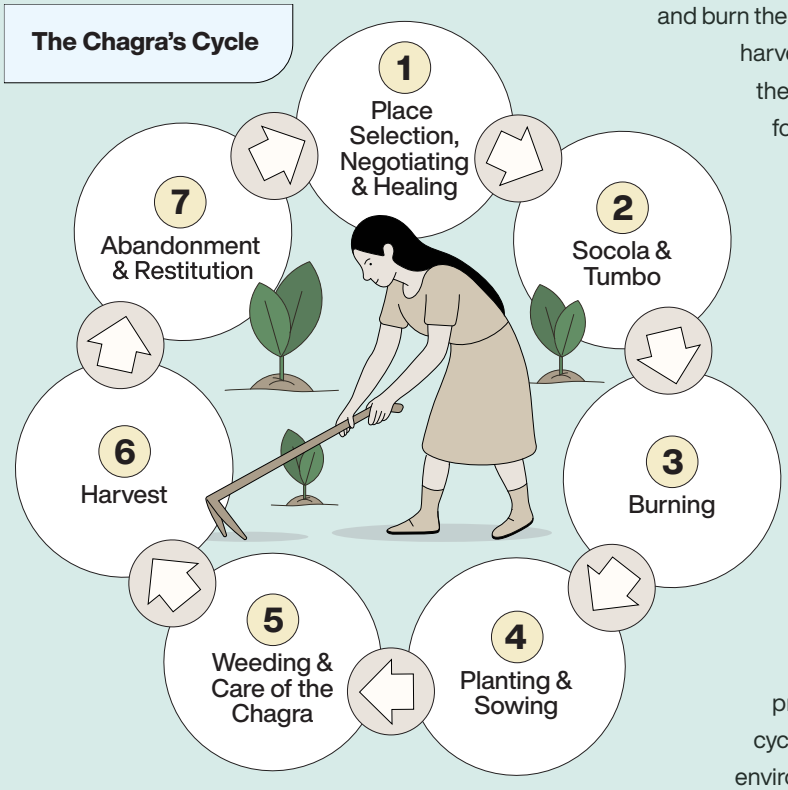

Figure 2. Chagra's cycle

These gardens follow cyclical rhythms: burning takes place in January, secondary-growth plots are established in July, and larger *chagras* are prepared toward the end of the year. When these cycles are disrupted, food availability declines. Today, environmental changes have altered this regularity, but for many families, the *chagra* remains both a source of resilience and a form of resistance—a sovereign piece of land that ensures household food security under women's care (Figure 2). In other words, those who manage the *chagra* also sustain the forest.

ECOLOGICAL-CULTURAL CALENDARS: LIVING MEMORY OF THE FOREST'S CYCLES

The cyclical logic of the *chagra* is formalized in the ecological-cultural calendars, tools that interweave time, practice, and territory. The Vaupés calendar (Figure 3) reveals the close connection between belief systems, the *chagra*, and food dynamics. At its center stands the *maloca*—the traditional communal house used by many Indigenous groups in the Amazon and across South America. It is where the most important and symbolic community decisions are made and where connection to the cosmological system and ancestral knowledge takes place.

In this calendar, the *maloca* embodies the link between nourishment and ritual life, reminding us that eating is not merely a biological act but one infused with symbolic and social meanings. The calendar also marks the different "seasons," each tied to the availability of food and to rituality: the season of the fish people (*Waimãsã*), the season of the stars and constellations (*Nocõãrõ*), the season of the worms (*Jĩãmasã*), and the season of frogs and toads (Wogá).

These cycles have traditionally guided the Indigenous Peoples of Vaupés, but climate variations and colonial contact have profoundly altered their rhythms. For instance, the early onset of rains now disrupts the burning phase in the chagra, leading to production imbalances and, in many cases, food scarcity.

Yet the peoples of Vaupés continue to enact strategies of resilience, grounded in an awareness of the historical responsibility and colonial roots of the climate crisis. As local elders explain:

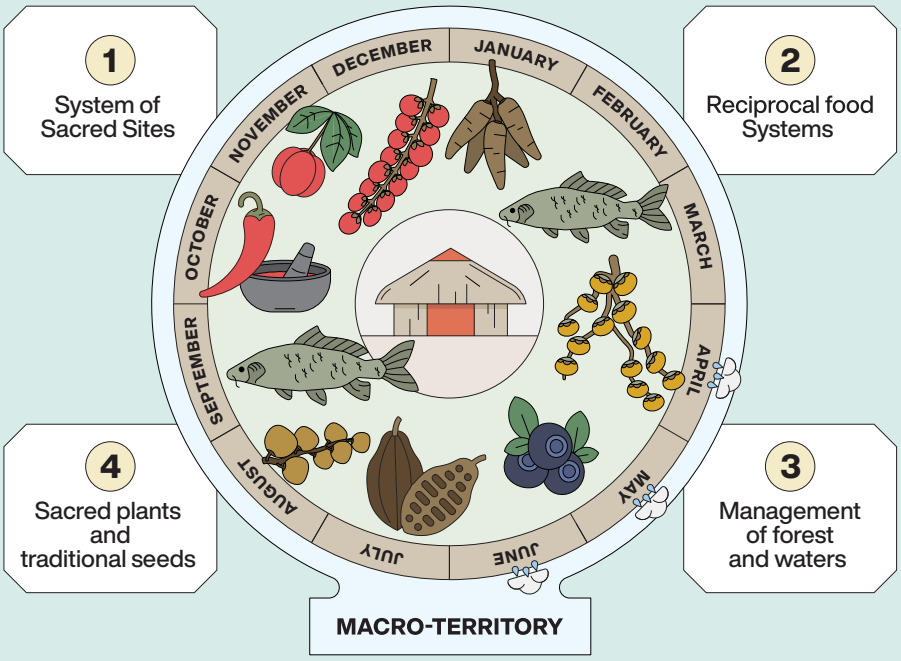

Figure 3. Ecological-Cultural Calendar based on Sinergias (2022) and Sánchez (2024).

"Today settlers do not care for the environment—they clear the forest just to claim land, without seeing the harm they cause to all living beings of the ecosystem. The elders tell us that when we harm our surroundings, life itself demands payment, through earthquakes, torrential rains, storms, and pollution. If we do not care for nature, the world will end". (García & García, 2003, p.8; editors' translation)***.***

Colonization has shaped not only the expression of nature but also the rituals once used to regulate climate and sustain connection with the environment. In the past, nature was managed through thought and preventive rituals synchronized with ecological cycles, ensuring that rain and drought arrived at the proper times. These rituals gained strength through collective participation. Today, that degree of communal cohesion has changed; yet even as the ritual force in Vaupés has transformed, ecological-cultural calendars remain vital tools of wisdom, guiding community decisions in harmony with environmental rhythms.

These calendars embody the *Amazonian Indigenous Peoples' Food Systems* (SAIA), defined as the set of human capacities and practices—knowledge, strategies, and techniques—through which culturally recognized and nutritious foods are produced and obtained. Distinctively, these systems are founded on reciprocity and balance among all living beings; they are biocentric rather than anthropocentric, recognizing humans as only one among many agents whose sustenance depends on maintaining harmonious relationships within the natural world (Sánchez, 2024).

An essential feature of these systems is their dual function as mechanisms of use and conservation of biodiversity through care for the *macroterritory*—a shared space where multiple Indigenous Peoples unite through common traditions, knowledge, and responsibilities for territorial stewardship. This care is expressed through networks of sacred sites, "routes of thought" that heal the world and are structured by ecological-cultural calendars, reciprocal food systems, and the cultivation of sacred plants and traditional seeds (Sánchez, 2024).

Despite clear evidence of practices rooted in responsibility toward nature and world conservation, Western perspectives continue to frame Indigenous food systems as inadequate for ensuring food security. Interventions that introduce external foods and logics frequently disrupt their integrity, undermining not only food security but also food sovereignty. Nevertheless, in the face of colonization and climate change, Indigenous Peoples continue to generate adaptive responses to sustain their ancestral knowledge and practices.

This tension is also reflected in public policies that often disregard Indigenous particularities in pursuit of improved indicators. However, alternative frameworks are emerging that seek dialogue between Western nutritional health concerns and Indigenous traditions. One such initiative is the *Food-Based Dietary Guidelines* (FBDGs), developed by FAO

and WHO to provide governments in developing countries with guidance on healthy diets. Known in Latin America as *Guías de Buen Comer*, these guidelines have informed national policies on food, nutrition, health, and agriculture, as well as educational programs promoting healthier lifestyles and eating habits (FAO, n.d.).

Just as the FBDGs represent one possible pathway, it is essential that public health policies make real efforts to integrate intercultural and territorial approaches that acknowledge Indigenous food systems. This requires articulating nutritional aspects with ecological-cultural calendars, *chagra* dynamics, hunting, fishing, and gathering practices. Such perspectives invite us to imagine food sovereignty and food security as part of the same current—nourished by the ancestral knowledge of those who, for generations, have lived with the forest as mother and sister.

In this sense, public policies on nutritional health should aim to design a model that integrates traditional knowledge and Amazonian Indigenous Food Systems. This model should establish clear guidelines for knowledge exchange and incorporate ancestral practices and understandings into the formulation, implementation, and evaluation of policies that are currently grounded primarily in Western epistemologies.

Supplementary Materials

https://gs-anthropocene.org/publications/

Recommendations

- **Acknowledge Indigenous territories as living systems** that integrate food production, biodiversity conservation, and climate resilience, rather than treating them solely as areas of social assistance or environmental protection.
- **Co-design policies with Indigenous authorities and women's networks**, ensuring that decision-making power reflects traditional governance and community priorities.
- **Align public health and nutrition programs with ecological-cultural calendars**, respecting the seasonal, ritual, and territorial rhythms that structure local food systems.
- **Promote horizontal knowledge exchange between biomedical and ancestral frameworks** to build plural approaches to nutrition and well-being.
- **Integrate Amazonian Indigenous Peoples' Food Systems (SAIA) into policy frameworks**, linking agriculture, health, and education through intercultural and territorial perspectives.
- **Value traditional crops such as *yuca brava* as examples of biocultural resilience** and promote their sustainable use in national food-security strategies.

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4. Heritage Integration

4.1 From Cultural Heritage to Climate Justice: Frameworks to achieve Ecological and Human Resilience

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Food systems, often not considered as part of "cultural heritage", are far from being relics of the past, these landscapes and practices represent innovative strategies developed by past societies to adapt to shifting environmental, climatic, and social conditions. Many of them continue to be managed by Indigenous Peoples and Local Communities, providing vital contributions to present and future food security. These enduring agroecosystems function as carbon sinks, enhance ecosystem services, and exemplify the co-benefits of nature-based solutions for climate regulation and sustainable development.

In this line, the Globally Important Agricultural Heritage Systems (GIAHS) initiative—launched by the FAO in 2002—offers a global framework for recognizing and safeguarding such living examples of resilience. GIAHS identifies dynamic agricultural systems that have co-evolved through the interaction of people and their environments, demonstrating how Indigenous Peoples and Local Communities' Knowledge can sustain biodiversity, ecosystem functionality, and rural livelihoods over centuries. By valuing these systems as "living heritage," the initiative underscores their potential to inform transformative pathways toward resilient and equitable food systems.

Since formal recognition began in 2005, the FAO has designated 102 sites across 29 countries as GIAHS. Each site showcases how context-specific innovations and traditional practices can contribute to the UNFCCC's objectives on climate adaptation and mitigation, the UNCCD's targets on land restoration, and the CBD's goals for biodiversity conservation. As such, the GIAHS initiative exemplifies how integrating time-tested local strategies into global policy frameworks can advance the transition toward climate-resilient, inclusive, and sustainable food systems. Only to

Figure 1. Chinampa system is an historical system adapted to face hydrologic and climatic constraints and the pressure by the high city's food demand. ©FAO/Tania Gómez Ríos.
Credit: Jakob Sußmann, chinampas at Xochimilco, Mexico

mention some remarkable examples of this enormous knowledge capital, the Chinampa agricultural system of Xochimilco, Mexico, is an exemplary GIAHS that illustrates how traditional ecological knowledge can generate resilient and regenerative food systems. The Chinampas of Xochimilco exemplify how long-standing Indigenous Peoples and Local Communities' practices that originated around ca. 1000 years ago (Morheart & Frederick 2014) can inform transformative pathways toward climate adaptation, biodiversity conservation, and sustainable urban food systems.

Developed to meet hydrological and climatic challenges while sustaining urban food demand, the *chinampas* represent a form of wetland agroforestry based on raised fields built from lake sediments and organic matter. This

Figure 2. Aohan Dryland Farming System.
Credit: Photo courtesy of GIAHS China.

design enables continuous nutrient cycling, flood control, and microclimate regulation, functioning as a nature-based solution for urban sustainability. The system maintains exceptional agrobiodiversity, with over 50 domesticated and nearly 100 non-domesticated species, and supports aquatic habitats that enhance ecosystem services and biodiversity. Sustained by communal labor, equitable land tenure, and rich cultural traditions, the chinampas integrate food production, ecological engineering, and social organization into a multifunctional landscape that bridges rural and urban spaces (Figure 1).

As an example of dryland farming with resilient species—such as foxtail millet and broomcorn millet—, the The Aohan Dryland Farming System in Inner Mongolia, represents over 7,500 years of continuous grain cultivation (GIAH, Wang *et al.*, 2024), making it one of the world's earliest and longest-enduring agricultural traditions. Terraced dryland cultivation, sand-fixation through tree planting, and soil conservation have shaped a distinctive agricultural landscape (Figure 2). This heritage landscape integrates farming, forestry, and animal husbandry, forming a resilient livelihood system where 90% of the population depends on agriculture. Aohan farmers cultivate a wide diversity of crops adapted to dryland conditions, including foxtail millet, broomcorn millet, buckwheat, sorghum, barley, wheat, corn, soybeans, peas, and beans, alongside economic crops such as peanuts, sesame, sunflower, flax, rapeseed, tobacco, fruits, and vegetables. Millets—covering nearly 40% of arable land—remain the core of local food security and cultural identity. Through intercropping and rotation systems (*e.g.*, broomcorn millet–potato–grain–bean–millet cycles), Aohan farmers maintain soil fertility, reduce erosion, and enhance moisture retention without relying on mechanization. Traditional techniques—such as alternating root irrigation to minimize evaporation—reflect a deeply adapted water management strategy for arid climates. Forests and grasslands, covering roughly 50% of the territory, stabilize soils, reduce wind erosion, and conserve water.

The system's biodiversity richness includes over 30 major crop species and hundreds of local landraces, supporting pollinators and livestock. In 2010, total grain output reached 0.8 billion kg, with additional production of 100,000 tons of meat, 19,000 tons of milk, and 3,500 tons of wool, highlighting its contribution to regional food and livelihood security. Furthermore, Aohan's cultural heritage—expressed in farming proverbs, folk songs, and seasonal rituals—embodies a living knowledge system that links community values with environmental stewardship.

In this line, the GIAHS initiative in partnership with the International Council on Monuments and Sites (ICOMOS) both offer strategic frameworks for recognizing how cultural heritage underpins ecological resilience and human well-being. Similarly, ICOMOS, the global advisory body to UNESCO on cultural heritage, has played a leading role in redefining heritage as a lever for transformative climate action. This year , ICOMOS reaffirmed that "*culture is not optional in times of crisis*" (*MONDIACULT Summit 2025*), emphasizing that it anchors identity, carries memory, and strengthens community resilience. It called for cultural rights to be fully embedded in climate and environmental policies, underscoring that the erosion of cultural heritage equates to a form of *cultural extinction* with direct implications for human and environmental rights. ICOMOS advocates for the explicit recognition of culture as the fourth pillar of sustainable development and as a core pathway for achieving the Paris Agreement and Agenda 2030 goals.

Taken together, the GIAHS initiative and ICOMOS's cultural policy framework illustrate how heritage-based approaches can foster positive systemic change—supporting communities to adapt, regenerate, and assert their rights to land, knowledge, and cultural continuity. Integrating these perspectives into food and climate policies means recognizing that the right to culture is inseparable from the right to a healthy environment. Agricultural heritage systems thus emerge not only as models of resilient food systems but as living expressions of climate justice, where safeguarding heritage and respecting human rights directly translate into the restoration of ecosystems and the renewal of human–environment relations.

Legal Frontiers of Biodiversity: Between Common Heritage and Genetic Commodities

Eduardo Relly[1]

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In the wake of the globalization of the green revolution (second half of the 20th century), a series of international agricultural research centers were established in what was then known as the Third World. In 1971, on the initiative of the Rockefeller Foundation and with support from the World Bank, the Food and Agriculture Organization of the United Nations (FAO), and the United Nations Development Program (UNDP), the Consultative Group on International Agricultural Research (CGIAR) was established, which promoted agricultural research in light of recent advances in molecular biology and genetic engineering at the global level. These developments radically altered agricultural research and created the conditions for new forms of plant and genetic resource ownership. From 1970 onwards, the advancement of intellectual property mechanisms such as patents and plant varieties has divided activists, scientists, and governments around the world. In general, northern countries had a strong interest in expanding agricultural research in southern countries, which were seen either as laboratories or as sources of resources accessible to large seed breeding companies. These resources involved radical transformations in the food systems of southern countries, as well as the misappropriation of the traditional practices and knowledge of peasant peoples. A question emerged: who owns biodiversity, the very fundament of agricultural research? From the answer to this question and the power relations that shape it, the architecture of global governance of agrobiodiversity has emerged over the last 30 years.

With the rapid advancement of biotechnology, this territory of appropriation has increased significantly, putting at risk the physical and cultural territories of Indigenous Peoples and Local Communities across the planet, especially in the Global South where biological and cultural biodiversity is most pronounced.

Until the emergence of the Convention on biological diversity (CBD) in 1992, the answer was very clear: until 1992, at least from the perspective of global regulation, biodiversity was a common good of mankind (Scholtz, 2008). One of the principles of the common heritage of mankind was that it focused on domains that had not (yet) been appropriated, that belonged to no one. With the rapid advancement of biotechnology, this territory of appropriation has increased significantly, putting at risk the physical and cultural territories of Indigenous Peoples and Local Communities across the planet, especially in the Global South where biological and cultural biodiversity is most pronounced. In 1983, the FAO created the Commission on Genetic Resources for Food and Agriculture and upheld the principle of the common good of humanity for “plant genetic heritage”. That same year, Pat Mooney’s influential book

Seeds of the Earth (1983) was published, politicizing biotechnology by accusing intellectual property instruments such as patents and cultivar rights, as well as bioprospecting practices of biological and genetic resources in peripheral countries, of being instruments of exploitation. In fact, since the 1980s, researchers and activists have used the term 'biopiracy' to criticize the misappropriation of Indigenous Peoples and Local Communities' (IPLC) knowledge of seeds or plants by biotechnology companies (Shiva, 2004). The dispute between IPLCs and biotechnology corporations entered the 1990s and underpinned the environmental and agricultural governance of the planet in the neoliberal era. In 1995, the Agreement on Trade-Related Aspects of Intellectual Property Rights (TRIPS), within the framework of the World Trade Organization Trade Organization (WTO), has become an international instrument for expanding the legal possibilities of patenting so-called "genetic resources" worldwide. Counterbalancing the interests of breeding companies, the Convention on Biological Diversity (1992) offered new possibilities for the protection of traditional knowledge and ended the era of common heritage of mankind. The CBD has a broad scope, covering all forms of biodiversity—plants, animals, microorganisms, and ecosystems. Access and benefit-sharing (ABS) arising from the utilization of biodiversity's genetic resources and traditional knowledge is the third objective of the CBD; it aims at protecting the holders of traditional knowledge and establishes a framework for compensations arising from utilization of (agro-) biodiversity.

Counterbalancing the interests of breeding companies, the Convention on Biological Diversity (1992) offered new possibilities for the protection of traditional knowledge and ended the era of common heritage of mankind.

Some years later (2001) and under both auspices of the FAO and the CBD, The International Treaty on Plant Genetic Resources for Food and Agriculture (TIRFAA) came to life and became the specialized agreement that focuses specifically on plant genetic resources for food and agriculture. This means that it implements the CBD's principles within the agricultural and food sector, which has specific dynamics such as ongoing seed exchange and plant breeding, and it avoids duplication or legal conflicts by establishing a Multilateral System (MLS) for Access and Benefit-Sharing (ABS) that works in harmony with the CBD and the Nagoya Protocol (2010), but through distinct mechanisms tailored to agriculture. Unlike the Nagoya Protocol, which governs bilateral access and benefit-sharing through case-by-case agreements (with a broader focus on global biodiversity), the TIRFAA establishes a multilateral system that provides facilitated access to the genetic resources of 64 key food and forage crops listed in Annex I. These crops—selected for their global importance to food security and interdependence—are exchanged under a standardized agreement (SMTA), with benefits shared collectively through an international Benefit-Sharing Fund to support sustainable agriculture, conservation and farmer's rights.

Defining what is "agricultural" and what is not remains a major challenge in both international and national (agro-)biodiversity governance. In Brazil, for instance, this distinction is particularly complex under the Biodiversity Law (Law No. 13.123/2015), which regulates access to genetic resources and associated traditional knowledge. This law implements the Nagoya Protocol in the latter country. The law treats agricultural activities differently from other uses of biodiversity, exempting certain practices related to plant breeding and food production from the same access and benefit-sharing (ABS) requirements applied to non-agricultural or commercial uses of native biodiversity (Relly, 2024). At the same time, the Brazilian National Policy on Medicinal Plants and Herbal Medicines (Política Nacional de Plantas Medicinais

e Fitoterápicos) recognizes the cultural, social, and economic value of native plants and promotes their conservation, sustainable use, and integration into public health policies. This dual framework reveals the ongoing tension in Brazil between agricultural innovation and biodiversity protection, showing how the boundaries between high-tech agriculture, traditional knowledge, and peasant interests are often blurred and politically contested. Some critics consider that the concept of genetic resources associated with traditional knowledge gives biodiversity an instrumental and monetary value and, at the same time, distorts the idea of its intrinsic values of (agro-) biodiversity.

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5. Rooted Knowledge: Indigenous Peoples and Local Communities' Actions

5.1 Introduction

Incorporating interviews in this report follows the principles of knowledge co-production and rights-based documentation recognized by FAO, IPBES, and the UNFCCC.

The voices of Indigenous Peoples and local actors are presented not as testimonials, but as knowledge contributions that convey situated expertise on land, climate, and food systems. Recognizing these perspectives as integral components of environmental research ensures that traditional knowledge is treated as evidence, on par with scientific data, while respecting community agency, intellectual property, and cultural context. This approach aligns with ongoing efforts to advance climate justice, cultural rights, and the inclusion of diverse knowledge systems in sustainability governance.[4]

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Watch the interviews

https://gs-anthropocene.org/publications/

[4] These interviews are presented in this text in some cases in a shorter version to adjust the length of this report. Cuts are marked with (...) Full video versions can be found in the supplementary material online.

5.2 Interview: Edson Krenak

Edson Krenak from Krenak People in Brazil is a PhD researcher at Vienna University. He also works for a USA-based organisation called Cultural Survival. Here he presents his views on agroforestry strategies with Mariya Antonosyan and Michael Ziegler.

Maria Antonosyan: We meet today as a part of the Indigenous Voices initiative within the Perspectives from the Global South on Anthropocene project, and our team has been working on putting together a report on Regenerative agriculture and resilient food systems. (...)

Michael Ziegler: We are joined with one of our Voices of the Global South conference participants Edson Krenak and I'll let him introduce himself, and then we'll dive into the interview.

Edson Krenak: Hi. Thank you for having me. My name is Edson Krenak from Krenak People in Brazil. I am finishing a PhD research at Vienna University and also work for a US-based organisation called Cultural Survival. Which work is focused on supporting Indigenous People's rights and self-determination. Also, I work at the executive committee of SIRGE Coalition. SIRGE stands for Securing Indigenous People's Rights in the Green Economy, dealing with issues of just transition, transition minerals and the impact of this new, and not so new, mining on Indigenous Peoples and traditional communities' territories.

Mariya Antonosyan: Thank you, Edson, for accepting our invitation and taking the time for the interview. And I'll start with the first question. We are wondering how you see heritage management and territorial management working together to help keep ancestral knowledge alive.

Edson Krenak: From the perspective of Indigenous Peoples, because there are two perspectives here to see heritage management and territorial management. There is the perspective of Indigenous Peoples and the perspective of the government and state agencies that deal with Indigenous knowledge. And unfortunately, there is a, we call it abyss, but it can also be called a crossroads. Indigenous Peoples don't feel safe. I can say almost all of the world. I can say legally, socially, and culturally safe in their territories to protect their heritage.

> | *Edson Krenak*

Because the state, the government, the corporations, they represent a threat many times. Instead of protecting, guaranteeing the security and the protection of Indigenous heritage and territories, they are actually trying to transform these territories and the commodities, transform this heritage and put that in a trading market, and, I can give you an example. When Indigenous Peoples have some food practices, let's say, their diet is based on fish, on hunting game, it's based on knowledge of herbs and vegetables from the forest. When the state doesn't guarantee the protection of this environment, the Indigenous Communities suffer a huge impact, not only from climate change, but state projects, corporate projects like mining and deforestation that if these do not affect Indigenous territories directly, they affect them indirectly. Then, Indigenous Peoples lose access to traditional food sources, they lose the ability to protect this heritage for the next generations, for example.

Michael Ziegler: Very interesting, and along these lines it sort of reminds me of part of your presentation. A lot of things were interesting for me, but one of them was that you mentioned knowledge as an experience and a connection. It leads into my next question here: if you could potentially share your thoughts on how communities might sustain and pass on cultural knowledge and about the environment and about resilient food systems?

Edson Krenak: Well. I will use the word territory because territory is the heart of Indigenous system Knowledge. The land is the heart of their heritage. Because there is no knowledge without land. There is no knowledge without territory. There are no Indigenous heritage ceremonies,

knowledge systems without the territory. We live to learn the land, what some have called the land pedagogy, the land teachings. Because the territory is not a commodity, a property, a possession, but it's a living archive from our ancestors. The territory is the geographic knowledge applied from these ancestors that bring to our practices, our ceremonies, our ways to fight and to defend the territory. The resilience of Indigenous Communities can be also translated into care and protection. We cannot be resilient if the territory is not resilient or cared [for] as well.

That's why. The number one priority of Indigenous Peoples when they are defending their knowledge, their food system, and their rights is the defense of their territorial rights.

They have to first have the territory demarcated, in some areas to have the titles, to have the right to tenure management, governance. And to have these rights in the territorial demarcation secured by the state, by international law, by national law in Brazil, in Peru, in Canada, many places.

The state has the obligation to protect Indigenous Peoples' territories as well. We say that the fight for the land is the mother of all fights. Then, when we talk about resilience or heritage we are talking about a knowledge that is holistic. The land is not only a geographical resource or space, but it's a biocultural space.

We see our rights or our territories as a biocultural space where we don't possess or own the resources, but we have a relationship with this territory, and then we exchange gifts of this relationship. There is no resource.

The word resource, the word development and many other words that the states use to frame Indigenous territories. They are unfamiliar, they are colonising terms, because Indigenous People don't have these terms to define their relationship with the heritage, the food system and the territory.

This is holistic, this is all interconnected and the only way we found to protect it and to enjoy it is through autonomy, if we have our governance systems in place and protected. We don't want, for example, a mining company coming and impacting our governance, our food systems, because they are mining for the just transition, mining for any other type of green solution, while, they are contaminating our river, killing our fish, stressing the environment around with explosions, and with, building logistical infrastructure for these so called resources from our lands. Then, we defend the territory, as I mentioned before, as the main policy, the main action to defend our food systems and our heritage.

> ***"I will use the word territory because territory is the heart of Indigenous system Knowledge. The land is the heart of their heritage. Because there is no knowledge without land. There is no knowledge without territory. There are no Indigenous heritage ceremonies, knowledge systems without the territory. We live to learn the land, what some have called the land pedagogy, the land teachings."***

Mariya Antonosyan: (...) Could you give more details on how policy-makers can better support the respectful management of ancestral territories and specifically how the role of Indigenous actors in this process would be.

Edson Krenak: Well, most of the policy and legislation and interaction from the state, civil society and corporations with Indigenous Peoples are based on two main words. You can scan all the discourse and narratives and documentations about that, it's recognition and consulting.

As if it was enough to protect Indigenous Peoples. Of course, recognition is the first step. We have been fighting for recognition of our rights, our existence and the importance, the role of Indigenous Knowledge and governance to protect biodiversity, to fight climate change to advance what is called the Green Agenda. We have been fighting for this recognition. We have achieved some progress in terms of recognition.

We have in the context of the UNFCCC the platform of Indigenous Peoples and the Local Communities, for example. We have the last IPCC report recognizing the role of Indigenous Peoples' Knowledge in fighting climate change, fighting the food insecurity that the entire world is living (under). Because food security is not only having food, but having healthy food, protecting the sources of healthy

food because the industry has sequestered, they have changed the frame of what is food security.

They frame it as a market issue. If you have a grocery, if you have a supermarket close to your home, you are safe in terms of food, but many people do not question, or they don't talk about what type of food is being sold there. How healthy and safe is the supply chain to extract this food and bring to the grocery in Europe, in America, and in many places in the so-called Global North. (...)

Then, what the Indigenous Peoples are doing. They are fighting these corporations in their own capacity, almost alone, because we almost don't see universities, academic institutions and other actors in the civil society fighting these dirty sources of food.

And we wanted to move from recognition to full participation in the processes of policy making, decision making at multiple levels. We wanted to move from a consulting or stakeholders position to right holders position, and to have these rights protected.

For example, we don't want to see our main mechanism for ensuring recognition and participation called FPIC, Free Prior, and Informed Consent - being misused by companies, states and other actors as if it were merely a consultation process. It's not a consultation. It is a consent, a right to give or withhold consent. As I described in many papers, it is free because it should never be exercised under any threats, coercion or or with only one imposed alternative onto Indigenous Peoples. "Either you accept this project,or we will do it anyway". When this happens, the "free" element is destroyed, Indigenous Peoples lose their autonomy.

When freedom is respected, we can move to the prior and informed parts because, free prior informed consent.(...) It's been framed, it's been owned, and it's being misused by big tax, by governments, to prevent Indigenous Peoples, to have access to the real important information, technical information about the impact of these policies, the "Green Deal" policies, the "Green Economy" policies, the "Green Energy".

I'm using these terms between quotes because these terms are not from Indigenous People, but from those who are violating our rights. They name it with this grammar of Green to justify mining, deforestation and impact on Indigenous Peoples' territories. Then, the information we receive is, for example, this mining of lithium, cobalt or copper or nickel is to produce clean energy. But, it's only clean in some areas in the Global North.

It's clean for the final users, but if you go to the Indigenous Peoples' territories, where more than 50%, more than 54%, to be precise, is a number given by the World Bank by the magazine Nature and many other important international agencies that more than 54% of the transition minerals are placed on Indigenous territories or near Indigenous territories. And, the extraction of these minerals is very, very dirty, and it's contaminated the entire supply chain.

That's why we are calling for these so-called voluntary mechanisms to become binding obligations for states Today only a few countries have ratified the ILO Convention 169, the International Label Organization Convention 169, which explicitly recognizes Free Prior and Informed Consent (FPIC) or have meaningfully implemented the UN Declaration on the Rights of Indigenous People. Too often, governments and companies treat these international instruments as optional, as merely moral commitments rather than legal duties under International laws and Constitutional provisions, as in Brazil.

And on the other hand, we see that when you don't respect these mechanisms, they are violating not only Indigenous Peoples' rights, but also the food security of these communities. They are also violating the right of all society, the entire humanity, to live in a healthy environment, which means to have access to a healthy water, to a healthy food, to a healthy well being. Then we are being undermined without access to real information.

And then we could talk a lot about how Indigenous Peoples' actors are fighting for that, but we want to engage in processes that are not green washing anymore. Greenwashing our food security, greenwashing our rights, green washing our capacity to build resilience in a climate crisis we are living in. This is our challenge.

Michael Ziegler: The exploitation of food-rich lands and transition to food deserts with equitable access to healthy foods is definitely extremely prevalent, and what you mentioned, that sort of subtle advertisement of greenwashing what environmentally conscious electric vehicle without the realization of the repercussions to the Indigenous lands to make that vehicle is something that should not be understated and it's definitely a direct result of the government and government policies. In those lines, you mentioned a few times about defending the food system and heritage, and I imagine this defense would be sort of what you mentioned in your presentation. You said "activism as a

method to reforest politics." That message really stuck with me. I think it applies to this next question.

As an Indigenous scholar, how do you envision Indigenous perspectives shaping the future of research and policy making? And then what changes or practices would you like to see?

Edson Krenak: Thank you for the question. For mentioning that in my conference talk. First, I would like to perhaps give another line on this metaphor we are using in our activism and policy: Foresting policy, Foresting space.

Of course there are Indigenous Peoples from the Arctic, from the waters, from other biomes. But since I come from an area that is an intersection between three biomes. These three biomes have very unique forestry: the Atlantic forest, the Caatinga biome is unique from Brazil and the Cerrado, kind of a savannah like forest or landscape.

These forests, like the Amazon rainforest, deeply depend on regulation of the weather, the climates and the environment. They are ecological hubs, which means they depend on each other. You cannot isolate one forest and think it will be resilient and sustainable if we destroy everything around it, if you contaminate the river, if you deforestate several parts of this forest, especially the buffer areas, close to the borders, we will keep the forest reserves, the natural reserves concept.

For Indigenous Peoples this is a fundamental mistake, to see these spaces not interconnected. And the foresting policies are to understand that the policies should not target one single aspect. The policies we wanted to see being decolonized or forested should have more participation of Indigenous Peoples.

I will give you two examples or two justification for why we need more Indigenous People actors in the spaces of policy making and decision making spaces, like the UN. We have a space, but how I will criticize the space in a minute[5].

The first reason is because our livelihood, our knowledge, our knowledge systems, our ways, as we like to say, our ways of being, ways of knowing, ways of doing do not harm the environment, do not create an unhealthy place to live.

We don't represent a threat to life, to the next generations. We have a deep compromise with the past generations, our ancestors and as we like to say in a strong slogan: "We think seven generations ahead."

We are always thinking about what kind of a heritage, legacy we are going to leave for the next generations. This is already enough to justify our participation.

But the second one, the key element for climate resilience in the planet, in our planet, the planet that we all share is biodiversity. Biodiversity is the key element for any economic model. Without biodiversity, we don't have food. Without biodiversity, we don't have life conditions to really thrive. (...)

Michael Ziegler: Fantastic. I have one more question for you. I think about food security and resilience. Resilience in itself implies that there's periods of struggle or there has to be some point of conflict, whether it be natural or imposed by colonial or anthropogenic forces. But, one thing that struck me in your presentation as well, and maybe this can be some of your final messages to us here is that you referenced Robin Wall Kimmerer about moss. Lessons we can learn about moss. I was wondering if you maybe wouldn't mind sharing a little bit about this and the connection to resilience.

Edson Krenak: Well, thank you. This is a very sweet memory from this conference because moss has been a special topic for Krenak people, for me, as a researcher of my people, because I discovered some old stories, traditional stories mentioning mosses and then I encountered the extraordinary work of , especially her reflections in [Gathering Moss and Bradining Sweetgrass]Robin Kimmerer in her astonishing research and knowledge on that. It really came together as a powerful tool for us to rethink how we interact with other societies. Let me go to your question, to the point.

I think three aspects about moss and resilience that speak to us. The first is the fact of persistence, that we don't abandon our territories. As the moss, they don't abandon the territory even when there's no water there is no light. The moss holds on, waiting patiently until life returns. In this moss teaches us something essential about Indigenous Peoples: we do not abandon our territories. Even when they are invaded, burned, polluted, we remain.

Some mosses can wait for decades, for centuries to receive, again, the light, the resources they need. They depend entirely, they trust, the territory they trust that other animals, other plants, other conditions will bring and provide life or nutrition for them.

That's why some mosses are dormant for generations. And Indigenous People's insistence of the territory, to build the resilience of the territory, is the fact that we don't abandon that.

[5] To see Edson Krenak's critique to UN mechanisms such as the LCIPP refer to the complete interview in the supplementary material

We adapt. We use our dynamic, ever evolving knowledge from our ancestors from our ideals of the future. To create a sense of respect, of reciprocity with the territory. When we know the territory cannot give anymore, we give it to rest. We protect it.

We wanted to use new technologies for this. We are using, actually, mapping, GPS and scientific research how to restore how to build new forms of forestry in areas that has been impacted by industrialization, et cetera.

We adapt. We don't abandon the territory. This is one aspect.

The second one is, the mosses are known because they don't have roots, right? They have other ways to feed themselves. They use surfaces, they use neighbors, they use other species. They use other species of mosses to feel safe, to protect themselves and to grow as well. It's kind of a foresting metaphor I am also using. Indeed. What we have to do is to create more alliances and network I think we cannot afford anymore to live in silence or bubbles in our society.

Science has to walk and create meaningful alliances with other knowledge systems. With other ways to engage with society. We cannot be seated in our academic golden chair and wait that one day, people will come to us and we have the answers. We have to be more proactive.

We have to be more courageous. Trust the knowledge we are building with alliances and networks. Connecting different knowledge systems is key to build resilience. It is how moss build their resilience. They understand the weather, they understand climate change.

There is a type of moss, I don't remember the technical names of them, but let's put all them in this big, huge and diverse family of mosses. There is moss that they even change their gender to adapt when they realize they don't have enough alliances or networks to grow.

Then they change their gender because they think "My network here is not really pro life. I have to create a network pro life, pro resilience. I have to collaborate with others by changing myself."

That's why I wanted to challenge the sciences, I went to challenge governments and corporations and other sectors, to build resilience in a humble way. Be like a moss. If it's necessary, change yourself. Look around you.

What is missing? What is the need? Create a powerful web of mutual support, collaboration and share the learning because it's what Indigenous Peoples are.

For decades, or maybe for centuries, anthropology scientists saw Indigenous Peoples as stuck in time, frozen in their knowledge systems. But, the more you know Indigenous Knowledge systems, the more you learn that we build our knowledge system by sharing knowledge, by creating a network of knowledge systems. We never stuck in time.

The last aspect, I think, is the fact that resilience is a call to be humble. That we are in a society that thinks technology, especially the digital, industrial technologies and scientific knowledge will solve everything. It will not.

Well, perhaps I can add one fourth aspect of this moss knowledge and resilience is the fact that Indigenous Peoples use rituals and ceremonies to connect with our planet. Rituals and ceremonies teach us about the respect we have, the relationality we must build with the planet.

Sometimes. I hear society actors in no Indigenous society talking about the planet as we were two different entities, humanity and the planet. As if we are just travelers from other civilizations from other planets. Like we were aliens on this planet. We came here to colonize and use everything. Then we go to another planet. I'm not far away from the reality when we see some big tech guys dreaming of colonizing other planets.

Today, we see humanity investing billions in building expensive technologies to reach other planets, while destroying the one that gives us life. This mentality is the real disease, a type of cancer of separation - the illusion that we are outside of nature, that salvation will come from escaping Earth rather than healing it Indigenous Peoples through rituals and ceremonies, through our ways of being, defend something radically different: a return to connection to the planet. We remind the world that we are not on the planet, we are the planet. We are Biome, as the Indigenous women in Brazil chant and cry. Somos Bioma. We are the forest, the river, the wind, the soil, and the voice of the ancestors living through it all. To care for the Earth, our Mother, as She cares for ourselves.

Mariya Antonosyan: Thanks so much. You gave a lot of food for thought, and I really hope that our platform can help to bridge your critical ideas to scientists, policymakers, and other involved people (..)

5.3 Interview: Vanuza Cardoso

Vanuza Cardoso, leader of Abacatal Quilombo. 2025.

Vanuza Cardoso is a spiritual and political leader of the Abacatal territory in Brazil. She is a social scientist, graduated from the Federal University of Pará, through the affirmative action program. She's also conducting a Masters in Cultural Anthropology. Here she presents her views on agroforestry strategies with Danielle Heberle Viegas.

Danielle Heberle Viegas: Thank you for accepting our invitation to talk with us. I'm Danielle Viegas, and I'm here representing the *Voices of the Global South on the Anthropocene* group, based at the Max Planck Institute in Germany. On behalf of the group, I sincerely thank you for sharing your time and knowledge with us.

So, Vanuza, I'd like to start by asking if you could tell us about the history of the Abacatal quilombo.

Vanuza Cardoso: First, I'll introduce myself, because that's where my strength begins.

Agô Mojuba, I weave blessings and ask permission from my elders and from the younger ones, from all the ancestry that guides me, sustains me, and allows me to be in this place of speech. My social name is Vanusa Cardoso, my ancestral name is Maberu inyko. I am the granddaughter of Rosa and Matilde, the daughter of Raimunda, mother of Felipe, Tharisson, and Taris, grandmother of Ana Luisa. I am a spiritual and political leader of the Abacatal territory. I'm a social scientist, graduated from the Federal University of Pará, through the affirmative action program. I'm currently pursuing a master's degree in cultural anthropology, because I understand that this education is not mine alone — it serves my movement. My goal is to work on anthropological reports and RTIDs to strengthen the struggle for territorial titling for my people.

That is my mission.

Today, I coordinate policies for racial equality in my municipality, and I'm also a national co-coordinator of the Consultation Protocol Observatory, based at PUC Paraná. We work to defend human rights and the rights of non-human beings as well.

Our territory, Abacatal, is located in the metropolitan area of Belém, in the southern part of Ananindeua — where you have set foot. Abacatal is 315 years old, according to oral history — which I believe and defend. The territory covers about 518 hectares. Today we are around 162 families, about 500 people. It's classified as a *peri-urban area*. It's not that Abacatal is approaching the city — it's the city that is moving toward Abacatal.

The community lives directly from family farming, through productive home gardens. Most of our production is açaí, cupuaçu, and cassava fields, with small vegetable gardens and the raising of small animals like pigs and free-range chickens, and fish through aquaponic systems that also feed the plants. We have reinvented ourselves over the years, fighting against state neglect and the absence of public policies, while resisting many attacks within this metropolitan area.

Our production is distributed among nearby neighborhoods and in the central fair of Ananindeua, where producers sell their goods. Others distribute to the surrounding areas. So the economy circulates within the community — we buy from each other. It used to be based on exchange; now, under capitalism, we buy and sell. People who make flour sell it; others buy it. The same with açaí, free-range chickens, herbs like scallions, caruru, kale, jambu, cassava, and other vegetables. All of it is produced and sold within or around the community.

Vanuza Cardoso: Abacatal achieved its collective land title in 1999, after much struggle — with strong support from the urban Black movement SEDEMPA and a group of Catholic nuns, the Missionary Sisters of the Eucharistic Heart, who

came to help organize the community.

They arrived at a time when Abacatal had fallen back into a kind of enslavement. In the 1960s and 70s, a man — I'll just call him that — took advantage of people's faith and started charging workers to sell their own produce. He created a leasing system where he profited the most while doing nothing.

This trapped families in a system of control and exploitation. My father and others rose up against it, and there were many conflicts. The land was sold off, there were eviction attempts, houses were demolished to pressure families to leave. My house was destroyed when I was still a child. So, I grew up surrounded by struggle and resistance. When people call me a warrior, I say — it wasn't a choice. I was drawn into this world of struggle because we had to fight to survive. As the eldest daughter, I had to take care of my younger sisters — we were five — while my father was forced to leave due to threats, and my mother had to work. We are large families, so it was normal for children to be raised collectively.

In our community, we say that a child doesn't belong only to their parents — they belong to everyone. Everyone shares social and cultural responsibility. Any loss affects us all. I was raised by women — strong, wise women — who worked all day in the forest, collecting plants, vines, herbs, pounding açaí by hand, preparing food, and still planning resistance for the next day.

So, I'm made of that — of women's strength and resilience.

Vanuza Cardoso: These women didn't know how to read or write, but their wisdom was immense — indescribable.

Today, many of my nieces and daughters have gone to university, but their knowledge doesn't come close to that of those women. They were deeply observant; they understood the moon, the timing, the weather. They knew when to plant, when to burn, when the soil was ready — by feeling, by the texture, by the humidity of the soil.

We've lost much of that. The soil is not as fertile, the climate has changed. The elders sense it, even if they don't use the word *climate change*. They just say, "These are different times. The end of the world is near." They notice the changes — the sun, the moon, the rain — even if they don't name it scientifically.

Twenty years ago, production was greater, losses were smaller. The açaí didn't fall early; the cupuaçu didn't crack; the peach palm didn't dry. Everything has changed. Abacatal used to be a rural quilombola community. Now we're peri-urban, and soon they'll classify us as urban — or transform us into one.

When we defend human rights and environmental rights, we mean all forms of life — not just human... We cannot quantify the value of the territory economically. We've never had money, and the land is not just ours — it belongs to all beings who inhabit it.

We've been labeled a *sacrifice zone*. Around us are two landfills, several housing complexes, an electric substation, transmission lines, and now the so-called "Liberty Avenue" — a state project that, ironically, takes away our freedom. It blocks our main road, our right to come and go. They built a detour through our land — a violation of our freedom.

Beyond that, it destroyed animal habitats. We see disoriented capybaras, monkeys, even jaguars coming closer — because they've lost their space.

When we defend human rights and environmental rights, we mean all forms of life — not just human.

We cannot quantify the value of the territory economically. We've never had money, and the land is not just ours — it belongs to all beings who inhabit it.

I'm the seventh generation descended from Maria Margarida and Olímpia. My granddaughter, the ninth generation, already knows our story and introduces herself that way:

"I am the granddaughter of Raimunda and Vanuza, daughter of Tamires."

Our responsibility is to prepare our children to continue the struggle — but hopefully in a lighter way. That's why I take Ana Luisa to the field, to the stream, to healing rituals — so she never loses that connection with nature, with ancestral knowledge, with the words of our elders. It's about responsibility — to those who fought before us and made it possible for me to be here.

Danielle Heberle Viegas: That was wonderful, thank you, Vanuza. You've already touched on many of the questions I had, but I'd like to go deeper. Thinking about traditional knowledge and the construction of resilient food systems

— what specific strategies does the quilombo use to strengthen and maintain this resilience?

Vanuza Cardoso: Before, we used to cultivate many separate crops. Now we've reorganized our system, which we call *afroecological*. It combines ancestral and academic knowledge — it's a form of agroecology within family farming.

We plant cassava first, then açaí, cupuaçu, peach palm, bacaba — multiple crops in the same space. We've also revived raising small animals: chickens, pigs, and fish. We're teaching the younger generation to "peel more and uncan less" — to move away from packaged foods.

Through community and household gardens, we promote healthy diets without agrochemicals. We produce our own compost, and we're developing vermiculture — worm-based fertilizer. Having our own food — chicken, pork, fish, flour, açaí, and herbs — means we buy much less from outside. We've even gone back to cooking with pork fat instead of industrial oil. We're reinventing ourselves to resist consumerism and the processed-food industry, which has also caused growing obesity in our community. So, through afroecology, composting, and self-sufficiency, we're rebuilding healthier, sustainable systems. It may seem small to the city or the state, but for us, it's deeply important.

Danielle Heberle Viegas: And as the seventh generation in a lineage of women, what role do women play in maintaining these resilient food systems?

Vanuza Cardoso: Women have always been on the frontlines — in struggle and in production. They plant, care, harvest, sell, cook, and sustain. They raise chickens, tend gardens, work the fields, make flour, and run the fairs. We always say: *If not for us, there will be no revolution.*

Men may try, but they rarely have the same sensitivity. Women feel the land differently — we nurture it as we nurture life.

Passing that on to my daughter, my granddaughter, my nieces — it's not only resistance, but also survival. And we must remember — we're human too. We get tired, sick, and sometimes fragile. We can't be strong all the time.

For women, and especially for Black women, the struggle is much harder.

Danielle Heberle Viegas: And regarding current challenges — you mentioned that the quilombo is in a sacrifice zone. What are the main challenges you face today, and how are you responding to them?

Vanuza Cardoso: Our biggest challenge is to keep living the way we always have — resisting external interference from the nearby city. Urban expansion brings cultural clashes, even with other marginalized Black groups from the peripheries. We face cumulative impacts from infrastructure projects — power lines, landfills, housing complexes, highways — all of which will affect us for generations: socially, economically, environmentally.

We are literally surrounded, yet still the largest green area left in the metropolitan region — preserving the Bologna watershed, which provides potable water.

And yet, nobody seems to see that. They only talk about "development."

But without water, there is no life. Without nature, there is no life. We're already in a state of no return — extreme droughts, floods, fires. Nature has been giving us warnings. I don't have much hope that COP meetings will change that. Powerful people will come to the Amazon, see its remaining wealth, and want to exploit it further.

It could bring social chaos — and we'll still be running against time, carrying a responsibility that isn't ours. We're blamed for the destruction we didn't cause. The planet could live without us — but we can't live without it.

Danielle Heberle Viegas: Within that perspective, how do you see public policies? Do you think they can help promote more respectful management of ancestral territories? And what is the role of forest peoples — especially the Abacatal quilombo — in this context?

Vanuza Cardoso: We've always practiced sustainable living — agroecology, mixed-crop systems, maintaining legal reserves that protect water sources.

But public policies under the so-called "green economy" — carbon credits and such — are not fair.

Those who truly protect nature receive no resources, no investment. The transition isn't just.Here in Pará, we see hybrid and electric cars, solar energy — but that technology is expensive. Communities like ours can't afford solar panels or maintenance.

So this "energy transition" excludes us. Those who will suffer most are the poor — those without access to fair financing. And honestly, I don't believe fossil fuels will end anytime soon. I haven't seen any real substitute proposed. So, for now, we just keep resisting.

Danielle Heberle Viegas: Thank you so much, Vanuza, for sharing your story and reflections. I've personally witnessed much of what you described during my visits to Abacatal and Marituba.

5.4 Interview: Uraan Anderson Suruí

Uraan Anderson Suruí

Uraan Anderson Suruí is a Paiter Suruí leader, living in the Sete de Setembro Indigenous Territory in the state of Rondônia in the Brazilian Amazon. He is also the president of COOPSUR, a Paiter Suruí agroforestry cooperative. Here he discusses Paiter Suruí agroforestry strategies with Freg J. Stokes.

Freg J. Stokes: The contact [of the Paiter Suruí] with the Brazilian government is relatively recent, in the 1960s. So, what has happened since then, and what is the situation now? Has the community's practice of agroforestry changed significantly? What are the current challenges?

Uraan Anderson: Freg, I would say that we lost something very significant when we distanced ourselves from the recent agricultural practices of our pre-contact ancestors. In the contact with the surrounding [Brazilian] society, various new agricultural practices were introduced to us, in particular the practice of monoculture farming, aimed at quantity and profit. This was very different from the vision our people had, which was premised on producing food for subsistence. Our ancestors knew that they were going to move from place to place, so they planted native species in each location. But this stopped after contact, when there were only monoculture practices – with soil depletion, with logging, and also cattle ranching, which is devastating, in terms of the area of pasture required – all this was introduced. So, I see that there has been a very radical change after contact and the biggest challenge is to return to the previous reality, aiming at the protection and the management of Paiter Suruí territory.

Freg J. Stokes: As I understand it, this protection is for the communities, the villages, the Paiter Suruí way of life, and also the forest itself. So, what are the plans for the future in your village for agroforestry and forest protection?

Uraan Anderson: Since 2019, my father and I have been very vocal about the need for strategies to prevent monoculture agribusiness from entering our territory. Because forms of land-renting [by outside farmers] were infiltrating our territory, both for cattle ranching and for coffee and banana production. So those were the risks, but we hadn't quite realized the level of risk. So, in our conversations, my father said to me, look, this is going to cause problems because these are individualised practices, outside the collective vision that our people had, and the more dispersed and divided we are, the greater our weakness and our vulnerability to harassment.

So then, one of the ways for us to return to that collective vision we had of subsistence is the transformation of these monoculture practices, with a system of thought more connected to the protection of territorial boundaries, creating agroforestry units instead of monoculture units and eradicating these land-leasing practices. So, returning to a collective vision will prevent the entry of these individualised practices such as land-leasing, which can pose serious risks to the protection and management of our territory.

Since 2020 we have built a Cooperative for ourselves, to seek support for these initiatives, and to create agroforestry systems that are in line with our cosmovision and also aiming to return to that collective vision, starting with our village. The idea is to expand these areas across Paiter Suruí territory so that this becomes the model of economic development inside this Indigenous territory in the Amazon.

Freg J. Stokes: That's great. When I visited you, I saw both men and women from the community involved in this process, for example, in the harvesting of Brazil nuts. Could you talk a little bit about that, about the involvement of the community, of men and women, and what each person's role is, how they participate in this collectively, but also as individuals within the collective.

Uraan Anderson: We have been working a lot, in particular to encourage women to return to their pre-contact practices,

because today the role of women is very much to stay at home, and this is a way of life that comes from the colonists, from those who arrived here in our territory.

So today, with agroforestry, many women go searching for seeds that we replant in our fields, and the children accompany their mothers and so with this, the daily routine returns to a dynamic of living in harmony with the forest. Consequently, children are educated with these types of knowledge, and women also get out of a situation where they were stuck at home. Today we are bringing back this dynamic, where each individual, and the family as a whole, are part of this process.

So today, with agroforestry, many women go searching for seeds that we replant in our fields, and the children accompany their mothers and so with this, the daily routine returns to a dynamic of living in harmony with the forest. Consequently, children are educated with these types of knowledge, and women also get out of a situation where they were stuck at home.

For us, it is very important to know that this work will not only depend on the father or older brother, but that everyone from childhood onwards has the knowledge and intelligence to live this life on a daily basis, and that women can participate in an environment where they possess this knowledge. So that is what we are doing today with this project, aiming for a daily dynamic where we can return to our pre-contact cosmovisions...

To address one more point, with our agroforestry model, we currently have 10 hectares already prepared, then we have 50 hectares of *muvuca*, an area where we replant all the different species, and we plan to have 60 more hectares. So, we are investing heavily and seeking support so that we can transform pasture and degraded areas into agro-forestry zones on the edge of our territory. By doing this, we create barriers to prevent the entrance of illegal activities and land-renting, with this strip of agroforestry around our territories. We are seeking more support so that we can strengthen our fight, bringing back this collective vision through agroforestry and also through the cultural practices that we lost after contact.

Freg J. Stokes: Agroforestry as a barrier against deforestation

Uraan Anderson: Exactly.

Freg J. Stokes: Good. *Yeteh iter* [‘Thank you’ in Paiter Suruí] Uraan

Uraan Anderson: *Yeteh iter*!

5.5 Interview: Concepción and Candelaria Trejo

Concepción and Candelaria Trejo

The interview was conducted by Verónica Zuccarelli Freire with Concepción Trejo, a member of the Tourism Commission of Cusi Cusi, and Candelaria Trejo, the current President of the same commission. Both women belong to the Indigenous Community Orqho Runas de Cusi Cusi, located in the Department of Santa Catalina, Province of Jujuy, in northwestern Argentina. Cusi Cusi is a highland village situated in the Puna region, near the borders with Bolivia and Chile, at an elevation of over 3,700 meters above sea level. The area is characterized by its arid climate, scarce water resources, and striking Andean landscapes of volcanic rock formations and deep valleys. Despite these challenging environmental conditions, the community maintains a vibrant cultural heritage rooted in traditional pastoralism, textile production, and small-scale agriculture, sustaining practices that have been passed down through generations.

Verónica: Conce, Cande — would you like to introduce yourselves? Could you tell people your names, where you live, and your current roles in the community?

Concepción: Hello, good morning. My name is Trejo Concepción. I am currently part of the Tourism Commission. I also work at "Rincón de Cusi", a local inn.

Candelaria: Hello, my name is Candelaria Trejo. I'm currently the President of the Tourism Commission in Jujuy, Argentina. My village, where I live, is Cusi Cusi — which means "Joy, Joy" in Quechua.

Verónica: The community is called Orqho Runas, right?

Concepción: Yes, the community is called the Indigenous Community Orqho Runas de Cusi Cusi, in the Department of Santa Catalina, Jujuy.

Verónica: Very well. Welcome and thank you very much for taking the time for this conversation. I'm really happy that people can get to know you — also those who will watch this interview. I'll ask you a few questions; we'll talk them through. It's not like an exam — just what comes to your mind. Some are about the past, some about the present, and others about the future. They all relate to the many changes we're living through as humanity — climate change and everything that's happening.

In your community, you produce, raise animals, have llamas, sometimes grow crops, weave — all sustainable activities that don't harm the environment. So I'd like you to tell us a bit about that.

The first question, about the past: Do you think protecting cultural heritage can help preserve ancestral and community knowledge?

Concepción: Yes, all cultural heritage is ancestral, and it's something to conserve, to value, to revalue — everything that our parents and grandparents used to do. Nowadays, we still maintain much of it — maybe not one hundred percent — but we continue, and that's a way of keeping our culture alive.

Verónica: Could you tell us, for example, what things were done in the past that are no longer practiced, and what things are still being maintained?

Candelaria: Well, before, during the patron saint festivals, there were bands, the cuarteada, the kacharpalla... Now we don't do it like before. The same with Carnival — it's not the same anymore. And Easter — we don't celebrate it the way it used to be, with prayers and songs; that's been lost.

Verónica: And did those celebrations relate to things like agriculture or herding llamas — activities of production?

Concepción: I think they did it as a form of gratitude — to give thanks for what they had. There were different saints;

almost every house had one. They had small oratories with images, and each family would celebrate in its own way to give thanks. I believe that was the main meaning behind the festivities. As Cande mentioned, there was the cuarteada, the kacharpalla, and a person who dressed as a "little monkey" and danced with the people — it was for fun. Today, we still do the cuarteada, but not the kacharpalla.

Verónica: And regarding production — llama herding, growing food, and other activities for subsistence or livelihood — what has changed, and what continues?

Concepción: Most of it continues — especially the planting and livestock raising. We no longer keep sheep or goats, but about 90 to 95% of people here still raise camelids. Everyone has llamas, so that hasn't been lost. Some still cultivate small plots or home gardens, growing a variety of products. So, no — that hasn't been lost either. We're still maintaining those traditions.

Verónica: You also raise animals and produce food in a high-altitude, arid environment where water is often scarce. Do you think your experience in managing these conditions — water, grazing, and production — is important, especially as water becomes scarce in many places?

Concepción: Yes, we've noticed water scarcity. There's less water than before, so we have to go to other sectors. Across the Puna region, water has decreased. Grass is also affected — that's a big problem for our animals. By June or July, the grass dries, but by this time of year (October), there's little left. So we help the animals — with alfalfa, for example — especially the weak ones or baby llamas that lose their mothers to pumas. That's one of our risks. The loss of pasture is serious, probably due to lack of water. The entire Puna is suffering from this.

Verónica: Many people make small veguitas (note: irrigated patches) to grow more grass, right?

Concepción: Yes, we make small irrigation channels, but not everyone has that possibility. Some areas have no wetlands at all — only dry grasses and shrubs. Rainfall is scarce. That's what we depend on — and that's what the animals eat. But it's not enough to keep them healthy all year. So yes, we suffer from lack of pasture and water, because the water has clearly decreased.

Candelaria: As Conce said, the lack of water is worsening with climate change. Sometimes it's too cold during this season; sometimes it looks like it will rain, but it doesn't. The heat also affects us. Everything is changing, and it impacts us a lot.

Verónica: Could you tell us about the community projects — those that are communal and linked to your sustainable ways of producing, weaving, etc.? I call them "sustainable" because they come from your families, from hundreds of years of practice, and you continue them today — like spinning wool, for example.

Candelaria: Yes, we continue preserving our culture mainly through crafts. We raise and care for llamas, shear them, spin and weave the wool to make handicrafts. Each of us teaches our children — it's passed down. It's not easy; sometimes crops fail because of frost, or we lose animals to pumas. We can't recover those losses easily. With crafts, it's similar — the prices are not high, but we keep working and continue.

Verónica: And there are community projects — like the "Flor de Puya Puya" weaving cooperative, the quinoa cooperative, and tourism, right?

Concepción: Yes, the quinoa cooperative works only a little — modestly — but it functions, with three certified products every six months. The crafts cooperative is working almost at 100%; we produce daily, both as a group and individually — many artisans sell from home. It's something that's always been maintained year after year. Regarding the Tourism Commission, we have a major project — our great dream — to make Cusi Cusi a tourist village. We want to preserve the natural and cultural wealth of the Puna landscape. It's advancing well, and we're grateful to those who support us. It's hard work, but we won't give up — it's a big project that will always provide work for people. We want tourism to allow young people to study and return to work in the community. That's our biggest goal.

Verónica: I know a bit about the eco-tourism project, but others don't. Could you tell us more about it?

Concepción: The project started many years ago, with various community commissions, but it was never completed. Now, as the current Tourism Commission, we're focused on the "Hito 5 y 6 Abra de García" project — formally called the High-Andean Ecotourism Corridor Hito 5 y 6 Abra de García (a border crossing area between Argentina, Chile, and Bolivia).

In January, our president and I signed an agreement with the Tamarugal Program in Chile to develop this dream — a tourism project to preserve our beautiful landscapes and prevent mining from destroying them. Our goal is to establish a cross-border route linking northern Argentina, southern Bolivia, and northern Chile — small communities that share the same vision of protecting what our ancestors left us.

Verónica: So this involves other Indigenous communities from Chile and Bolivia, right?

Concepción: Yes. I don't remember exactly how many from each country, but several are included in the Hito 5 and 6 corridor. It started with just our community, but recently, during a meeting in San Salvador de Jujuy, six other local communities from the Department of Santa Catalina joined. So now we're many, all sharing the same dream — to conserve and protect our environment.

Verónica: Do you feel that there are projects threatening your way of life — water, livelihoods, the community itself?

Concepción: Yes. Recently, a mining company sent a proposal to explore in the Ramadal area — not yet to extract, but to carry out exploration tests. Our community doesn't agree, but sometimes, even if we oppose it, the government proceeds anyway. That's why we want to accelerate our tourism project and have the area declared a tourist zone — so mining can't operate in our beautiful landscapes. Mining would destroy the scenery, the climate, and the water — and water is essential for all life here.

Water is what sustains us and our animals; it's what reaches Cusi Cusi. If mining diverts it, we'll lose it — and every year we already see less water due to climate change. If companies come, we'll have even less, because they use and contaminate underground aquifers.

Verónica: Ideally, what should governments do to protect your community and what you value?

Concepción: I would like the government to support communities according to how they wish to live. In our case, we've chosen to become a tourist village. Year after year, people are starting small businesses — hostels, restaurants. I wish the government would help us speed up the creation of an international tourist route, because tourism would bring steady work all year and more employment for our people. Mining might offer jobs today, but tourism can provide a sustainable future. We're developing this project ourselves, as a community, without external funding, because we believe in it.

Verónica: And regarding food production — do you think mining could affect your crops or livestock?

Concepción: Yes, if mining started nearby, contamination would affect the air, the plants, and the animals — especially llamas. The crops might not grow the same; the plants could change. Right now, everything we grow is natural. We'd lose that.

Verónica: Do you know of other communities whose food systems have already been affected by such projects?

Concepción: I've heard of some — people said llamas were born blind, or with two heads, or other deformities. Imagine — if that happens there, what could happen to us as humans too? That's why we've clearly chosen tourism — not mining.

Verónica: And finally, what would you like to share with people who don't know your community — people who've never visited Cusi Cusi or seen your way of life?

Concepción: For us, living in Cusi Cusi means peace — peace and safety. Children can play in the streets; the air is clean and quiet. We have beautiful places to visit, with accommodations for about 70 people, restaurants, and fuel sales. We welcome everyone who wants to visit — you'll be warmly received. I think the kindness of our people makes a difference anywhere in the world.

Candelaria: Yes — we want people to come and discover the Puna, especially Cusi Cusi, where you can find peace and tranquility, and meet kind people who will talk to you, guide you, and teach you what you need to know. We're waiting here with open arms to share our daily lives, our work, and our traditions.

Verónica: Thank you so much — really, thank you both.

6. Conclusions

No human society alive today reached this point by pursuing entirely self-destructive ecological or economic development. Archaeology demonstrates that humans have historically managed vulnerability and risk through cooperation and adaptive strategies. While the archaeological record does include instances of violence and conflict, these are generally contextualized within broader patterns of intraregional prosocial behavior, except in cases where the social system experienced total collapse (Wright, 2019).

Today, as the world approaches multiple tipping points in climate change, biodiversity loss, and pollution, historical and contemporary experiences demonstrate the constructive potential of human ingenuity. The examples in this volume, that align with the UNFCCC's concept of Nature-Based Solutions, have proven to be optimal in the long term to protect, restore, and create sustainably managed ecosystems to sequester carbon, enhance resilience, and provide co-benefits for biodiversity and livelihoods. To fully realize these solutions, policies and programs must integrate principles of climate justice, human rights, and Indigenous rights, ensuring Free, Prior, and Informed Consent (FPIC) of affected communities and aligning climate finance to support locally led, equitable, and sustainable initiatives. Such an approach redefines development, centering resilience, equity, and the harmonious integration of social and ecological well-being.

To foster such pathways globally, it is imperative that climate finance mechanisms prioritize equity and inclusivity. This includes upholding human and Indigenous rights, ensuring FPIC, and integrating traditional knowledge systems into climate policies. These pivotal principles, however, are often stated but randomly respected in practice by states, policy-makers or market agents, as the interviews in this volume exemplify. As Edson Krenak states in an interview within this publication : "*And we wanted to move from recognition to full participation in the processes of policy making, decision making at multiple levels. We wanted to move from a consulting or stakeholders position to rightholders position, and to have these rights protected.*"

The recent commitments at COP29, notably the New Collective Quantified Goal (NCQG) aiming to mobilize $1.3 trillion annually by 2035, highlight the financial scale required. The effectiveness of these funds, however, hinge on their alignment with the principles of climate justice and their capacity to support locally led adaptation initiatives. As negotiations continue toward COP30 in Belém, Brazil, it is crucial that financial flows are directed towards empowering communities, respecting their rights, and facilitating a just transition.

In conclusion, embracing nature-based solutions grounded in traditional ecological knowledge offers a path toward resilience and sustainability that generally aligns with broader COP objectives. Achieving this requires a concerted effort to ensure that climate finance is both adequate and appropriately directed, fostering a global environment where communities can thrive in harmony with their ecosystems.

As Edson Krenak states ... *"we wanted to move from recognition to full participation in the processes of policy making, decision making at multiple levels. We wanted to move from a consulting or stakeholders position to rightholders position, and to have these rights protected."*

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