2025 Yale Institute for Global Health Case Competition

Climate Change and Food Security:

Impacts on Indigenous Communities

in the Ecuadorian Andes

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Introduction

"What sets Indigenous food systems apart is that food is not seen as a commodity. It is not something you can buy or sell. For Indigenous Peoples across the globe, food is part of our identity, our culture, our values and beliefs system. We are trying to tell the world that we see food differently, and that there is not one single model that can apply to everyone. … Indigenous Peoples are the victims of climate injustice. We did not cause the climate crisis. We did not benefit from any of the activities that are at its roots. And yet, we are heavily impacted by it, as our seasons have changed."

Hindou Oumarou Ibrahim, Chair of the UN Permanent Forum on Indigenous Issues
August 8, 2024 (1)

The Ecuadorian Andes is a spectacular region renowned for its unique ecosystems, rich biodiversity, and vibrant indigenous communities. However, it is also one of the epicenters of the climate crisis. For centuries, indigenous communities in the Andes have cultivated staple crops like potatoes, maize, and quinoa. These crops are more than just sources of sustenance—they are woven into the cultural and spiritual fabric of these societies. Rising temperatures, erratic rainfall patterns, and glacial retreats are destabilizing this delicate equilibrium, threatening both food security and cultural heritage. (2)

Climate change has several consequences in this region, such as the retreat of glaciers, with some losing up to 40% of their mass, significantly reducing meltwater availability for irrigation during dry seasons. This has dire consequences for the 84% of Ecuador's smallholder farmers, many of whom rely on subsistence agriculture. (3,4) These farmers are grappling with shrinking crop yields, new pest infestations, and shifting growing seasons, leaving rural Andean communities disproportionately vulnerable. As a result, it is estimated that 14% of Ecuador's population faces urgent food insecurity, and indigenous communities in highland areas experience the most severe impacts. (5)

The cascading effects of these environmental changes extend beyond agriculture. Malnutrition rates among children under five in the Andean region exceed 27%, significantly higher than Ecuador's national average of 23%. (6) Water scarcity, exacerbated by glacial retreat and erratic precipitation, further compounds the issue, leaving some families spending up to four hours daily collecting water. Moreover, warmer temperatures drive vector-borne diseases, such as dengue and Zika, into higher-altitude areas, further straining already limited healthcare resources in rural Andean communities. (7)

This case illustrates the critical intersection of climate change, cultural preservation, and socioeconomic resilience. It examines how environmental degradation not only undermines food security but also threatens the survival of indigenous practices and traditions that have endured for generations. By exploring the challenges highlighted in the case and faced by one of the world's most historically resilient populations, participants are invited to propose innovative solutions that address climate change-induced food insecurity in Indigenous communities living in rural areas of the Ecuadorian Andes while balancing environmental sustainability, cultural heritage preservation, and the promotion of equity.

Case Prompt

Background

Climate change is a worldwide problem with immense consequences. Rising temperatures and distinct changing weather patterns are causing significant variations in the environmental climate around Earth. Many sources contribute to the rise in temperatures and changing weather, including human activities that cause air pollution and the destruction of the ozone layer, changes in greenhouse gas levels, and ocean acidification due to increased carbon dioxide concentrations in the atmosphere. These climate-related changes have significant effects on other aspects of human life, including food and health (8).

One part of the world that is at significant risk of facing climate-related health impacts is the Ecuadorian Andes. This portion of the mountain range has been home to indigenous communities, including ancestral farmers and cultivators, for thousands of years (9). The region includes high-altitude ecosystems, glacial watersheds, and crops that play a crucial role in local agriculture and water supply (10). Rising temperatures and altered precipitation patterns are disrupting traditional farming practices and threatening food security for the indigenous and rural communities living in the Ecuadorian Andes. This could threaten the livelihoods and well-being of the Indigenous communities due to food shortages.

Climate change has intensified health and food security challenges, with rising temperatures and extreme weather expanding vector-borne diseases to previously unaffected highlands. Poor air quality from urban smog and biomass burning further exacerbates respiratory illnesses. Simultaneously, disrupted agriculture caused by erratic precipitation, glacier retreat, and rising temperatures has reduced yields of staple crops such as maize, rice, and quinoa, worsening malnutrition, economic hardship, and cultural erosion in rural and indigenous communities. Limited access to climate-resilient tools and infrastructure compounds these vulnerabilities, leaving many struggling to adapt.

International organizations have made efforts to address these issues through health interventions, sustainable agriculture, and water management. Programs like nutritional supplements, climate-resilient crops, and rainwater harvesting have shown promise but encounter challenges such as logistical delays and maintenance costs. The Ecuadorian government has also enacted healthcare and agricultural reforms, but systemic issues, including political instability, impede progress. Indigenous groups, central to Ecuador's identity, remain marginalized, facing legal and economic discrimination, despite their critical role in shaping sustainable and culturally sensitive responses to climate change.

The risk of food insecurity for these communities will continue to rise as the climate change worsens in Ecuador. With so many lives at stake, solutions must be developed to protect the health of Indigenous communities and ensure they receive adequate support to mitigate the risk of a food insecurity crisis. Through effective public health intervention, this issue can be addressed, and solutions can be created to foster a sustainable future that reduces the risk of food insecurity for Indigenous and rural populations in the Ecuadorian Andes. This approach should also establish a framework to ensure that solutions to the health impacts of the climate crisis are culturally sensitive and equitable for all affected populations.

Team Instructions

In light of the critical challenges posed by climate change, food insecurity, and cultural erosion confronting Indigenous communities in the Ecuadorian Andes, the Food and Agriculture Organization (FAO) is seeking innovative contractor assistance to tackle these overlapping crises. FAO has released a Request for Proposal (RFP) for a cooperative agreement of USD 5 million over five years. The objective is to engage new, creative partners in developing community-level solutions that enhance food security, preserve cultural heritage, and improve climate resilience for Indigenous populations disproportionately impacted by climate change.

You will take on the role of a social impact company, a small NGO, or an academic institute to submit a bid for the award. Your proposal should outline a locally implementable intervention to address the cascading impacts of climate change-induced food insecurity in rural Andean Indigenous communities, with a focus on balancing environmental sustainability, cultural preservation, and socioeconomic resilience.

You will have **10 minutes to present your proposal** to a panel of judges, including FAO program officers, representatives from Indigenous communities, and Ecuadorian government agencies. A **5-minute question-and-answer session** will follow. Proposals will be assessed following eight criteria:

- **Local Relevance**
  Solutions must demonstrate a deep understanding of local contexts, cultural sensitivities, and community priorities. Describe intended levels of community engagement, ensuring alignment with Indigenous traditions, values, and needs.
- **Implementation (1–2 Years)**
  The intervention should be operational within the first two years to address immediate threats to food security and health, focusing on deployment and initial impact.
- **Scalability (3–4 Years)**
  The intervention should be designed to scale effectively within three to four years, adapting to shifts in demand, population needs, and environmental conditions.
- **Feasibility (5 Years)**
  The proposal should be realistic, cost-effective, and operationally viable. It must demonstrate measurable outcomes, including enhanced food security, community engagement, and resource efficiency, within five years.
- **Applicability**
  The design should align with the UN's Sustainable Development Goals (SDGs), national policies, and the specific needs of Indigenous communities.
- **Integration**
  While addressing food insecurity, the intervention should include secondary priorities such as water security, mental health, healthcare access, climate resilience, and economic empowerment, creating a multi-dimensional impact.

- **Sustainability (Beyond 5 Years)**
  The proposal must demonstrate long-term viability by outlining strategies for maintaining operations and impact beyond the initial five-year period. This includes local capacity building, financial sustainability through partnerships, and community-driven leadership to ensure self-sufficiency.
- **Adaptability**
  The intervention should exhibit flexibility to respond to unforeseen challenges or emergencies post-implementation. This includes mechanisms for monitoring and evaluation, real-time feedback loops, and iterative design to address changing environmental, social, or economic contexts.

A successful proposal will include:

- A detailed and well-researched project plan covering the full funding timeline.
- A clear outline of how funds will be allocated.
- Specific metrics to measure progress and impact.
- Summaries of high-quality evidence supporting the feasibility and relevance of the proposed intervention.
- A strategy for managing relationships with stakeholders, including local communities, government bodies, and funders.

Presentations should clearly articulate how the proposed project addresses food insecurity while promoting the preservation of cultural heritage, equity, and environmental sustainability. Additional elements, such as a public relations strategy or innovative tools for engaging Indigenous communities, may strengthen your proposal.

Supporting Information

Climate Change and Environmental Challenges

Climate change is a global emergency characterized by significant changes in Earth's weather, natural disasters, and temperature patterns. This phenomenon has been exacerbated by greenhouse gas emissions that lead to global warming, primarily due to human activities. The frequency of extreme weather events is rising, accompanied by shifting patterns of precipitation. These changes have devastating impacts on natural ecosystems, agricultural practices, public health, and economic structures. There are new impacts that remain to be understood for developing communities, especially rural areas and those comprised of indigenous peoples. Understanding these impacts within these communities is essential to ensure an equitable response to climate change.

Impact of Climate Change on The Burden of Disease In Ecuador

Climate change is significantly impacting the epidemiological landscape in Ecuador. For instance, vector-borne diseases, such as yellow fever, dengue, Zika, and chikungunya, are being introduced into new areas that have been subjected to increased temperatures. The distribution of these diseases is highly dependent on the spread of vectors, including mosquitoes such as *Aedes aegypti,* which have been part of the Ecuadorian ecosystem for a significant period. The onset of *A. aegypti*-driven dengue fever, Zika, and chikungunya are of public health importance to Ecuadorians as arboviral disease management is made difficult by the complex vector dynamics of mosquitoes such as *A. aegypti*. In Ecuador, the Ministerio de Salud Pública (MSP) (or Ministry of Health) is responsible for managing the public health response to such threats and has employed several measures that investigate the distribution of *A. aegypti*. However, climate change threatens the distribution of these mosquitoes due to the rises in temperature and fluctuations in environmental conditions caused by an increased frequency of El Niño events. An extreme climate change scenario can include increased mosquito presence across various elevations of the Andes mountain region, with over 12,000 individuals facing additional risk for vector-borne diseases. Western coastal regions of Ecuador are projected to be suitable for *A. aegypti* habitat, leading to exposure in vulnerable highland rural indigenous communities with reduced exposure to mosquito-borne diseases. This can have significant challenges with regard to the allocation of preventative or treatment resources and education of such conditions to the indigenous population (7,11).

Furthermore, the region faces a significant impact of air pollution due to factories and fire-burning, which has led to an increase in temperature throughout the highland regions and extreme heat events. Temperature increases in the highland Quito region have included an over 1-degree Celsius increase from 1960 to 2010. Furthermore, the rural Cotopaxi region has reported an increase of over 1.5 degrees Celsius. Scientific projections suggest that by 2070, Ecuadorian highland regions will experience a temperature increase of up to 2.3 degrees Celsius from today (2,12). This poses a substantial stressor on the human body, as many studies have demonstrated the physiological effects of rising temperatures, including heat

fatigue, exhaustion, and an increase in non-communicable diseases. Moreover, smog and air pollution in urban areas, particularly Quito, can lead to upper respiratory infections. This smog results from particulate matter emissions from combustion sources like vehicles, open burning, forest fires, and industry, which can disperse to other rural areas in the Pichincha region surrounding Quito. Rural regions in the Amazonian areas of Ecuador (such as Orellana, Pastaza, Sucumbíos, etc.) experience significant biomass burning and oil extraction, which introduces toxic compounds that further contribute to pollution in rural areas. Particulate matter concentrations in these regions can reach up to 100 micrograms per cubic meter (13,14). Therefore, these effects not only raise temperatures but also have specific health-related consequences for communities throughout rural Ecuador.

Impact of Climate Change on Food Security in Rural Areas of Ecuador

Climate change threatens the food security of Ecuador's rural and indigenous communities by disrupting food production pathways, including growing conditions and distributional systems. By 2030, scientists predict that climate change is going to impact Ecuadorian communities significantly. For instance, there will be up to a 60% decrease in rice production and a significant decrease in soybean production (2). Both of these crops are a significant portion of the country's agricultural output, which overall is around 27% of the territory of Ecuador and employs around 6% of the workforce. Changing climate patterns can have distinctive social and economic effects, which can significantly impact the food security in these regions.

The absence of a proper food support structure in Ecuador's rural areas makes these impacts particularly severe. As mentioned previously, unstable precipitation patterns significantly reduce crop yields, affecting both the collection of crops and harvest frequency. As early as 2009, a severe drought impacted over 100,000 people, resulting in food production and distribution challenges (4). Additionally, half of the communities in the Pichincha province of Ecuador experience chronic malnutrition due to insufficient infrastructure, high poverty levels, and increased vulnerability to natural disasters. This situation creates a precarious environment that dramatically heightens the risk of food insecurity for rural populations.

Furthermore, the retreat of glaciers and changes in rainfall have shifted water availability for agricultural use, further exacerbating the decline in yields. This has significant public health and economic repercussions in the region; for instance, children in Pichincha Province, home to the Tsa'chila and Kitu Kara Pueblo indigenous peoples, face significant chronic malnutrition, which correlates with insufficient crop yields. Decreased crop yields also impact the export of goods that provide economic support to the region, causing many communities to suffer financially due to climate change. As a result, food insecurity has become a substantial consequence of climate change in rural areas of Ecuador.

Climate Change and Food Security in the Andes

Climate change severely affects farmers in the Andes, particularly smallholder farmers, who account for over 84% of Ecuador's agricultural producers (3). These farmers, who depend on small-scale agriculture for their livelihoods, are facing increasing challenges as rising temperatures, altered precipitation

patterns, and the retreat of glaciers disrupt traditional farming practices, reducing agricultural productivity in the region.

A key concern is the loss of glacier meltwater, historically providing essential irrigation during the dry season. As glaciers on Cotopaxi and Chimborazo in Ecuador retreat (15), the availability of this crucial water source decreases, making it more difficult for farmers to maintain consistent crop yields and sustain their livelihoods.

The International Cryosphere Climate Initiative reports that temperatures in the Andes have increased at a rate of 0.10°C per decade over the past 70 years (16). This warming has altered growing seasons, intensified droughts, and triggered extreme weather events, all of which complicate farming efforts. Additionally, warmer temperatures allow pests and crop diseases to spread to higher altitudes once unaffected by such threats. Consequently, traditional crops like potatoes, maize, and quinoa are becoming harder to cultivate. Quinoa, once celebrated for its resilience, now faces significant challenges due to hotter, drier conditions and soil degradation, resulting in declining yields and escalating food insecurity(2).

Furthermore, many smallholder farmers lack access to essential resources and climate-resilient tools, such as modern irrigation systems, drought-resistant seeds, pest-resistant crop varieties, and affordable fertilizers. Limited access to agricultural machinery, such as tractors or processing equipment, hinders their productivity. For example, in the Peruvian highlands, farmers struggle with high costs of fuel and equipment rentals, forcing them to rely on traditional preservation methods like making chuño (dehydrated potatoes) to mitigate food insecurity (17). This lack of access and support significantly exacerbates food insecurity, particularly among vulnerable indigenous communities, where the challenges of sustaining livelihoods and preserving cultural practices are deeply intertwined.

Food Insecurity in Ecuador

Food insecurity in Ecuador is a persistent issue, particularly in rural areas, where 14% of the population faces urgent food insecurity (5). The country's agricultural system, heavily reliant on subsistence farming, is vulnerable to climatic instability, which disrupts food production and threatens the stability of local food systems. These rural communities, already grappling with economic inequality, with nearly half the rural population living in poverty compared to a third of people nationwide (18), are further burdened by the unpredictable effects of climate change on crop yields.

Rising food prices and unequal land distribution make access to food even more challenging, as many farmers struggle to meet their basic needs. Additionally, the lack of financial resources and technical support hampers their ability to implement climate-resilient farming practices, further reducing agricultural output. This combination of factors contributes to a worsening cycle of food insecurity, particularly in vulnerable rural areas. The situation is compounded by the lack of adequate infrastructure and resources to adapt to the challenges posed by a changing climate.

Impacts of Food Insecurity in Rural Areas of Ecuador

Food insecurity in Ecuador, particularly in rural indigenous communities, is a multifaceted issue that extends beyond the immediate concerns of malnutrition and health. According to the World Food Programme, about 14% of Ecuador's rural population faces urgent food insecurity, with indigenous groups experiencing disproportionately high rates of hunger and poverty (5,19). This food insecurity is primarily driven by the loss of agricultural productivity due to climate change. Essential crops such as potatoes, quinoa, and maize—key staples in indigenous diets—are increasingly vulnerable to erratic weather patterns, such as droughts and frosts, which reduce yields (20). This leads to malnutrition, especially in children, manifesting as stunted growth, anemia, and other health conditions, undermining the community's physical well-being (21).

However, the impacts of food insecurity in rural Ecuador go beyond health and nutrition. For indigenous communities, food is not just about nutrition—it's an integral part of cultural identity. Indigenous food systems, based on traditional knowledge and deep relationships with the land, are fundamental to their social fabric and spiritual beliefs. Food is seen as part of the sacred bond with the earth, passed down through generations, and deeply tied to the communal values that define Indigenous life (1,22). When climate change disrupts the cultivation of staple crops, it threatens not only the physical health of the community but also the continuity of cultural practices and heritage.

The loss of crops like quinoa and potatoes, cultivated for centuries, has significant cultural ramifications. These crops are central to rituals, festivals, and communal gatherings, fostering a sense of identity and belonging. As these crops become harder to grow, cultural practices associated with food preparation, sharing, and celebration are at risk of fading. This cultural erosion is further exacerbated by migration patterns; younger generations, seeking better economic opportunities in urban areas, often leave behind traditional farming practices. This migration disrupts the transmission of traditional agricultural knowledge, which is essential for adapting to changing environmental conditions (23). Consequently, both food security and cultural resilience are weakened.

Moreover, food insecurity disproportionately affects women in rural Ecuador. Women, who are often responsible for household food production and care, bear the brunt of food shortages. They must manage both the physical labor of food cultivation and the emotional labor of ensuring the well-being of their families (18,24). This added stress, combined with the economic pressures of food insecurity, can exacerbate existing gender inequalities.

Therefore, food insecurity is not merely a matter of hunger but a challenge to the very survival of indigenous ways of life. Addressing food insecurity is essential not only for improving health outcomes but also for preserving cultural heritage and ensuring the long-term resilience of these communities amidst the ongoing impacts of climate change.

Population Health and Healthcare in Ecuador

The Andean region of Ecuador, characterized by its mountainous terrain and unique ecosystems, faces significant challenges in population health and healthcare. Despite improvements in Ecuador's healthcare system, disparities persist, particularly in remote Andean communities (25). Climate change exacerbates these issues by influencing critical health determinants, such as food security, water availability, and disease exposure (26).

According to a 2022 report by the Ecuadorian Ministry of Health, 45% of rural Andean households experience food insecurity, with rates as high as 60% in some provinces like Chimborazo (27). Malnutrition, particularly stunting, affects approximately 27% of children under five in the Andes, significantly higher than the national average of 23% (6). Prolonged droughts and erratic weather patterns have directly impacted crop yields, reducing access to affordable and nutritious food (28).

Additionally, incidences of waterborne diseases, such as diarrhea and cholera, have increased by 15% in rural Andean communities over the past decade due to flooding and water contamination (29). Limited healthcare infrastructure further compounds the issue, as 40% of rural clinics lack adequate medical supplies and trained personnel to address these growing challenges (30–32).

To address these issues, the Ecuadorian government has implemented several healthcare programs focused on improving access and quality in rural areas (33). The Ministry of Public Health has expanded mobile health brigades to remote Andean communities, providing basic medical services and vaccinations (34). In 2023, over 200 mobile health teams conducted outreach programs, benefiting approximately 100,000 residents in isolated areas.

Additionally, the government's "*Salud para Todos*" initiative aims to strengthen primary healthcare by increasing the number of rural clinics and training healthcare workers to address climate-related health impacts (35). This program has been particularly successful in expanding access to healthcare in remote Andean communities, with over 100 new clinics established since 2020 and a 20% increase in the availability of healthcare services in underserved areas. The initiative focuses on equipping clinics with telemedicine capabilities, ensuring access to specialist consultations despite geographic barriers. Training workshops for healthcare workers emphasize managing malnutrition, waterborne diseases, and other climate-induced health conditions, leading to a reported 15% improvement in health outcomes for vulnerable populations. However, challenges persist, including difficulty retaining healthcare professionals in remote areas due to harsh working conditions and limited career advancement opportunities. Additionally, logistical issues, such as delays in delivering medical supplies to rural clinics, have occasionally disrupted service delivery. Despite these obstacles, the program's community-centered approach and investment in capacity-building have been widely recognized as a model for addressing health disparities in climate-affected regions.

Key Health Metrics

The life expectancy of Ecuadorians has steadily improved over the past few decades, with an average of **77.5 years** in 2023—79.7 years for women and 75.3 years for men (36). However, significant disparities persist within the Andean population. Rural communities often experience a lower life expectancy due to limited access to healthcare, malnutrition, and the burden of preventable diseases.

Key health metrics for the Andean region highlight these disparities:

- **Maternal Mortality Rate (MMR):** In rural Andean areas, the MMR is significantly higher, estimated at **120 deaths per 100,000 live births**, compared to the national average of 59 deaths per 100,000 live births (37).
- **Child Malnutrition:** Chronic malnutrition affects **23.9% of children under five** nationally but reaches over 30% in Indigenous communities within the Andes (38,39).
- **Disease Burden:** Respiratory infections and diarrheal diseases remain leading causes of morbidity among rural populations, exacerbated by poor access to clean water and healthcare (40,41).
- **Healthcare Access:** Approximately **30% of rural Andean residents lack access** to consistent healthcare services, highlighting the need for targeted interventions in infrastructure and workforce distribution (40).

Humanitarian Challenges in Rural Areas of Ecuador

Rural Andean regions face unique and multifaceted humanitarian challenges that are deeply influenced by geographic isolation, socioeconomic inequality, and the escalating impacts of climate change. Agriculture, a cornerstone of livelihoods in these areas, has been severely disrupted by changing climate patterns (25,42). According to the Food and Agriculture Organization (FAO), annual agricultural output in the Andean region has decreased by 20% over the last decade, primarily due to shorter growing seasons, increased pest infestations, and extreme weather events such as droughts and hailstorms (43).

Food insecurity is one of the most pressing challenges. Many subsistence farmers, who rely on traditional crops like maize and potatoes, struggle to adapt to unpredictable weather conditions (44). A 2023 survey by the Ecuadorian Ministry of Agriculture revealed that 65% of rural households in the Andes reported reduced crop yields in the previous year, with 40% experiencing severe food shortages (45,46). Women and children are particularly vulnerable, as they often bear the brunt of food scarcity and are at higher risk of malnutrition.

Water scarcity is another critical issue in rural areas. Glacial retreat—accelerating by 30% since 1990, as reported by the Ecuadorian National Institute of Meteorology and Hydrology (INAMHI)—has significantly reduced freshwater availability. This impacts both household consumption and agricultural activities, creating a cycle of poverty and deprivation. In some communities, residents spend up to four hours daily collecting water, a burden that disproportionately falls on women and girls (47,48).

Healthcare access remains limited in these remote regions. Many rural communities are located hours away from the nearest medical facility, and 40% of rural clinics lack essential medical supplies, as noted by the Ministry of Public Health (25,40,49,50). This lack of infrastructure is particularly problematic during climate-induced disasters such as floods or landslides, which can isolate entire villages and delay emergency responses.

Migration patterns further underscore the humanitarian crisis. A 2023 study by the International Organization for Migration (IOM) found that 25% of rural Andean households have at least one member who has migrated to urban areas or abroad in search of better opportunities (51). While migration can provide some financial relief through remittances, it also disrupts traditional family structures and leaves communities with fewer working-age individuals to sustain local economies.

Social inequality compounds these challenges. Indigenous populations, who make up a significant portion of the Andean rural demographic, often face systemic discrimination and are disproportionately affected by climate change. Limited access to education, land ownership, and financial resources further marginalizes these communities, making it difficult for them to adapt to changing conditions or advocate for their needs (52,53).

Current Humanitarian Responses by International Organizations

Efforts to address these issues involve international organizations, local governments, and community-based interventions. While some initiatives have been transformative, others have faced notable setbacks, providing valuable lessons for future efforts. The World Health Organization (WHO) and organizations such as the Food and Agriculture Organization (FAO), the United Nations Development Programme (UNDP), and CARE International have launched targeted initiatives to address the humanitarian challenges in Ecuador's Andean regions. These efforts focus on improving healthcare access, enhancing food security, and building community resilience to climate change.

World Health Organization (WHO)

WHO's initiatives have targeted health-related vulnerabilities that exacerbate food insecurity. A 2022 program trained 1,000 healthcare workers in managing climate-induced health risks, enabling rural clinics to better address malnutrition and climate-related diseases (54,55). Additionally, WHO's vaccination campaigns in partnership with the Ecuadorian Ministry of Public Health reduced the incidence of preventable diseases, such as measles and diarrheal diseases, by 12% (56,57).

One notable program involved the distribution of nutritional supplements to pregnant women and children under five in the Chimborazo province, where stunting rates remain high. According to a *Lancet Global Health* report, the initiative led to a 15% reduction in malnutrition-related complications in children within two years (58). However, logistical challenges hindered the program in remote areas, where harsh terrain delayed the delivery of medical supplies and reduced the program's overall reach (59).

Food and Agriculture Organization (FAO)

FAO's emphasis on sustainable agricultural practices has yielded substantial results. The introduction of climate-resilient crops, such as quinoa and amaranth, has been transformative. According to a 2023 FAO report, the yields of these crops increased by 25%, benefiting over 5,000 farmers (60).

Another success was the implementation of **Farmer Field Schools**, which trained communities in soil conservation, crop rotation, and pest management. In Cañar province, a project focused on soil conservation resulted in a 30% reduction in soil erosion and improved long-term agricultural productivity (61,62). However, some FAO programs faced setbacks. For example, a program aimed at introducing drip irrigation technology struggled due to insufficient training for local farmers and limited access to repair services for malfunctioning equipment.

United Nations Development Programme (UNDP)

UNDP's water management projects have addressed one of the region's critical issues: access to clean water for irrigation and drinking. Over 3,000 rainwater harvesting systems installed in rural Andean households have significantly reduced water scarcity, especially during drought periods (UNDP, 2023).

In Loja province, UNDP collaborated with local governments to construct micro-irrigation systems that benefited 2,000 farming families. A *Journal of Environmental Science and Policy* study found that these systems increased agricultural productivity by 18%, with many farmers reporting better crop yields and higher incomes (63–65). UNDP's workshops on disaster preparedness have also been impactful. In 2023, 1,500 community members were trained in disaster risk reduction, enabling villages to respond effectively to floods and landslides (66). Despite these successes, maintenance costs for water infrastructure remain challenging for low-income communities.

CARE International

CARE International has prioritized empowering women and marginalized groups in the Andes. Microfinance programs have supported 1,200 women entrepreneurs, enabling them to diversify income sources and improve household food security (67,68).

One standout initiative involved distributing solar-powered water pumps to 500 families, significantly reducing the labor required to access water. These pumps enabled farmers to irrigate crops consistently, even during prolonged dry spells (69,70). CARE's nutrition workshops have reached over 10,000 participants. A 2023 study published in *Food and Nutrition Bulletin* highlighted that families who participated in these workshops reported a 20% improvement in dietary diversity and nutritional awareness (71).

World Food Programme (WFP): Emergency Food Security Kits

WFP has introduced **Emergency Food Security Kits** designed to support families during crises. These kits, containing fortified cereals, protein bars, and essential vitamins, have been distributed to 15,000 households in the Andean region (72).

A pilot program in 2023 targeted communities affected by landslides in Tungurahua province. A study in *Disaster Medicine and Public Health Preparedness* showed that malnutrition rates among children under five decreased by 20% in the six months following kit distribution (73,74). Challenges with distribution logistics, especially in remote areas, have highlighted the need for improved infrastructure to ensure timely delivery during emergencies (75).

Ecuadorian Government Initiatives

The Ecuadorian government has played a central role in scaling food security programs. One major success has been the **Agrocalidad Certification Program**, which helps small farmers meet international standards for organic and climate-resilient produce. By 2023, 1,200 farmers in the Andes had obtained certifications, allowing them to access higher-paying export markets (5,76).

In addition, the government's collaboration with international organizations to implement telemedicine services has bridged healthcare gaps. Between 2021 and 2023, over 10,000 remote consultations were conducted, reducing the burden of travel for medical advice in isolated communities (77,78). However, government programs have occasionally faltered. For instance, a plan to distribute subsidized fertilizers to rural farmers was marred by delays and allegations of mismanagement, limiting its effectiveness (79,80).

Other Prominent Examples and Lessons Learned

1. **Failed Program: Livelihood Diversification Projects**
   A project aimed at introducing alpaca farming in high-altitude areas faced significant challenges. While initially successful, the program failed to account for the lack of veterinary services and community expertise, leading to high mortality rates among livestock (81).

2. **Innovative Approach: Community Seed Banks**
   Local NGOs have successfully established **Community Seed Banks**, where farmers store and share native seeds adapted to local climatic conditions. These banks have increased resilience to climate shocks by ensuring farmers can access seeds even after extreme weather events (82).

3. **Collaborative Success: Agroforestry Systems**
   Agroforestry projects, where trees are integrated with crops, have gained traction in the Andes. A collaborative effort between FAO and local governments in Chimborazo province saw a 40% increase in soil fertility and a 30% reduction in crop losses due to wind erosion (83).

Social Determinants of Health

A complex interplay of social and structural factors affects the health of members of communities living in the Ecuadorian Andes. These include socioeconomic status, access to education and healthcare facilities, employment opportunities, and government policies (40). Perhaps the most critical aspect affecting all who live in these communities is their overwhelmingly rural nature, with approximately 36% of the population living in rural areas (84).

The latest statistics from 2022 report that the average number of years of schooling in Ecuador is 9.0 years, but despite this, the literacy rate was 96.4% (41). However, the literacy rate for the Indigenous population, at 11.9%, lags behind the white and mestizo populations (85). In 2022, the countrywide unemployment rate was 3.6%, and 25.2% were living below the national poverty line. Between 2000 and 2022, the Human Development Index improved by 11.8%, from 0.684 to 0.765. In 2021, public spending on health accounted for 5.28% of gross domestic product (GDP) and 14.76% of total public expenses. The majority of inhabitants (76.2%) have an internet connection.

Recent decades have seen significant improvements in key health indicators. For example, between 2000 and 2020, infant mortality decreased 49.7%, from 15.5 to 7.8 (deaths/1000 live births), and maternal mortality decreased 45.3%, from 120.1 to 65.7 (deaths/1000 live births). Unfortunately, some indicators have worsened, including measles vaccine coverage decreasing from 84% to 74% over the same period. The percentage of low-weight births (less than 2500 grams) also increased from 3.6% to 9.3% between 2000 and 2022; this is an important metric of maternal nutritional status. The overall age-adjusted mortality rate decreased 22.8% between 2000 and 2019, from 6.2 to 4.8 (deaths/1000 population).

Sociopolitical Context

Universal healthcare was established in Ecuador in 2008 through a series of constitutional amendments. While its passage theoretically ensured healthcare for all individuals, the public healthcare system faces several issues, and well-resourced citizens frequently avail themselves of private healthcare. Universal healthcare came from a history of political and economic instability in Ecuador that began in 1996 and lasted ten years (86). This instability contributed to significant consequences on the performance of the healthcare system, including reductions in the health service budget, infrastructure deterioration, worsening of the quality of healthcare services, and the lack of a coherent institutional structure. These effects led to an increase in out-of-pocket expenditures, especially among the poor and rural poor. In response, the 1998 Constitution enshrined the principles of equity, universality, solidarity, quality, and efficiency and set the country on a path to guaranteeing the right to health.

After this, a new Social Security Law was passed in 2001, which established guiding principles for social security in Ecuador. This law defined the institutions that were part of the National Social Security System and established the participants, resources, and risks covered. Unfortunately, after these laws, health indicators did not exhibit significant progress, likely hindered by political instability and the dollarization of the economy (87).

In response to this, the Constitution of 2008 was passed, which expanded the right to health originally enshrined in the 1998 Constitution from the welfare of body and the mind to a more expansive definition, which included other areas related to public policy like access to public services (water, sanitation, and electricity), education, work, healthy environment, and other services that improve population health (88). This reform, coupled with the Social Development Agenda and the Millenium Development Goals, contributed to the construction of the Model of Comprehensive Family, Community, and Intercultural Health Care, that seeks to guarantee the right to health and social protection for the entire population.

Indigenous people in Ecuador represent at least 14 distinct groups, with each group representing a unique combination of cultural practices and behaviors that mediate health outcomes. Successful interventions supporting food security in these populations will allow for individual tailoring to each group's specific culture and needs, including dietary restrictions and practices and foods used in cultural or religious rituals. Indigenous and minority populations constitute a significant percentage of the population of Ecuador, with 14 distinct indigenous nationalities (including Quichua, Shuar, Chachi, Achuar, Awa, Tsáchila, Epera, Shiwiar, Cofán, Siona, Secoya, Sápara, Andoa and Waorani) representing 7.7%, Afro-Ecuadorians representing 4.8%, and mestizo people (Montubios) representing 7.7%. While these numbers are based on the most recent census, the Confederation of Indigenous of Nationalities of Ecuador reports that the true population of indigenous peoples represents 25% to 30% of the total population.

Indigenous and Afro-descendent populations experience high rates of racism and discrimination, which contribute to social inequality (89). In Ecuador, indigenous and Afro-descendent groups have historically experienced exclusion, social marginalization, and poverty (90). Comparatively, Ecuador is one of the Latin American countries with the most significant disparities in sexual and reproductive health between ethnic groups. Ecuador has among the lowest coverage in modern contraceptive use, antenatal care, and skilled birth attendant use (91). Furthermore, indigenous populations in Ecuador have poorer use of and access to any health services, irrespective of economic status (50).

In addition to limited access to health services, indigenous populations face legal discrimination, particularly through economic development in regions of the Amazon that are home to indigenous populations (85). For instance, in March 2024, 70 environmental campaigners, including indigenous leaders from Las Pampas and Palo Quemado, were charged with terrorism after demonstrating against several mining projects to take place on their ancestral lands. The Ecuadorian government has also continued resource extraction in the face of indigenous opposition, including after invalidating a community referendum during which 92% of people voted against an extraction project in the Andean highlands of southern Ecuador in October 2011.

One of the most important political features of Ecuador was the founding of the Confederation of Indigenous Nationalities of Ecuador (CONAIE) in 1986 (85). Critical to pan-indigenous mobilization, CONAIE has demanded land restitution for indigenous communities and advocated a future based on territorial autonomy. Its thirteen-point plan, passed in 2015, advocates for the protection and defense of indigenous lands, prior consultation on the use of water resources, rejection of the criminalization of protest, and rejection of the continued extraction of natural resources.

Geographic Context

Ecuador is a geographically diverse country with three primary zones: the coastal region in the West, the mountainous region in the center, and the Amazon region in the East. Ecuador is connected to international trade and shipping through its ports on the Pacific Ocean as well as its cross-border trade with Colombia to the north and Peru to the east and south. The Andes mountain range serves as a natural barrier between the east and west of the country. The Amazon region, while isolated from the country's major cities and coasts, has extensive connections with other communities in Peru and Ecuador due to the distributed network of rivers between the countries. While indigenous populations live throughout the country, they are particularly identified as living in the Andean and Amazonian regions. Afro-Ecuadorians primarily live in the coastal region of Ecuador.

The 2008 Constitution includes the concept of sumak kawsay ('good living'), which recognized the right of supporting the flourishing of ecosystems. The passage of this Constitution made Ecuador the first country in the world to recognize the right of nature to exist and persist, and there is significant tension between this clause and the permitting actions of the Ecuadorian government. Furthermore, this concept is based on the beliefs and traditions of indigenous communities in Ecuador, and emphasizes the importance of intercultural dialogue.

Key threats to environmental health in Ecuador include deforestation in the Amazon region, river fragmentation due to excessive hydroelectric power development, access to freshwater and pesticide-driven water pollution, and high rates of illegal international fishing and overexploitation of small fisheries (92). Importantly, for its size, Ecuador has the highest annual deforestation rate of all countries in the Western Hemisphere (93). This is particularly significant as Ecuador is home to a high percentage of the world's biodiversity, and mining and forestry operations in regions of the Amazon destroy natural resources and unique habitats at a dangerous rate.

Economic and Geopolitical Context

Long-viewed as a beacon of stability in South America, Ecuador has recently seen several significant political issues, including the impeachment of former president Guillermo Lasso in November 2023 (94). After his impeachment, the current president, Daniel Noboa, was elected and became the youngest person to assume the presidency in Ecuadorian history. Since his election, his agenda has focused on economic recovery, boosting employment, and strengthening public security. Notably, he has done work to improve access to healthcare by increasing investment in medical infrastructure and made efforts to address the concerns of indigenous communities by promoting dialogue and supporting policies that protect their rights and territories.

Key industries in Ecuador include petroleum, food processing, textiles, wood products, and chemicals (95). Of food exports, the most important agricultural products are sugarcane, bananas, oil palm fruit, milk, maize, rice, plantains, chicken, cocoa beans, and pineapples. The real GDP of Ecuador is $260.213 billion, with 59.7% originating from services, 26.9% from industry, and 7.7% from agriculture. The Ecuador Central

Bank reported that the GDP grew 1.5% in 2023 and 0.8% in 2024. Primary export partners include the United States (24%), China (18%), Panama (14%), Europe (13%), and Chile (3%). Primary import partners include the United States (27%), China (21%), Europe (10%), Colombia (7%), and Brazil (4%) (96). Foreign direct investment (FDI) remains low in Ecuador, and well-underperforms other countries in the region. In 2023, FDI was only $372.3 million, a 58% decrease from 2022 levels, and 43% lower than 2021 levels (97). Ecuadorian FDI as a percentage of GDP has been just above or just below 1% for the past decade.

Particularly challenging to the economic status of Ecuador is the ongoing political instability. Divided government under the former administration hindered efforts to pass Lasso's investment and other economic reforms (97). The violent protests in June 2022 that led to Lasso's impeachment also cost over $1 billion to the economy. In order to end protests, Lasso made several important concessions that complicated future investments in natural resources, including a 12-month moratorium on new oil and mining concessions. In April 2024, the current Noboa administration passed all five of its urgent economic reforms and announced a new program with the International Monetary Fund. The impacts of these reforms are limited by widespread corruption and structural obstacles, including inefficient bureaucracy and ingrained protectionist policies.

Supplementary Figures

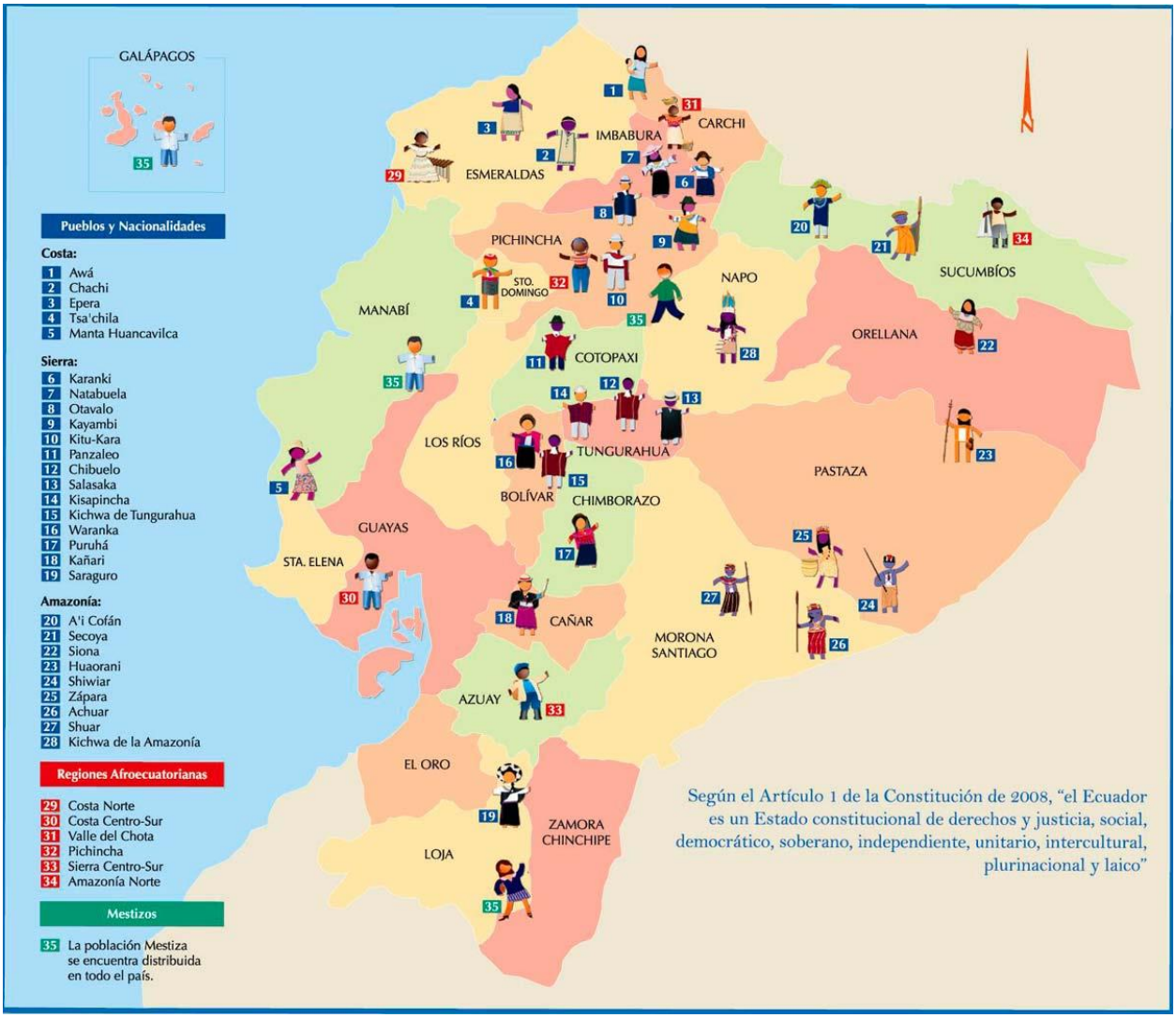

Figure 1. Map of Distribution of Principal Indigenous Groups in Ecuador. (98)

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