Land Use Planning and Risk Management in Andean Perú

Anna Connor, Reed Herter, Robert Hoal,
Chloe Long & Charlie Tebbutt

March 2023

UNFCCC

CORNELL UNIVERSITY FOUNDED A.D. 1865

About the Authors

Anna Connor is a second-year graduate student in the Department of City and Regional Planning at Cornell University's School of Architecture, Art, and Planning. She is working on a Master's in Regional Planning, concentrating in International Studies.

Reed Herter is a second-year law student at Cornell Law School. They are looking into public defense work and environmental law, and are currently establishing a chapter of the Clean Law Pledge at Cornell University.

Robert Hoal is a fourth-year undergraduate student in the Charles H. Dyson School of Applied Economics and Management at Cornell University. He is pursuing a Bachelor of Science in Applied Economics and Management, concentrating in environmental, energy, and resource economics.

Chloe Long is a graduate of Cornell University's College of Agriculture and Life Sciences. She holds a Bachelor of Science in Environment and Sustainability with a concentration in sustainable urban development, and will be pursuing a Master of Regional Planning at Cornell University.

Charlie Tebbutt is a Ph.D. student in the Department of Natural Resources and the Environment at Cornell University. He employs participatory methodologies in collaboration with diverse communities to strengthen the holistic management of social-ecological systems in Latin America.

Acknowledgments

We are grateful to all of the participants who offered their time and expertise over the completion of this report. We extend particular thanks to Dr. Allison Chatrchyan of Cornell University's College of Agriculture and Life Sciences, who provided valuable feedback, and Dr. Carlos Carrillo of Cornell University's College of Engineering, who acted as our technical partner. We would also like to thank Tina Christmann and Isaías Cjuno Turpo for facilitating outreach to other interviewees. Our thanks also extend to the staff of the Nairobi Work Programme for their advice and input throughout the process.

Cover photo by Tina Christmann

Table of Contents

Executive Summary

Successful adaptation to climate vulnerability requires the closure of knowledge gaps regarding national and regional capacities to coordinate territorial development and mitigate risk. The Lima Adaptation Knowledge Initiative – a joint action pledge under the Nairobi Work Programme between the UNFCCC Secretariat and the UN Environment's Global Adaptation Network (GAN) – has identified land use planning and risk management in Perú as a priority knowledge gap threatening the state's adaptive capacity.

In the Peruvian Highlands, climate impacts such as drought, landslides, fires, and rising temperatures threaten the livelihoods of local communities. Decentralized land use planning aims to accommodate differential climatic subzones and region-specific land use practices. Nonetheless, high variability across geographies complicates comprehensive planning and risk management, requiring extensive coordination between multi-scalar actors to address climate vulnerabilities and the barriers inhibiting local adaptive capacity.

This study performed an extensive literature review and interviewed experts and community stakeholders to inform the land use planning issues identified within the following report. The results were categorized into four main themes: Planning, Technology, Knowledge, and Communication. Barriers to effective land use planning arise from short- and long-term planning mismatches, governmental power shifts, and incomplete risk identification. Our results indicated that greater participation from individuals on the ground, the integration of local risk information into overarching land use plans, and the strengthening of capacity-building systems would assist in implementing effective land use planning policy. Key technological issues include the limitations of current environmental data sources and storage systems, as well as the need for more integrated climate solutions that incorporate multiple regions and address multidisciplinary institutional goals. Knowledge exchange through special interest councils, community forums, and dialogues in indigenous languages can integrate important ancestral knowledge into adaptation plans. The communication of climate-related information through scaled-up environmental education will allow for a greater degree of awareness and inclusion of climate resilience within development outcomes. Our conclusions guided the creation of relevant recommendations, as well as an Assessment Checklist for Climate-Resilient Land Use and Territorial Planning aimed at identifying potential planning gaps and proposing steps to address them.

Background and Key Issues

The Lima Adaptation Knowledge Initiative (LAKI) has identified land use planning and risk management in the Peruvian Andes as a crucial climate change adaptation knowledge gap in the Andean subregion. LAKI is a joint action pledge under the Nairobi Work Programme between the UNFCCC Secretariat and UN Environment's Global Adaptation Network (GAN) to close priority climate change adaptation knowledge gaps in subregions around the world. Enhancing adaptation action in the Peruvian Andes is part of the implementation of LAKI within the Andean subregion.

The knowledge gap around land use planning and risk management encompasses the need for mechanisms that include adaptation in current planning tools and methods. This report, therefore, identifies strengths and opportunities within Perú's Andean current land use planning systems to reduce climate vulnerability, defined here as "the propensity or predisposition to be adversely affected [by climate change] including sensitivity or susceptibility to harm and lack of capacity to cope and adapt" (IPCC, 2022, p. 5). Risk is defined as "the potential for adverse consequences for human or ecological systems, recognizing the diversity of values and objectives associated with such systems" (IPCC, 2022, p. 5).

Information was gathered through a literature review and expert interviews to assess the current state of territorial and land use planning in response to climate vulnerability in the Peruvian Andes. We then used our findings to provide expert-based recommendations for future planning efforts in the region. These include aligning planning durations with climatic timescales, financing high-quality data systems, incorporating ancestral knowledge, and promoting accessible environmental training. We supplement these recommendations with an Assessment Checklist for Climate-Resilient Land Use and Territorial Planning [Appendix C] to assist local and regional governments in sustaining climate-resilient land use planning.

The Peruvian Andes

The Andean region of Perú comprises three (northern, central, and southern) mountain ranges (*cordilleras*) that traverse the length of the country. Distinct ecological zones extend vertically across the "highlands," which include intermontane valleys, *puna* grasslands, the Altiplano plateau, and glaciers situated among the highest peaks (Velásquez & Stewart, 2022). Due to the abundance of water resources from glacial melt in the high altitude (*sierra*) mountains, the highlands support greater human populations than the Pacific coastal (*costa*) region to the west and the Amazonian Forest (*selva*) region to the east (Schoolmeester et al., 2018).

The diversity of climatic zones affects their corresponding potential land uses. This has incentivized highland peoples to develop region-specific socioeconomic strategies corresponding to each environment, such as agrarian activity in the Peruvian Highlands. According to Navarro-Castañeda et al. (2021), the highlands region contains more than half of the country's total

agrarian land, which is occupied by small farming plots. In 2019, 27.4% of Perú's entire population was engaged in agriculture and raising livestock, and many highland communities rely on agriculture and mining for their livelihood (Bergmann et al., 2021; Velásquez & Stewart, 2022; World Bank, 2022). These diverse geographical and sociocultural conditions contribute to complicated land use planning politics in the Andes, as different economic and political actors have competing legal claims to occupying the land (Navarro-Castañeda et al., 2021).

Climate Change

Despite marked climatic differences, Perú's *costa*, *sierra*, and *selva zones* are all experiencing impacts from climate change. Temperatures have risen across Perú, with the southern Andes observing the highest increases of up to 0.3°C per decade since 1981 (Bergmann et al., 2021, p. 117). Depending on low or high emissions scenarios, temperatures are expected to continue increasing throughout the Peruvian Andes by an additional 0.75-2°C by mid-century. Glaciers in the Andes Mountains, which account for 71% of the world's tropical glaciers and serve as a primary freshwater source for Perú, are melting as a result of the rising temperatures. This trend is expected to escalate, putting further stress on water supplies (OECD, 2020; Bergmann et al., 2021; Vuille et al., 2008). Week-long instances of cold spells (*friajes*) that lower minimum air temperatures from 22°C to 11°C now occur six to ten times a year, entering Perú through the Titicaca plateau to produce storms and sharp temperature drops (Bergmann et al., 2021). These cold waves (*heladas*) affect the Peruvian highlands, killing the crops that are adapted to the regions and threatening food security and livelihoods. Rainfall trends are becoming less predictable. Although models show a general tendency towards higher-intensity rainfall events, overall rainfall will be more infrequent than in previous decades (Bergmann et al., 2021). The south-eastern Andes and Titicaca Basin are expected to share this increase in extreme rainfall alongside longer stretches of dry spells, potentially exacerbating drought (Vera et al., 2006; Vuille et al., 2008).

In 2021, approximately half of Perú's physical territory was exposed to recurring hazards, with millions of people at risk from floods, droughts, and low temperatures (Bergmann et al., 2021). Extreme weather events in 2017, partly due to the El Niño phenomenon, affected 1.7 million people and placed Perú among the top 10 countries most affected by natural disasters (OECD, 2020). Droughts, already frequent in southern Perú, have become more intense, reducing food security while increasing the demand for irrigation and groundwater withdrawals (Bergmann et al., 2021). Excluding

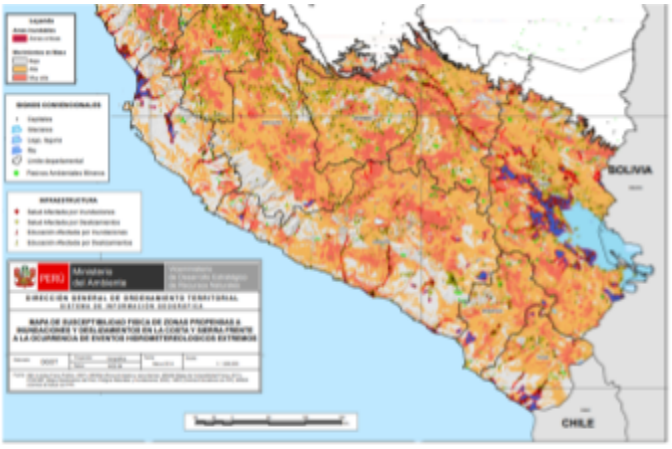


Figure 1. Map of the vulnerability of the Peruvian regions to landslides, flooding, and extreme hydrometeorological events. Full version available in Appendix D.
Source. MINAM, 2014

deserts, Perú had ten instances of drought between 1981-2018, with the Altiplano region (above 3,500 meters) experiencing some of the most severe cases (Bergmann et al., 2021). Flooding has also been more frequent in recent decades and is predicted to increase with more extreme rainfall in the future (Bergmann et al., 2021). Figure 1 shows a composite risk map of flooding, landslide, and extreme hydrometeorological events in the Southern Andean region of Perú. Climate change also drives migration; individuals are moving within and between regions to escape the worst impacts, furthering the need for comprehensive and sustainable land use planning and development (Bergmann et al., 2021).

Deforestation remains a pressing climate-related issue in Perú, with the Land Use, Land Use Change, and Forestry (LULUCF) sector representing the largest source of greenhouse gas emissions nationwide (Climate Action Tracker, 2022; USAID, 2012). Although Perú committed to zero deforestation by 2021, challenges persist. Deforestation escalated by 58% between 2009-2016, and in 2021, National Forest Programme "reported the highest deforestation rate in the last two decades" (Climate Action Tracker, 2022; Vázquez-Rowe et al., 2018). Deforestation reduces Perú's ability to mitigate carbon emissions, while increasing biodiversity loss and the risks from natural hazards such as landslides (Bergmann et al., 2021; Torres Mallma, 2021).

The Strategic Plan for National Development to 2050 (PEDN 2050) acknowledges that climate change threatens the country's terrestrial and marine ecosystems and biodiversity, increasing the risk of extreme temperatures, glacial melting, erosion, floods, and the transmission of zoonotic diseases (Government of Perú, 2022a). Perú's updated Nationally Determined Contribution (NDC) includes 84 adaptation measures to confront these risks, focusing on the priority areas of water, fishing and aquaculture, agriculture, health, and forests (Government of Perú, 2020). Although these adaptation measures require the design and implementation of strong land use planning at the national, regional, and local levels, the lack of existing capacity and conflicting development agendas restricts climate-resilient land use planning (Government of Perú, 2022a, p. 107).

Peruvian Planning

Peruvian planning is characterized by a focus on regulation and zoning "framed under a static, legalistic, and procedural view" that limits flexibility while attempting to balance the tension between local and national aims (Fernández-Maldonado, 2019, p. 374). Perú's political-administrative organization is arranged within a hierarchy consisting of four levels: the state at the top, followed by the regional governments, provincial municipalities, and district municipalities (Torres Mallma, 2021). These levels of government work within a planning framework comprised of three planning processes: (1) strategic planning (*planeamiento estratégico*), (2) environmental planning *(ordenamiento territorial*), and (3) territorial planning (*acondicionamiento territorial*) (Fernández-Maldonado, 2019). The first two processes are addressed at all scales while territorial planning is reserved for municipalities.

National planning strategies are put forth in the National Development Plans (PEDN) created by the National Center for Strategic Planning (CEPLAN), such as PEDN 2050 (Government of Perú, 2022). Environmental planning is incorporated and primarily overseen at the national level by the Ministry of Environment (MINAM) (Torres Mallma, 2021). To aid in planning efforts, the Peruvian Government has a suite of Geographic Information System (GIS) tools available to the public, allowing planners to access and overlay data on risk and vulnerability with geographic and demographic information such as urban areas, infrastructure, and poverty. These include the National Platform of Georeferenced Data for Perú (Geo Perú), the Risk and Disaster Management Information System (SIGRID), and the Territorial Information Platform for strategic planning (provided by CEPLAN).

Recent decades have seen a shift towards decentralization, with individual regions bearing more responsibility for writing and implementing plans. Regional governments must draft Concerted Regional Development Plans (PDRC) that span an eight-year horizon and align with the National Development Plan (PEDN) and Sectoral Strategic Plans (PESEMs) created by the various state Ministries. In order to meet the requirements for territorial planning under the Law of Municipalities, municipal governments must create local development plans (*planes de desarrollo local*) and Territorial Conditioning Plans (*planes de acondicionamiento territorial,* PAT). The former guides the "investment, allocation, and execution of municipal resources" to develop the local economy, while the latter integrates the "physical planning of urban and rural areas, river basins, and coastal spaces of the province" through a more spatial component (Fernàndez-Maldonado, 2019, p. 376-377). Together, these plans form the basis of the Concerted Development Plan (PDC) which is the strategic plan for the municipality.

Territorial Arrangement Plans (POT) and Ecological & Economic Zoning (ZEE) work in concert with the aforementioned documents and serve as key environmental planning mechanisms for local governments (Fernández-Maldonado, 2019). Although territorial plans are expected to coordinate with those of neighboring regions, there is a lack of clarification on how precisely to accomplish this task (Fernàndez-Maldonado, 2019). Limited communication across the different provinces and larger policy-making bodies result in slower and less effective policies; furthermore, local goals may not always align with national goals (Dupuits, 2021). Weak state planning and management, combined with a lack of capacity to create and implement a variety of mandated plans, has contributed to low levels of local compliance, particularly regarding climate vulnerability. Torres Mallma (2021) notes that of 196 provinces studied, 23 (11.7%) had a Territorial Conditioning Plan (PAT); of the 1874 districts, only 233 (12.4%) had an Urban Development Plan (PDU).

Many of the plans are enforced through zoning, which is one of the primary tools for land use management in Perú. Zoning plans may often be found even in localities that lack all of the other mandated development plans (Fernández-Maldonado, 2019; Torres Mallma, 2021). Zoning maps enable governments to classify land according to its use and occupation, providing a clear overview of how to divide the territory in terms of development and map out the primary

locations of urban activities. The inclusion of ecological risk on zoning maps can also enable governments to steer development away from fragile ecosystems, concentrating resources in more environmentally appropriate areas (Torres Mallma, 2021). Even when risks are included in the maps, a lack of continuity between successive risk plans may lead to the rezoning of ecologically vulnerable areas for intensive use. One example is the Lurigancho-Chosica district on the periphery of Lima, where newly-created zoning maps counteracted the previous identification of high-risk areas and changed their permitted use to residential and commercial construction (Torres Mallma, 2021). In addition, the national government has the power to override the land use designations created by regional governments, which has created tensions such as the 2011 political crisis surrounding the Conga mine in Cajamarca (Gustafsson, 2017; Perú Const. art. 66/67, 2021). Because the state owns the rights to mineral resources, it has the determining power over the ownership and use of these resources, regardless of private land ownership ((though in some cases this power can be curtailed by social and judicial powers)DL No. 109 Ley General de Minería, 1992; Perú Const. art. 67, 2021).

Disaster risk management (DRM) is also an important part of land use planning, especially in the face of increasing natural hazards (Bergmann et al., 2021). The Framework Law on Climate Change, adopted in 2018, "[makes] it mandatory for all levels of government to incorporate climate change into development planning," encouraging a thoughtful approach to planning for risks that result from natural hazards and climate change (OECD, 2020, p. 123). The National Disaster Risk Management System (SINARGERD) coordinates DRM at the national, regional, and local levels, and requires regional and local governments to create DRM plans (OECD, 2020). The localization of adaptation – often embodied in DRM plans and zoning – provides flexibility for regions to focus on specific hazards threatening their areas, but can lead to difficulties in complying with national plans (Dupuits, 2021).

PEDN 2050 outlines key issues with Perú's effective management of risk and disaster, such as creating land use plans without due consideration of risk and weak governance on managing risks (Figure 2, Government of Perú, 2022). The plan also notes that this combination of factors leaves 87% of Perú's municipalities without up-to-date territorial management plans (Government of Perú, 2022). Although 72% of Peruvian municipalities had established Working Groups on Disaster Risk Management by 2016, only 70 of the responding 735 municipalities had created Disaster Risk Prevention and Reduction Plans (OECD, 2020). The following sections of the report offer recommendations to enhance land use planning for climate vulnerability drawn from interviews with a range of relevant experts.

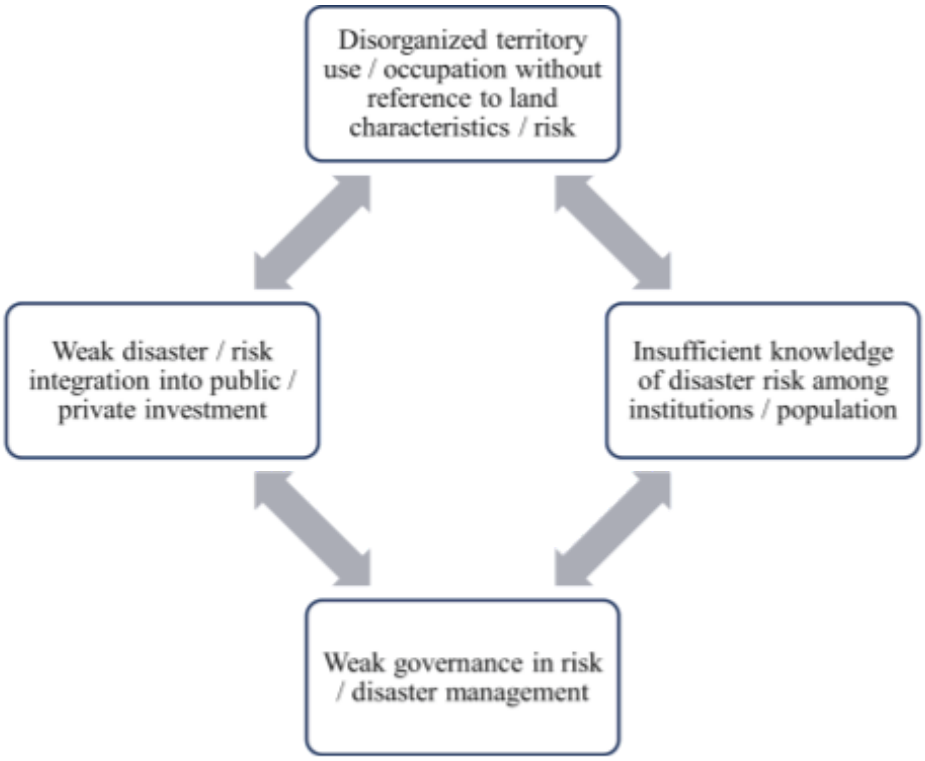


Figure 2. Summary of the challenges facing Peruvian risk and disaster management.
Source. Government of Perú, 2022; adapted and translated by authors.

Methods

Region of Focus

Following an extensive literature review of climate issues affecting the Peruvian Andes, we interviewed stakeholders with expertise in climate adaptation and planning, primarily within the Southern Highland regions of Cusco, Junín, Apurímac, and Puno. Ranging from the eastern edge of the Andes bordering the rainforest and the Lake Titicaca Basin, the Southern Highlands' political boundaries roughly overlay the zone between the Cordillera Oriental and the Cordillera Central between 11° and 17° South (Figure 3). These areas represent a nexus of Andean ecosystems and associated climatic challenges. They are united by a shared vulnerability to cold spells, water scarcity, and fluctuating rainfall patterns, all of which are contributing factors to climate risk and associated migration (Bergmann et al., 2021).

Figure 3. Selected territories in the Peruvian Andes.
Source. Wikimedia Commons, 2009; edited by authors.

Interview Process

We conducted key informant interviews in English and Spanish with expert stakeholders, decision-makers, and researchers. The interviews followed a six-question semi-structured interview guide, which was collectively designed by the co-author team based on findings from the literature review and cross-checked with the project's technical partner [Appendix A].

Selection of Participants

Interviewees were selected based on their professional roles in the Peruvian environmental and planning sectors. These include representatives from international IGOs, national institutions, and relevant NGOs [Table 1]. Interviews were sourced by snowball sampling from initial institutional contacts and their relevant networks (Atkinson & Flint, 2001).

Table 1. List of interviewees and their affiliation

Name	Organization	Title
Jorge Alvarez	United Nations Development Sustainability Program	UN Official
Carlos Carrillo	Cornell University	Research Scientist
Juan de Dios	Asociación Arariwa	NGO Representative
Mirella Gallardo	Instituto de Montaña (IM)	NGO Co-Director
Cristina López	Derechos, Ambiente y Recursos Naturales (DAR)	Regional NGO Coordinator
Sydney Moss	Periferia	NGO Co-Founder
Roger Quispe	Mamani Federación de Campesinos	Campesino Representative
Isaías Cjuno Turpo	Universidad Nacional de San Antonio Abad del Cusco (UNSAAC)	Conservation Biologist
Edwin Mansilla Ucañani	Consejo Regional de Cambio Climático (CORECC) de la Región Cusco	Technical Secretary

Interview Results, Conclusions & Recommendations

Interview Results

Our team conducted nine key informant interviews to validate and enhance the information gathered during the literature review. The results are analyzed here and incorporated into a Strength, Weakness, Opportunity, and Threat (SWOT) analysis (Figure 4), which informs the recommendations, conclusions, and Assessment Checklist [Appendix C]. The interview analysis and subsequent recommendations were divided into four key categories of Planning, Technology, Knowledge, and Communication outlined in the Conclusions and Recommendations below.

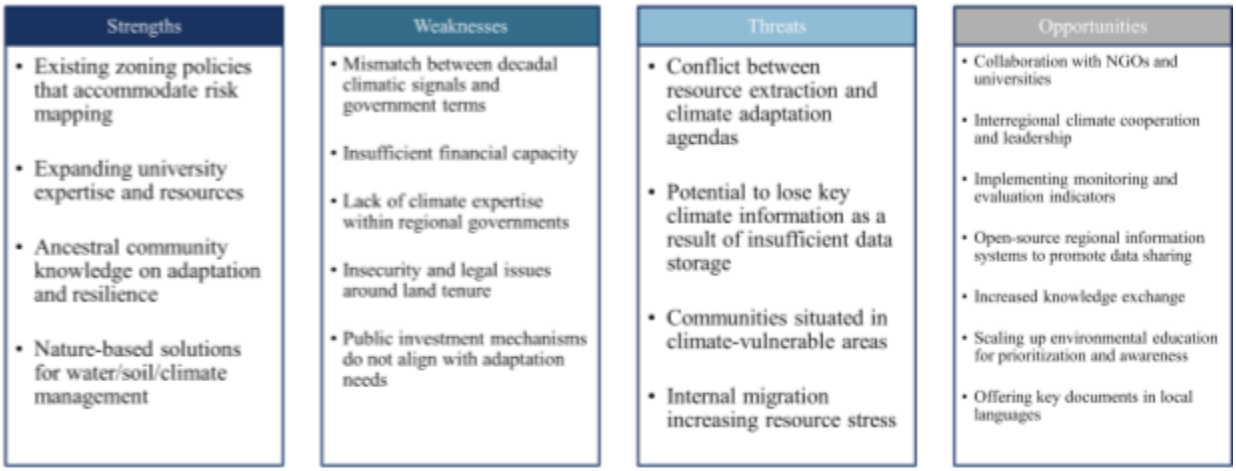


Figure 4. SWOT report generated from the interviews.

Conclusions & Recommendations

Planning Conclusions

Long vs Short Planning Horizons

Interviewees highlighted that the differences between the decadal climate variability resulting from the El Niño and La Niña cycles are not fully captured in current planning due to the misalignment between four-year governmental terms and the ten-year span of plans. The majority of participants expanded upon the literature review's finding that land use planning is limited by a lack of continuity, which they attributed to officials' relatively short political terms. In contrast, climate change and natural hazards occur on longer time scales, necessitating additional foresight when creating plans. Local NGO representatives noted that governments tend to prioritize politically visible actions with demonstrable economic outcomes over implementing climate adaptation policies:

"[A land use plan] is not visible to the community. What they see more are things like infrastructure, et cetera. Because generally, if you are going to do that study for land-use planning or micro zoning […] it's a document, right? It's an instrument, and it works great for the specialists. But the population isn't very aware of it, and the cost is considerable."

- Local NGO Representative

Thus, actions taken by previous regimes may be discontinued by new government officials in favor of more popular policies, halting progress towards climate-resilient land use planning.

Recommendation 1: The integration of climate adaptation plans, zoning policies, and risk scenarios into long-term regional climate strategies to guide development across planning scales. This will aid in the continuity of climate-resilient planning across and within government administrations, and will ensure that land use and territorial planning are responsive to updated risks and changing climate scenarios.

ZEE/Risk Plans

All interviewees emphasized the importance of risk-informed zoning maps and plans for climate-resilient land use planning, as the maps guide development away from ecologically fragile areas and ensure individuals are not living or working in high-risk zones. However, implementation issues persist throughout the Andean highlands, notably in terms of capacity. Despite the mandates to create ZEEs, some regions have yet to finish developing them as they lack the funds and staff to create and/or validate the plans. Therefore, implemented projects do not always fully consider the climate risks an area is facing, potentially worsening climate change effects in the future. In addition, risk maps are more common in urban areas than rural ones, though these are not always disseminated:

"Urban populations continue growing […] and many times they are in very vulnerable areas. Perhaps there are laws, policies, municipal bylaws restricting certain activities […] but there is no effective regulation, there is no supervision, perhaps due to lack of awareness, due to not informing people."

- Conservation Biologist

Interviewees described how existing local and regional zoning designations are often disregarded either by small-scale illegal mining or the state's prerogative to extract natural resources. Although mining and timber harvesting have economic benefits, they also significantly contribute to environmental degradation. Multiple interviewees stressed the detrimental impacts on water, a resource that is already at risk due to rising regional temperatures. Therefore, following their initial creation, "*The risk maps have to be used, [...] they have to be updated because the risks keep changing according to the conditions*."

Recommendation 2: Recognizing the complexities of resource mobilization and capacity-building, local and regional budgets should include funds for the renewal and implementation of risk maps. Actively sharing risk maps with communities for action and feedback also offers a low-cost way for governments to "ground truth" them, facilitating knowledge sharing between these groups. This would ensure risk zoning maps are accurate as well as help alleviate capacity issues by widening the pool of experts contributing to map creation.

Multi-Actor Coordination

Perú's decentralized planning system presents both an opportunity for governments and communities to collaborate on multiscalar issues and a challenge to ensure that plans align and that relevant actors are meaningfully involved. Climate mitigation and adaptation actions undertaken at the local level should, in turn, inform and enhance higher-scale policies, but this is not always the case due to insufficient funds or competing interests. Seven interviewees noted the limited capacity to create and implement risk mapping and zoning policies. Lack of finance, particularly at local levels, prevents localities from creating strong climate policies; although some localities coordinate with MINAM to access the Green Climate Fund, others lack such resources. Even climate adaptation actions directly aligned with the national NDC can struggle to accrue funding due to strict and siloed budgetary constraints.

At the same time, there is a need for climate experts to assess developments for negative environmental impacts to ensure effective ZEE and the accuracy of risk maps. An NGO representative stressed the need to "*channel more economic and technical resources [...] to be able to plan, to monitor, to be able to implement economic initiatives that allow [communities] to adapt to all these climate-level changes*." NGOs and universities can provide human resources to bridge capacity gaps; they can share expertise and data with governments, coordinate mapping activities, and facilitate adaptation workshops. An interviewee offered a successful example of

how the National State-Protected Natural Area Service (SERNANP) has collaborated with local volunteers and the NGO Asociación Ecosistemas Altoandinos to improve forest fire preparedness and training in Apurímac's Abancay Province (Government of Perú, 2022b).

Recommendation 3: National and local budgets and development plans should explicitly coordinate funding categories with Perú's NDC, supported by a comprehensive database of any potential funding sources. Local governments can apply with the assistance of NGOs and universities, who can share technical expertise and human resources to bridge the planning implementation-capacity divide.

Technology Conclusions

Data Systems

While the data available through platforms such as the National Meteorology and Hydrology Service of Perú (SENAMHI) was seen as vital for incorporating climate and risk information into land use and development plans, multiple interviewees outlined ongoing challenges to keeping the data current and accessible. The maintenance and accessibility of regularly updated climate information are limited by the costs associated with retaining staff at meteorological stations, as well as insufficient data servers. This issue is further compounded by the need for higher-resolution satellite imagery that can adequately capture geographical data across the steep altitudinal gradients of the Peruvian Andes. Current planning budgets lack the resources to facilitate the supplementation of these data with the in-depth ancestral knowledge of local communities.

Recommendation 4: Increased financial support for longer-term, high-quality data capture and storage systems is a key priority for effective territorial and land use planning. This includes the full-time employment of experts in regional climate adaptation and the social science techniques necessary for incorporating local community knowledge. Recommendation 3 outlines mechanisms for mobilizing the relevant funding.

Integrated Climate Solutions

Interviewees with experience implementing on-the-ground initiatives through NGOs and local organizations emphasized the need for integrated solutions to address the planning aims of multiple Ministries, such as Agriculture, Environment, and Health. One interviewee advocated enlarging the managerial scope from regions to:

"macroregions, which permit land management with more of a territorial, ecosystem focus, than a political distribution [...] For example, the issue of water resources: [the Departments] where you harvest and conserve the water are not the departments that consume the water."

- IGO Representative

Cooperating at a macroregional scale could help to avoid historic pitfalls such as the establishment of water-intensive eucalyptus near headwaters, for instance by taking into account the effects on downstream users within a watershed. Previous efforts to install new climate-adaptive infrastructure, such as irrigation canals, have had to overcome and adapt legal barriers to larger-scale public projects on private land. As post-pandemic and climate migration renew the demand for rural water sources, Community Irrigation Committees can be trained to utilize alpine lakes and pre-Incan irrigation networks to reduce pressure on the hydrological system.

These technological aspects require the training and long-term employment of experts in areas such as data management, nature-based solutions, and capacity-building that empower local campesino leadership to access, interpret, and act upon the information. Current potential funding sources include Perú's Mecanismos de Retribución por Servicios Ecosistémicos (MERESE). This Payment for Ecosystem Services (PES) initiative requires downstream resource users to pay for the maintenance of the watersheds that they benefit from, thereby creating funding streams for integrated climate solutions.

Recommendation 5: Integrated planning across Ministries and regions can create enabling environments for projects to address multiple aspects of climate mitigation and adaptation. Macroregional or ecosystem-level cooperation, for example through well-planned forestry projects organized at the watershed level, can bring economic, climate, and health co-benefits to neighboring regions at a reduced cost due to cross-sectoral synergies through land use planning and policy. Such initiatives may be supported by adapting relevant legal and constitutional limitations to allow for landscape-scale integrated climate action by the government. Funding can be sourced from the PES programs already being piloted across the country.

Knowledge Conclusions

Regional Information Sharing

The interviews revealed that regional information is often inaccessible, with large data gaps and an existing lack of monitoring and evaluation indicators for tracking climate adaptation progress. While nationwide systems exist through MINAM and SENAMHI, such as the National System of Environmental Information (SINIA), regional equivalents known as Regional Systems of Environmental Information (SIAR) are sparse and insufficient, creating difficulties for intraregional data compilation and limiting vital cooperation with research universities. Regional governments often lack the resources to maintain these systems; as a result, Cusco is exploring the use of open-source platforms for data communication with residents, which require significantly less capacity. In addition, NGOs such as Derechos, Ambiente y Recursos Naturales (DAR) already provide key environmental data, sometimes in direct partnership with governments carrying out regional development plans (GoreLoreto, 2015; Rojas, 2021).

However, without maintaining these collaborations to review and update these data and plans, this information can quickly become outdated.

Recommendation 6: Improved or newly established information systems should be regularly updated to include accurate and effective data. These should preferably take the form of an open-source platform to create ease in data sharing and reduce required resources. Where possible, the rich academic knowledge available through local universities and NGOs should be actively incorporated into these platforms, which can help ensure the longevity and relevance of information systems.

Participative Knowledge Exchange

Insufficient incorporation of diverse sectoral perspectives into higher-level climate adaptation planning remains a key knowledge gap. Multiple interviewees agreed that participative processes are necessary to incorporate valuable community, indigenous, and gender-specific perspectives, whose key insights for climate adaptation are often sidelined in issues such as mining. One interviewee noted, "*We would find the [adaptation] experts in the field in rural areas […] who knew how to live at 4,000 m with few resources and facing extreme weather conditions.*"

Many autonomous communities coordinate and disseminate field-specific knowledge through special interest councils focused on watersheds and climate change. However, communities often face challenges in realizing these aspects within municipal plan development and implementation:

"The [indigenous people] are currently the ones who possess the ancestral knowledge; what we're missing is reaching them and being able to explore that relationship between modern scientific knowledge and the current [ancestral] knowledge and exploring that vital alliance to move forward"

- Government Representative

Current barriers to the incorporation of ancestral knowledge include connectivity issues with rural indigenous populations and local groups' limited capacity to construct local plans. The publication of planning and educational documents in local languages such as Quechua, can both increase climate awareness and involve diverse local communities and their leaders in important planning conversations. One interviewee highlighted the "*need to start speaking their language,*" referring both to understanding the communities' traditional knowledge and engaging with local indigenous languages.

Recommendation 7: Local governments should facilitate broader stakeholder engagement in creating territorial land use plans. An emphasis should be placed on gathering information for policy creators from NGOs and local sources such as special interest councils,

community and indigenous leaders, and youth representatives (Fraser, 2017). Methods to resolve current knowledge gaps include allocating budgetary funds for consulting local communities and collaborating with NGOs to construct plans that merge local and indigenous knowledge with climate change and planning expertise. Equipping local leaders with the knowledge to represent and meaningfully engage communities with the land use planning process should be prioritized alongside governmental information acquisition.

Communication Conclusions

Environmental Awareness & Education

Prioritization and awareness of climate issues among citizens and regional government officials remain two of the largest communication gaps for climate-resilient planning. Although the Peruvian government increasingly works with new regional governments to train them in climate-resilient planning, NGOs continue to lead much of the public education efforts. Many municipalities lack environmental management staff, resulting in a diminished capacity to prioritize environmental issues. A regional advisor for climate change noted there is still much misinformation regarding climate change, leading to misunderstandings of the topic. However, as one interviewee noted about the state of climate education, "*While many did not have the technical knowledge of what it meant, they had experienced climate change […] [including] less water, more heat, changing seasons, and more pests in the crops*."

Recommendation 8: Environmental education and the dissemination of climate change resources to local populations are crucial to better inform planning outcomes. In addition, local governments should supply translations of key documents in local languages that are accessible to communities to facilitate effective participation. Increasing the number of environmentally-focused workshops, education programs, and research centers, such as is happening in Cusco, can also help to bridge regional awareness gaps. A system to assist local individuals in understanding and enforcing zoning policies should be in place to familiarize them with the laws and connect them with official enforcement means, including possible representation.

Limitations

The research project utilized key informant interviews due to the efficiency with which knowledgeable individuals can provide information for rapid synthesis and the development of recommendations (USAID, 1996). Alongside its many advantages, this approach carries the inherent limitations of potential bias and the difficulty of validating stakeholder perspectives. The team attempted to address these challenges by purposely interviewing a range of informants representing different backgrounds and viewpoints, ranging from IGO and Peruvian government employees to NGO and campesino representatives. A standardized approach to interview analysis was also adopted to minimize individual bias from each researcher; conclusions and recommendations were developed collaboratively and cross-checked for their fidelity to the original meanings expressed by interviewees.

The research team relied extensively on snowball sampling through local networks in order to facilitate remote analysis based on actual stakeholder experiences. This may reduce the representativeness, and therefore the generalizability of the resultant findings (Atkinson & Flint, 2001). We attempted to mitigate this effect by sourcing interviewees from multiple referral chains, rather than relying on a single network of informants. Consideration of the results and recommendations should take into account these methodological limitations, as well as the total number of interviewees and their proportional representation within the sample.

Final Summary

The literature review and expert interviews highlighted opportunities to strengthen Perú's efforts to decentralize land use planning and facilitate informed policymaking on climate adaptation. These are summarized in the conclusions, recommendations, and Appendix B. The Assessment Checklist [Appendix C] provides a framework for planning authorities to assess climate change issues and develop pathways for taking adaptive action, such as through policies or territorial plans.

The greater autonomy allowed by decentralized planning contains promising potential for localized adaptation across heterogeneous landscapes. However, this must be accompanied by sufficient resources and capacity to be effective. The decentralized planning approach needs to follow long-term policy strategies through greater communication between levels of government and citizens. This will be best facilitated through a combination of scientific research and local participation to inform risk identification, as well as the creation of mechanisms to build capacity.

From a technological standpoint, enhanced data acquisition and management systems can combine with integrated climate adaptation approaches to deliver evidence-based solutions to cross-sectoral risks and vulnerabilities. Knowledge gaps can be addressed through updated regional information systems and the incorporation of indigenous and community perspectives into adaptation discussions. Communicating climate risks and solutions through scaling up formal and informal environmental education can bridge gaps in misinformation and mobilize greater climate awareness.

Taking into account the limitations of this study, the recommendations developed from the interviews offer useful insights for enhancing and strengthening climate-sensitive territorial and land use planning in the Peruvian Andes.

Appendix

A: Interview Questions

1. From our research, we understand that current Peruvian planning is decentralized. Plans are made at the national, regional, and municipal levels and are coordinated with each other. Could you tell us more about how this manifests in local planning? Could you tell us about your experiences with these systems?

2. Considering climate change scenarios of increased drought, rainfall, and temperature increases in the southern highlands, what do you think are the key areas adaptation policy and land use planning should target?

3. Our literature review indicates that local and regional governments create development plans for their territory that in turn must align with the national development plan. How autonomous are the decentralized structures in implementing land use plans?

4. Do local authorities have the financial and technological capacity to implement climate-resilient land use planning and zoning?

5. Our research so far indicates that in the Southern highlands of Perú, zoning is a central piece of land use planning. Some studies have shown it can be combined with existing risk maps to help steer development away from vulnerable areas. In your experience, how effective is zoning as a tool for climate-resilient planning?

6. What key considerations should target knowledge users consider when identifying tools for land use and territorial planning?

B: Table listing recommendations for climate-resilient land use planning in Perú

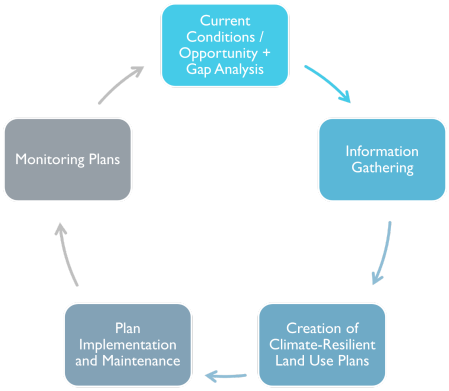
Category	Title	Recommendation	Example
Planning	1. Long vs. Short Planning Horizons	Better inclusion of regionally identified risks within comprehensive plans and greater policy continuity to facilitate long-term effectiveness of policies	Perú's New Urban Agenda utilizes regional data to address water-related risks in urban areas and monitor long-term plan implementation
	2. ZEE / Risk Plans	Increased communication between on-the-ground individuals and governments to identify risks	Sharing risk plans with locals to incorporate their experiences of currently unaddressed environmental risks and impacts
	3. Multi-Actor Coordination	Establish a database where local/regional officials can seek financial assistance and identify potential funding resources for gaps in capacity (e.g., hiring personnel)	Local governments coordinating through the Ministry of Environment to access Green Climate Fund financing
Technology	4. Data Systems	Increased investment in high-quality satellite imagery, long-term data storage systems, and full-time climate experts	Regional governments incorporate robust climate data from regularly updated databases to inform planning initiatives
	5. Integrated Climate Solutions	Inter-institutional implementation of climate adaptation projects with co-benefits across regions and development goals	Coordination between the Ministry of the Environment and local NGOs to plant native water-storing *stipa ichu* grass around headwaters

Knowledge	6. Regional Information Sharing	Create and update regional information systems to promote data sharing between stakeholders (government, NGOs, research institutions)	Open-source information platform for low-cost data communication with residents
	7. Participative Knowledge Exchange	Increase level of community involvement through participatory systems, leveraging NGOs to merge technical expertise and ancestral knowledge	Translating key documents to Quechua to increase local engagement
Communication	8. Environmental Awareness & Education	Scale-up environmental information dissemination to counter misinformation and give citizens the proper tools	Increasing environmentally-focused community workshops to inform planning

C: Assessment Checklist for Climate-Resilient Land Use and Territorial Planning

This document aims to support individual planning authorities in building climate-resilient land use and territorial plans. It is intended to be used as:

1) *An assessment framework of existing plans to ensure they are aligned with climate adaptation goals; or*
2) *A checklist to facilitate the development of climate-aware plans*



Using a five-step process, planning authorities will be able to identify gaps in their existing plans, methods for refining/developing plans, and guidance on implementing and monitoring plans.

Checklist Format

Each step follows the same basic format to allow for clarity and ease of use. A step (e.g. Step 1) begins with a title and explanatory statement to orient the user. Action items (e.g. 1A.), shown as subtitles with a set of probing questions, are given to meet the step's objective. The bulleted questions represent a starting point to understand the intent of each item and examples of potential questions, rather than a comprehensive list (NOAA, 2016). Each step is concluded with a real-world example demonstrating how existing land use plans have incorporated some of these questions to effectively implement climate-resilient land use planning.

Step #. Title
Statement about what the step means.

#[Letter]: Action Item
- *Probing Questions*

***Example** that provides instances of plans that utilize questions from the checklist, with relevant citations for further exploration.*

Step 1. Current Conditions and Opportunity/Gap Analysis

This step acts as a checklist to document pre-existing land use and territorial plans at both the local and regional levels. It also serves to identify opportunities to improve current and future plans so they are more in line with climate-resilient land use goals.

1A. Assess Current Conditions

- What are the existing conditions (i.e., environmental, social, economic) of the target area?
- What climate and hazard-related risks pose significant threats to land use planning and development?
- Where is the current and planned infrastructure located? Is it in or near ecologically-fragile or high-risk areas?
- What are the demographics of the area? Are there any vulnerable communities that require additional attention during the planning process?

1B. Identification of Existing Plans

- What are the existing land use and zoning designations for the target area?
- Which areas are targeted for future development and which are designated for preservation? Do either overlap with ecologically-sensitive sites?
- Which regional initiatives do the plans coordinate with and how well do the goals align?
- Do the existing plans address climate change and/or natural hazards that may lead to heightened risk?

1C. Analyze Gaps and Identify Opportunities

- Which required plans are missing or have not been recently updated? Is there a timeline for updating them in the near future?
- Which risks are not accounted for or have not been checked against community experiences?
- Have the plans been circulated to the community and, if so, has their feedback been incorporated?
- What is the biggest impediment(s) to completing the missing plans and/or linking them to climate adaptation (e.g. funding, personnel, relevant data)?

Example: Cusco's *Plan Base de Ordenamiento Territorial Región Cusco* (2005) defines the vision and objectives for regional development and serves as a primary coordinating document for local governments and organizations. There is a strong emphasis on recognizing the environmental impacts of land use planning and ensuring a cohesive development vision, with forest management zones and conservation areas clearly delineated. The primary risks identified for the region are water scarcity, drought, and frosts, although there is little discussion of climate-related risks or future trends that could complicate land use planning. In addition, the plan notes the difficulties with determining ecological risk within the territory; as a result, there is little planning for environmental risks included in the territorial conditional plan (Departmental Government of Cusco, 2005).

Step 2. Information Gathering

This step constitutes a checklist to understand pre-action circumstances and identify any outstanding knowledge gaps from Step 1. It also includes methods to analyze capacity and identify capacity issues. After acknowledging and minimizing the gaps from 2A-C, 2D-E presents guidance for developing possible next steps.

2A. Map and Assess Risk

- How are climate risks spatially distributed within the region?
- How do these intersect with socioeconomic data?
- What are the short-term and long-term consequences of climate risks?
- How do communities perceive the efficacy of existing climate mitigation/adaptation measures?
- Where can missing data on climate and associated risks be sourced?

2B. Evaluate Existing Knowledge

- How do ancestral and Traditional Ecological Knowledge (TEK) shape current regional

land use?
- What is the local understanding of climate change vulnerability? How does it impact community development?
- Is all existing institutional climate knowledge being utilized in land use planning? What additional sources of institutional climate knowledge are available?

2C. Understand Capacity and Expansion Pathways
- Who are the community leaders and key actors?
- What are the current systems of information dissemination? By whom are they disseminated?
- Where does funding currently come from (i.e. for policy enactment and research)?
- Who is currently spearheading climate action and/or implementing policy?
- Are any groups not represented in the planning process?

2D. Investigate Relationships between Issues
- Does the climate risk in question have the potential to exacerbate another risk or situation?
- How do all aspects of the issue connect (socioeconomic, policy, environmental, etc.)?
- Is there the potential for synergistic solutions?

2E. Create a Record of Research Findings for Data Preservation
- Which issues and resources were identified during the analysis?
- What technology was used to find this information?
- How do these findings apply to land use planning efforts and can they be utilized by other localities?

Example: In Junín, the increasing severity of droughts and floods has necessitated action to manage fluctuations in water supply and reduce water risks. Through local partnerships and assistance from larger organizations, communities are strengthening their adaptive capacity. For example, USAID has partnered with local communities to understand the sources and threats to local water supplies and implement community-based conservation management plans. Citizens learned how to monitor, evaluate, and validate the results of improved climate change practices, ensuring the sustainability of local conservation efforts. Notably, the organization has worked with rural communities to implement water harvesting techniques and other practical, low-cost adaptation measures to secure water resources. This includes natural infrastructure such as conservation, restoration, and sustainable use of ecosystems and indigenous technologies (USAID, 2022).

Step 3. Creation of Climate-Resilient Land Use Plans

This step outlines the questions that planning authorities should consider when drafting new plans, taking into account current conditions/gaps from Step 1 and the new information gathered from Step 2.

3A. Align Plans Across Multiple Scales
- Have national/macroregional/regional strategies been considered in the development of the new plan?

- Does the plan significantly change/contradict previous versions (e.g., high-risk zoning now designated for urban development)? If so, why?
- Do any aspects of the plan impact regions/provinces outside of the jurisdiction (e.g., zoning agricultural land near headwaters that sustain a neighboring populace)?

3B. Engage Multiple Actors

- How will the plan be communicated to stakeholders (via workshops, the Internet, etc.)?
- Do communities have the tools/resources/capacity to access and apply the plan?
- Does the plan include initial/ongoing partnerships with external entities (e.g., universities, NGOs)?
- How will relationships with stakeholders and external entities be maintained during and after the completion of the plan?

3C. Adapt and Innovate

- Has pre-existing infrastructure been taken into account and utilized (e.g., ancient 'amuna' canals systems)?
- Does the plan make use of nature-based solutions (e.g., tree planting for carbon sequestration and soil stabilization)?
- Does the plan consider and incorporate TEK (e.g., crop/livestock management techniques)?
- Have innovative funding systems been included to finance the plan (e.g., payment for ecosystem services)?
- Are the plans flexible to changes in climate scenarios and risk assessments during their lifespan?

3D. Plan for the Long-Term

- Is there a clear deadline for reevaluation/renewal of the plan?
- Are there sufficient personnel/resources for the successful establishment of the plan?
- Are the plan and its workflow backed up with robust and accessible data storage systems?

Example: Puno's *Plan de Desarrollo Regional Concertado* incorporates many of the Action items listed above with the potential to assist in climate mitigation and adaptation. For example, the management of hydrological resources at the watershed level is consistently listed as a priority, including at the international scale. NGOs are explicitly included within the list of actors involved in the execution of the plan, and the need to invest in strengthened management capacities for campesino communities is highlighted within particular provinces. The plan also incorporates nature-based solutions to risk management and carbon sequestration through the inclusion of tree planting initiatives to stabilize mountain slopes; the restorative management of native *totora* sedge in response to climate variability also takes into account the ancestral management practices of the indigenous Uros people. Provisions are also included for the creation of a centralized platform containing plan data and objectives (Regional Government of Puno, 2013).

Step 4. Plan Implementation and Maintenance

This section addresses the implementation and long-term maintenance of the plans designed in

Step 3. Emphasis has been placed on upkeep of data systems and public access.

4A. Implement Plans

- Are the plans being implemented in conjunction with the community?
- Are the new plans coordinated with other plans for the locality and the regional authority? Have the relevant officials been updated about the new plans?
- What types of platforms are being used to share plan information and data with the community?

4B. Maintain Capacity

- Does the government have dedicated servers/GIS platforms to host the collected data?
- What are the existing funding streams for employing data experts and planning technicians? How can these funds be supplemented?
- Is the locality coordinating with previously-identified partner organizations for maintenance?

Example: There are noted difficulties with maintaining regional data systems, often due to a lack of resources. One way to address this issue is through open-source data platforms, which allow NGOs and university partners to supplement the government's findings. The government of Cusco is exploring one such initiative for data communication with their residents. For example, the Climandes project helped connect smallholder farmers in Puno and Cusco with climatic and meteorological information. The exchange also helped identify community issues with accessing and using the data, which allowed the developers of the tool to incorporate local feedback to increase usage. In addition, the bi-lateral nature of the project enabled the capacity development of personnel in using and maintaining the data systems (Gubler et al., 2020).

Step 5. Monitoring Plans

This step is meant to keep track of the implementation from Step 4 and the externalities of policies. It covers observation of the plan's execution in the target area, the closeness with which the plan is followed, and the legal impacts of the created policies.

5A. Analyze Target Area

- Which indicators most effectively evaluate the impacts of the plan (e.g., water stability)?
- To what degree are the plans being accurately implemented? Are they being complied with?
- Are the predicted outcomes being realized? What are the impacts on the targeted areas?
- If the plan is not accomplishing its goals, why not?

5B. Evaluate Externalities

- Has this plan or policy had impacts outside of its intended consequences?
- To what extent are the consequences positive or negative?
- Does the plan need to be adapted? If so, will this affect any progress achieved by the plan to date?

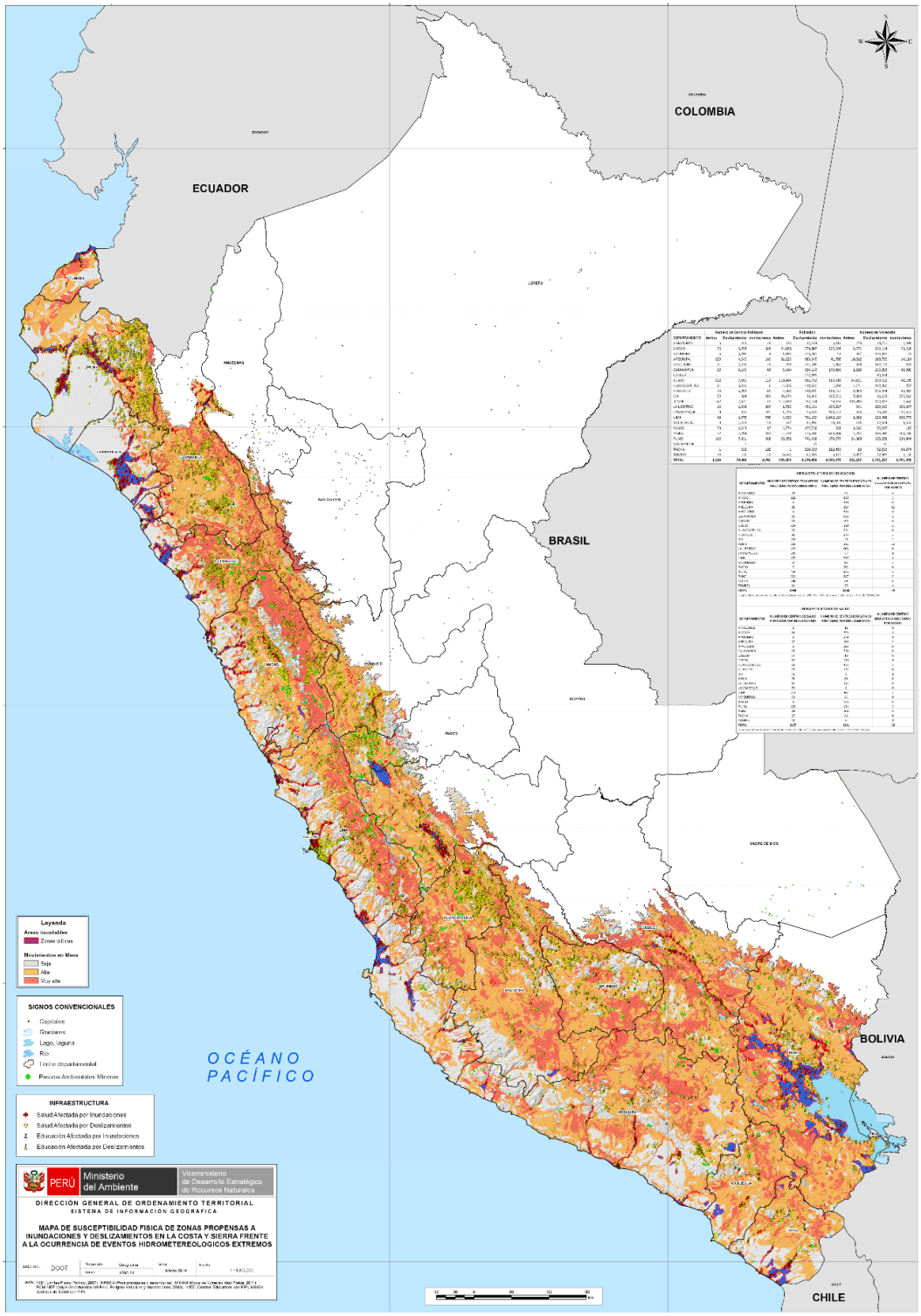
5C. Align with Requirements

- Does your plan still comply with relevant bodies or requirements across local, regional,

national, and international levels?
- Does the plan align with the Nationally Determined Contribution to the Paris Agreement?
- How can the plan be (re-)aligned with other required planning documents/policies? What aspects have yet to be addressed?

Example: The Report on the Implementation of the New Urban Agenda in Perú utilizes CEPLAN to measure the Agenda's effects on living conditions using predefined metrics. This allows service providers to evaluate their progress toward accomplishing the policies' goals and make adjustments where necessary. The providers also consider the Agenda's interaction with other national policies and priorities to address outstanding issues and avoid redundancy (Ministerio de Vivienda, Construcción y Saneamiento, 2021).

D: Map of the vulnerability of Peruvian regions to landslides, flooding, and extreme hydrometeorological events.



Source. MINAM, 2014.

References

Atkinson, R., & Flint, J. (2001). Accessing hidden and hard-to-reach populations: Snowball research strategies. *Social Research Update, 33*, 1–4.

Bergmann, J., K. Vinke, C.A. Fernández Palomino, C. Gornott, S. Gleixner, R. Laudien, A. Lobanova, J. Ludescher & H.J. Schellnhuber. (2021). Assessing the evidence: Climate change and migration in Perú. Potsdam Institute for Climate Impact Research (PIK), Potsdam, and International Organization for Migration (IOM), Geneva.

CEPLAN. (n.d.). Strategic Planning and Territorial Information Platform. https://geo.ceplan.gob.pe/#/downloads

Climate Action Tracker. (2022, September 20). Perú. https://climateactiontracker.org/countries/peru/

Departmental Government of Cusco. (2005). *Plan Base de Ordenamiento Territorial Región Cusco*. https://www.ima.org.pe/estudios/ot-cusco/OT_REGIONAL_CUSCO.pdf

DL No. 109 Ley General de Minería, Decreto Supremo No 014-92-EM. (1992). https://www.peru.gob.pe/docs/PLANES/94/PLAN_94_DL%20N%C2%BA%20109_2008.pdf

Dupuits, E. (2021). Climate change policies in the Andes: Dialogue between scales and perspectives for adaptation. Propuestas Andinas No. 18. Quito: Adaptation at Altitude, Andean Forests Programme, CONDESAN. https://www.weadapt.org/sites/weadapt.org/files/policy_brief-_climate_change_policies_in_the_andes.pdf

Fernández-Maldonado, A. M. (2019). Unboxing the black box of Peruvian planning. *Planning Practice and Research, 34*(4), 368-386. https://doi.org/10.1080/02697459.2019.1618596

Fraser, B. (2017, June 21). *Long road ahead to indigenous land and forest rights in Peru*. Forest News. https://forestsnews.cifor.org/50276/long-road-ahead-to-indigenous-land-and-forest-rights-in-peru?fnl=en

Geo Perú. (2022). National platform of georeferenced data for Perú. Government of Perú. https://visor.geoperu.gob.pe/

GoreLoreto. (2015). Strategic Environmental Assessment. Loreto's Participatory Regional Development Plan to 2021.

Government of Perú. (2020). *Contribuciones determinadas a nivel nacional del Perú (NDC)*.

https://unfccc.int/sites/default/files/NDC/2022-06/Reporte%20de%20Actualizacio%CC%81n%20de%20las%20NDC%20del%20Peru%CC%81.pdf

Government of Perú. (2022a). *Plan estratégico de desarrollo nacional al 2050*. https://www.gob.pe/institucion/ceplan/campa%C3%B1as/11228-peru-plan-estrategico-de desarrollo-nacional-al-2050

Government of Perú. (2022b). *Sernanp capacita a guardaparques y aliados de la Reserva Paisajística Nor Yauyos Cochas en prevención y control de incendios forestales*. Press release. https://www.gob.pe/institucion/sernanp/noticias/663650-sernanp-capacita-a-guardaparques-y-aliados-de-la-reserva-paisajistica-nor-yauyos-cochas-en-prevencion-y-control-de-ince

Gubler, S., Rossa, A., Avalos, G., Brönnimann, S., Cristobal, K., Croci-Maspoli, M., Dapozzo, M., van der Elst, A., Escajadillo, Y., Flubacher, M., Garcia, T., Imfeld, N., Konzelmann, T., Lechthaler, F., Liniger, M., Quevedo, K., Ramos, H., Rohrer, M., Schwierz, C., Sedlmeier, K., Spirig, C., de Ventura, S., & Wüthrich, B. (2020). Twinning SENAMHI and MeteoSwiss to co-develop climate services for the agricultural sector in Peru. *Climate Services, 20*, 100195. https://doi.org/10.1016/j.cliser.2020.100195

Gustafsson, M. (2017). The struggles surrounding ecological and economic zoning in Peru. *Third World Quarterly.* DOI: 10.1080/01436597.2016.125514

Intergovernmental Panel on Climate Change (IPCC). (2022). Summary for policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: Climate Change 2022: Impacts, Adaptation and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig,S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. Cambridge University Press, Cambridge, UK and New York, NY, USA. doi:10.1017/9781009325844.001

Ministerio del Ambiente (MINAM). (2014). *Mapa de susceptibilidad física de zonas propensas a inundaciones y deslizamientos en la costa y sierra frente a la ocurrencia de eventos hidrometereológicos extremos* [Image]. https://sinia.minam.gob.pe/mapas/mapa-susceptibilidad-fisica-zonas-propensas-inundaciones-deslizamientos

Ministerio de Vivienda, Construcción y Saneamiento. (2021). *Report on the Implementation of the New Urban Agenda in Perú.*

https://www.urbanagendaplatform.org/sites/default/files/2022-01/Peru%20National%20Report.pdf

National Center for Disaster and Risk Evaluation, Prevention, and Reduction (CENEPRED). (2022). SIGRID Risk and Disaster Management Information System. https://sigrid.cenepred.gob.pe/sigridv3/mapa

Navarro-Castañeda, S., Arranz, J. M., Burguillo, M., & Colla De Robertis, E. (2021). Land tenure security and agrarian investments in the Peruvian Highlands. *Land Use Policy*, *109,* 105651. https://doi.org/10.1016/j.landusepol.2021.105651

National Oceanic and Atmospheric Administration (NOAA). (2021, June 16). *US Climate Resilience Toolkit.* Retrieved March 20, 2023 from https://toolkit.climate.gov/tool/adaptation-workbook-natural-resources.

OECD. (2020). Approaches in Perú to increase coherence in climate change adaptation and disaster risk reduction. In Common Ground Between the Paris Agreement and the Sendai Framework: Climate Change Adaptation and Disaster Risk Reduction. OECD Publishing, Paris. https://doi.org/10.1787/3edc8d09-en

Perú Constitution. (2021). *Perú's Constitution of 1993 with amendments through 2021*. Comparative Constitutions Project. https://www.gob.pe/institucion/sernanp/noticias/663650-sernanp-capacita-a-guardaparques-y-aliados-de-la-reserva-paisajistica-nor-yauyos-cochas-en-prevencion-y-control-de-incendios-forestales

Regional Government of Puno. (2013). *Plan de Desarrollo Regional Concertado. https://www.gob.pe/institucion/regionpuno/informes-publicaciones/2548221-plan-de-desarrollo-regional-concertado-pdrc*

Rojas, E. (2021). *Riesgo de deforestación asociada a la infraestructura vial existente y proyectada en los departamentos de Loreto, San Martín y Ucayali, Derecho, Ambiente y Recursos Naturales (DAR).* Programa de Cambio Climático y Bosques. https://dar.org.pe/wp-content/uploads/2021/11/125-Resumen-Ejecutivo-NDC-18-noviembre.pdf

Schoolmeester, T., Johansen, K.S., Alfthan, B., Baker, E., Hesping, M. & Verbist, K. (2018). The Andean glacier and water atlas: The impact of glacier retreat on water resources. UNESCO and GRID- Arendal.

Torres Mallma, S. F. (2021). Mainstreaming land use planning into disaster risk management: Trends in Lima, Perú. *International Journal of Disaster Risk Reduction*, *62*(102404). https://doi.org/10.1016/j.ijdrr.2021.102404

USAID. (1996). Performance monitoring and evaluation tips: Conducting key informant

interviews. USAID Center for Development Information and Evaluation. https://pdf.usaid.gov/pdf_docs/PNABS541.pdf

USAID. (2012). Greenhouse gas emissions in Perú. Climate Links. https://www.climatelinks.org/sites/default/files/asset/document/GHG%20Emissions%20Factsheet%20Peru_v2_SC_11_02_15_edited_ref08-18-2016_Clean.pdf

USAID. (2022). Natural Infrastructure for Water Security (NIWS). https://www.usaid.gov/sites/default/files/2022-05/NIWS-FS-English-3Feb22_.pdf

Wieland, P. (2021). Sleeping beauty and the lottery miners: Law, power, and culture in Perú's artisanal mining frontier. *Labor Law Journal, 72*(3), 163-196.

Wikimedia Commons. (2009). *Perú location map* [Image]. https://commons.wikimedia.org/wiki/File:Peru_location_map.svg

World Bank. (2022). Employment in agriculture (% of total employment) (modeled ILO estimate) (2019) [Data Set]. https://databank.worldbank.org/source/world-development-indicators

Vázquez-Rowe, I., Kahhat, R., Larrea-Gallegos, G., & Ziegler-Rodriguez, K. (2018). Perú's road to climate action: Are we on the right path? The role of life cycle methods to improve Peruvian national contributions. *Science of the Total Environment, 659,* 249-266. https://doi.org/10.1016/j.scitotenv.2018.12.322

Vera, C., Silvestri, G., Liebmann, B., & P. González. (2006). Climate change scenarios for seasonal precipitation in South America from IPCC-AR4 models. *Geophysical Research Letters, 33*(13). DOI:10.1029/2006GL025759

Velásquez, M. T., & Stewart, N. R. (2022). The people of the Andes Mountains. In *Encyclopædia Britannica*. Retrieved October 5, 2022, from https://www.britannica.com/place/Andes Mountains/The-people.

Vuille, M., Francou, B., Wagnon, P., Juen, I., Kaser, G., Mark, B.G., & R.S. Bradley. (2008). Climate change and tropical Andean glaciers: Past, present and future. *Earth-Science Reviews, 89*(3- 4),79–96. DOI:10.1016/j.earscirev.2008.04.002