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Source: Mountain Research and Development, 42(2)

Published By: International Mountain Society

URL: <https://doi.org/10.1659/MRD-JOURNAL-D-21-00040.1>

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Implementing Climate Change Adaptation Policies Across Scales: Challenges for Knowledge Coproduction in Andean Mountain Socio-ecosystems

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The Andean region presents specific challenges related to its globally important natural heritage, the broad range of pressures on landscapes and ecosystems that accentuate the effects of climate change (CC), and a great diversity of institutional arrangements and policy tools to increase the adaptive capacity of socioecological systems and related disaster risk reduction strategies. In this context, regional readings are needed to generate a multiscale and multisectoral analysis of the responses of Andean countries in public policy and at the grass roots. This paper examines institutional challenges and local perceptions regarding the implementation of CC adaptation policies in the Andean countries. We analyze the regulatory, institutional, and policy framework related to CC policies in Andean countries over the last 5 years. Further, we analyze synergies and opportunities, as well as possible tensions and resistance, that the implementation of CC adaptation policies may generate among diverse actors (civil society organizations, peasant/indigenous communities, and local/regional authorities, among others). For this, we analyze 7 case studies at the subnational level across the Andes. These were chosen to reflect the diversity of local

governance contexts across the region and the progress and challenges faced in implementing CC adaptation policies on the ground. This analysis reveals how the implementation of CC adaptation policies in diverse territorial contexts often lacks articulation and coherence with the governance tools and platforms typically used by local actors. In response to this overall limitation, various representative strategies derived from the case studies are highlighted, illustrating different modes of multiactor and multiscale cooperation. Finally, based on our sociopolitical analysis, we propose some key recommendations for the different stakeholders, which could inform the development of an agenda for multiscale and multiactor CC adaptation governance in the region.

Keywords: climate change adaptation; mountain socio-ecosystems; multiscale governance; knowledge coproduction; Andes.

Received: 12 August 2021 **Accepted:** 13 January 2022

Introduction

Since the ratification of the United Nations Framework Convention on Climate Change (UNFCCC) in 1994, Andean countries have been formulating and implementing national climate change (CC) strategies and programs. In turn, they have progressively incorporated CC considerations into their national and subnational development plans (Maldonado et al 2012; Schoolmeester et al 2016; Barcena et al 2020; Llambí and Garcés 2021). Additionally, since 2015, the implementation of the 2030 Agenda for Sustainable Development has emphasized the need to better articulate responses to the problems and challenges related to CC and sustainability objectives, including disaster risk reduction strategies.

CC adaptation is gaining importance, especially given the institutional, financial, and political challenges related to the implementation of CC mitigation policies (Mills-Novoa et al 2020). According to the UNFCCC, adaptation refers to changes in processes, practices, and structures to moderate potential damages or, alternatively, to benefit from the opportunities associated with CC. Public funds for CC

adaptation increased globally by 35% between 2015 and 2018, reaching close to US\$ 30 billion (Climate Policy Initiative 2019). In this context, all countries must generate policy instruments, including national adaptation plans, and present adaptation measures as part of their nationally determined contributions (NDCs) to UNFCCC.

Several studies have highlighted the specificities of Andean mountain socio-ecosystems. These highlight the importance of developing particular strategies for CC adaptation (Llambí and Garcés 2021). Characteristics include a high topographic complexity and climatic heterogeneity, risks and hazards associated with melting glaciers, changes in the functions and services of Andean ecosystems (eg reducing drinking water access, affecting productive activities), high vulnerability to soil erosion, strategic provision of clean water in the context of increasing demand due to growing urbanization, global importance as biodiversity hotspots, high sociocultural diversity, vulnerability to extractive industries and mining, and a prevalence of small-scale productive practices.

The literature synthesizes the policy framework around CC in the Tropical Andes (Cuesta et al 2012; Maldonado et al

2012; Schoolmeester et al 2016; Mathez-Stiefel et al 2017). However, these studies do not include the policies developed in the southern Andes (Chile and Argentina). Progress made in the last 5 years needs to be evaluated. This includes key aspects of the implementation and status of monitoring and evaluation of CC adaptation plans; the level of intersectoral integration of policies that promote adaptive capacity, including disaster risk reduction strategies; and the level of coordination between tools designed at different levels of governance (Wiegant et al 2020). We adopt a critical perspective of CC adaptation, considering alternative approaches of community-based adaptation and the integration of local and indigenous knowledge, as well as the challenges and tensions arising from knowledge coproduction and policy formulation/implementation in this context (Ariza-Montobbio and Cuvi 2020; Mills-Novoa et al 2020).

This paper therefore aims to examine the institutional challenges and local perceptions regarding the implementation of CC adaptation policies in the Andean countries. We review and analyze the regulatory, institutional, and policy frameworks relating to CC in Andean countries over the last 5 years. Further, we analyze the synergies and opportunities, as well as the possible tensions and resistance, that the implementation of CC adaptation policies could generate in contrasting Andean territories among diverse actors (civil society organizations; local, peasant and indigenous communities; urban centers; and local authorities, among others). This analysis is based on 7 case studies at the subnational level across the Andes. These were chosen to reflect the diversity of local governance contexts found across the region and the progress and challenges faced in implementing CC adaptation policies on the ground.

The analysis reveals how the implementation of national CC adaptation policies on the ground often lacks articulation and coherence with the governance tools and platforms used by local actors. To respond to this limitation, various initiatives and alternative policy options are scrutinized through the case studies, and key recommendations are made to help define an agenda for multiactor and multiscale cooperation over the implementation of CC adaptation policies in the region.

Conceptual approach and methodology

The Paris Agreement has prompted a move from designing CC policies and adaptation plans to their effective implementation through the participation of the respective stakeholders. In this regard, the multiscale governance approach (Brondizio et al 2009; Andonova and Mitchell 2010) highlights the challenges of interinstitutional and intersectoral articulation when designing, implementing, and monitoring CC adaptation policies at the regional, national, subnational, and local levels. One of the greatest challenges is the connection between national regulatory frameworks and their adaptation to the realities and needs of the territories facing CC impacts. More broadly, institutional gaps may appear in the interaction between national policies on one hand, and local needs and expectations on the other, in implementing climate policies in the field (Dupuits and Cronkleton 2020; UNEP 2021).

Specific challenges include effectiveness, capacity building, legitimacy, inclusion of beneficiaries in the decision-making processes, information mechanisms, and accountability (Giudice et al 2019; Wiegant et al 2020). Additionally, institutional gaps materialize with a lack of guidelines on how to implement and articulate national normative instruments on CC with instruments at the local scale (eg development and management territorial plans).

Mechanisms of social participation and cocreation of local and technoscientific knowledge should be used to avoid reproducing power asymmetries and socioenvironmental conflicts (Mills-Novoa et al 2020). The knowledge coproduction approach is relevant in the field of CC adaptation to understand the interaction and articulation processes among multiple actors with diverse interests that affect the design, implementation, and monitoring of these policies (Budds and Zwarteveen 2020; Miller and Wyborn 2020).

Andean mountain socio-ecosystems present particular challenges for multiscale governance and knowledge coproduction (Figure 1) because of their high biophysical heterogeneity. This is reflected in complex mosaics of productive systems, the coexistence of hybrid formal and customary resources management systems, and the prevalence of poverty, especially in rural landscapes of small producers (Mathez-Stiefel et al 2017).

A qualitative and inductive methodology was used to collect first- and secondhand data. First, we conducted a review of gray literature and academic articles about CC adaptation policies (plans, strategies, national contributions, and communications) designed at the global, regional, and national levels that impacted Andean countries. A synthesis of the literature review is presented below, in the section “The state of CC adaptation policies in the Andes.”

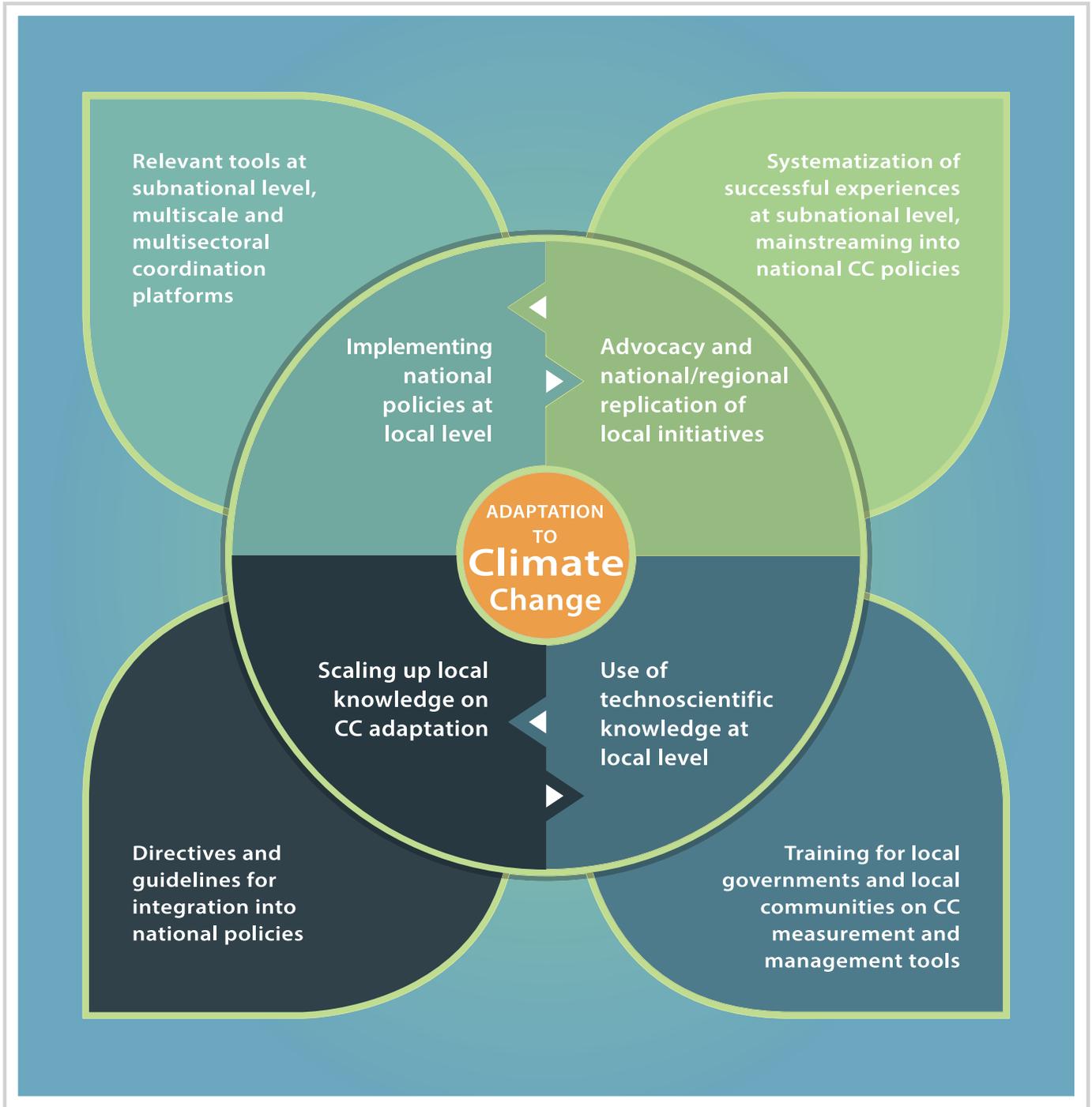
Second, we conducted a survey of regional and national decision makers during November 2020. This made it possible to identify the priorities and opportunities in the advancement of CC adaptation policies. Twenty-two key stakeholders from 6 countries across the Andes participated in the survey. The objective was to collect baseline information on the status and evolution of CC adaptation policies in the Andes during the last 5 years, contribute to the selection of relevant case studies, and identify key contacts for participation in workshops and subsequent interviews.

Finally, an online discussion forum on “Climate Change Policies and Adaptation Strategies in the Andes: A Multisectoral View From the Mountains” was held on 9 December 2020, within the framework of International Mountain Day. The event attracted 38 participants from 7 countries across the Andes, including regional and national decision makers, international experts, and civil society leaders. Gaps, opportunities, and priority issues were identified to guide the work and advocacy around CC adaptation policies in the Andes in the coming years.

Study area and case study selection

To explore local perceptions on the implementation of CC adaptation policies, as well as the possible resistances and the emergence of alternative proposals from the grass roots, 7 case studies were selected in September 2020. Selection was

FIGURE 1 Dialogue among scales and knowledge in climate change (CC) adaptation policies.



based on the research experience of the authors and available site-level data to represent the diversity of socioenvironmental, ecosystem, and institutional contexts throughout the Andes. Semistructured interviews were conducted virtually between October 2020 and February 2021, with 22 key actors (including 8 women) involved in selected case studies and partly in the survey. The interviews were conducted with local and national government representatives, international cooperation experts, nongovernmental organizations, and community-based and indigenous leaders. However, we acknowledge that the small

sample may not encompass all relevant perspectives and issues, and the final recommendations should be refined through further investigation and inclusion of additional voices in multiscale governance and knowledge coproduction. To process the semistructured interviews, a discursive analysis method was used to identify the interests and perceptions of the actors, as well as the power relations at stake at different scales.

Table 1 and Figure 2 provide details on the location and main characteristics of the 7 case studies considered in the analysis. They were selected according to 5 criteria: (1) the

TABLE 1 Main characteristics of the 7 case studies selected. (Table continued on next page.)

Case study	Dimensions	Main characteristics
Laguna de los Pozuelos Biosphere Reserve (high Andean wetlands, <i>puna</i>)	Country	Argentina
	Key sectors	Sustainable livestock management, environmental restoration, water management
	Key political–institutional instruments	National Monument and Biosphere Reserve Management Plan, Wetland Law Proposal
	Key programs and actors	Conserving the high Andean wetlands in partnership with local communities (2017–2024)—Wetlands International, Secretariat of Family Agriculture, Jujuy province
Totora and Tiraque municipalities, Cochabamba (wet <i>puna</i> , <i>yungas</i> , valley)	Country	Bolivia
	Key sectors	Sustainable management of agrobiodiversity, adaptation based on the community and ancestral knowledge
	Key political–institutional instruments	Life Systems, Territorial Integrated Development Plans
	Key programs and actors	Proposal for a municipal law for the protection of watersheds areas (2020)—Plurinational Authority of the Mother Earth, AGRECOLAndes
San José de Maipo municipality, Metropolitan region (high Andean mountains, lakes, glaciers)	Country	Chile
	Key sectors	Sustainable agriculture, regenerative livestock
	Key political–institutional instruments	Soil, Water, and Forest Conservation District; regional CC action plans; local-scale ecological planning (Eco-Local Plan)
	Key programs and actors	Strengthening of municipal capacities for the protection and monitoring of the Mountain Biological Corridors, 2016–2021 (Global Environment Facility Montaña)—Ministry of Environment, Municipality of San José de Maipo
Claro river basin, Los Nevados National Park (glaciers, <i>páramo</i> , high Andean wetland and forest)	Country	Colombia
	Key sectors	Environmental restoration, water management, sustainable uses, environmental monitoring
	Key political–institutional instruments	Management, Monitoring, and Conservation Plan of Los Nevados National Park; Law 1.930 for the Comprehensive Management of the Páramos
	Key programs and actors	Pilot strategy for integrated monitoring of High Andean ecosystems, 2018—Consortium for the Sustainable Development of the Andean Ecoregion, Institute of Hydrology, Meteorology and Environmental Studies, Humboldt Institute
Kayambi community water protection area (<i>páramo</i>)	Country	Ecuador
	Key sectors	Community management of water and <i>páramo</i>
	Key political–institutional instruments	Sustainable management plans for <i>páramos</i> , Cayambe Municipal Ordinance on Land Use and Management Plan
	Key programs and actors	Plurinational Water Fund Proposal, 2018—Kayambi People's Confederation, Municipality of Cayambe, Institute of Ecology and Development of the Andean Communities
Chocó Andino Biosphere Reserve (pluvial Andean forest)	Country	Ecuador
	Key sectors	Conservation, reforestation, sustainable livestock
	Key political–institutional instruments	Biosphere Reserve Management Plan; Commonwealth Territorial Plan, Andean Chocó Model Forest, Ordinance 137, Parish Land Management Plans
	Key programs and actors	Model Forest Network, 2017—Municipalities' association of Chocó Andino, Ministry of the Environment of the Metropolitan District of Quito

TABLE 1 Continued. (First part of Table 1 on previous page.)

Case study	Dimensions	Main characteristics
Nor Yauyos Cochas Landscape reserve, Cañete basin river (wet páramo, pluvial tundra, puna)	Country	Peru
	Key sectors	Environmental conservation, reforestation, peasant agriculture, hydrological services
	Key political–institutional instruments	Master Plan of the Reserve, Municipal Commonwealth, Management Committee of the Natural Protected Area, Law on Mechanisms of Remuneration for Ecosystem Services

FIGURE 2 Map of case studies for the sociopolitical analysis of climate change adaptation policies in the Andes.



diversity of political–institutional contexts and capacities of the implementers, including different governance scenarios and levels of incidence and appropriation of CC adaptation policies at the subnational and local level; (2) the link to mountain socioecological systems in the Andes (*páramos*, high Andean wetlands, Andean forests, lakes, and *puna*, among others); (3) the centrality of CC adaptation, in relation to the conservation of water resources and the mitigation of disaster risks, environmental restoration and reforestation, productive forest management, or ecoterritorial alternatives; (4) the diversity of actors, in terms of financing, design, implementation, or participation (eg international experts, national and provincial public authorities, academia, and local and indigenous communities, among others); and (5) the temporality of the selected cases, which are ongoing programs or have been implemented in the last 5 years.

The state of CC adaptation policies in the Andes

The literature review, social survey, and participatory workshop confirmed that the adoption of climate policies, within the framework of the objectives of the UNFCCC, in Andean countries has accelerated over the last 5 years compared with before 2015 (Maldonado et al 2012; Schoolmeester et al 2016). This is evidenced in the recent adoption of specific policy tools on CC adaptation through the approval, implementation, and actualization of NDCs, as well as CC plans, strategies, and laws (see Table 2 for a synthesis of key results). Another important trend is the design and approval of policies specifically focused on mountain socio-ecosystems and CC, as in the cases of Argentina (Committee for the Sustainable Development of Mountain Regions), Chile (Proposal for a National Policy for Sustainable Management of Mountains and Action Plan to 2030), Colombia (Law 1930 of *Páramos*), and Peru (National Glacier and Mountain Ecosystem Policy Proposal). A more detailed and extensive comparative analysis of CC adaptation policies in the different countries in the region is presented in Dupuits (2021a).

Case studies: dialogue among scales and knowledge perspectives on CC adaptation

The case studies feature a diversity of socioecological and multiscale environmental arrangements (eg national park, biosphere, and landscape reserves; municipalities and regions; and community water protection areas). Below, we present a synthesis of the analysis of the 7 case studies, focusing on the 2 key concepts of knowledge coproduction and multiscale governance, and their related variables: interinstitutional and intersectoral articulation, social participation, monitoring and evaluation, productive alternatives, and production of and access to information. These dimensions appeared as the most central and problematic throughout the study at the territorial scale, in terms of the creation of spaces for collaboration, conflict resolution among sectors and stakeholders' interests, and coordination between scales and knowledge. This comparative analysis illustrates the institutional challenges and local perceptions of the interviewees regarding the implementation of CC adaptation policies in the territories

and the potential for replication of local initiatives at national and regional levels.

Interinstitutional articulation between local and national scales

A first challenge identified through the case studies is the tensions that may arise between initiatives or spaces designed at the national level and their adaptation to local realities and needs (Dupuits and Cronkleton 2020). This is evidenced in the lack of concrete implementation or use of governance platforms and plans for CC adaptation designed at the national scale (eg regional CC committees, Chile; regional CC strategies, Ecuador). Conversely, initiatives taken at the local level are not explicitly linked to national CC strategies or policies. These observations resonate with the literature that questions the recent dynamics of “climatization” (Aykut et al 2017; Dupuits 2021b), the creation of new spaces for negotiation, and the multiplication of policies mainly articulated around the CC issue. These processes tend to overshadow the specific agendas and interests of each sector or scale and the impact of other processes such as land use change that, in many cases, have more direct impacts on mountain socio-ecosystems (Mathez-Stiefel et al 2017).

At the local level, the most relevant and effective political tools are those that have emerged from historical and context-oriented processes of stakeholder participation around specific issues. Some of the normative tools with a high potential impact are articulated around issues of water resource management (Law of Remuneration Mechanisms for Ecosystem Services, Peru; Organic Law of Use and Exploitation of Water Resources, Ecuador), protection of mountain ecosystems (Law 1930 of Integral Management of *Páramos*, Colombia; proposed Law of Wetlands, Argentina), and environmental restoration (National Plan for Ecological Restoration, Rehabilitation and Recovery of Degraded Areas, Colombia).

Additionally, there is a preference among local authorities and communities for local or subnational spaces for governance and collaboration to complement ones provided at the national level, which tend to overshadow local demands and needs. This is illustrated by the proposal to create a municipal natural reserve in San José de Maipo (latitude 33°38'39.6564"S; longitude 70°20'45.8988"W), Chile, within the framework of the Conservation District Master Plan and the Municipal Environmental Ordinance. Another example is the emphasis on effective participation of local stakeholders for the implementation of the Strategy for Integrated Monitoring of High Andean Ecosystems in Colombia in the Claro River basin (5°2'8.412"N; 75°30'34.056"W) pilot area, in parallel with the consolidation of the process at the national scale.

Intersectoral articulation

A major challenge is related to intersectoral articulation in CC adaptation programs and policies, especially between the environment and agriculture sectors, which tend to be disconnected or opposed in most of the case studies. To respond to this problem, policies have emerged that seek to better articulate the objectives of environmental conservation or restoration and productive development. This is illustrated with the adoption of laws or resolutions that support peasant family agriculture and sustainable rural

TABLE 2 Synthesis of the main progress, challenges, and opportunities on CC adaptation policies in the Andean countries. (Table continued on next page.)

Dimension	Progress	Challenges and opportunities
Interinstitutional articulation	All countries have defined the competencies of a national authority in CC management, which strengthens the interinstitutional articulation of adaptation policies. All 7 countries have adopted climate policies (plans, strategies, and laws) at the national level and have formulated their first NDCs. In addition, 4 countries submitted their updated NDCs in 2020 and have formulated long-term strategies to 2050, demonstrating ambitious goals on CC adaptation (Argentina, Chile, Colombia, Peru).	Some countries are still in the process of approving their national plans, strategies, or laws on CC adaptation because of issues of competencies or economic and political priority. The challenge is then to approve these policies and to devise strategies so that they can be effectively implemented and have a real impact at the territorial level. One opportunity is to learn from the progress of some countries in meeting international commitments in terms of updating the NDCs and formulating long-term strategies on CC.
Intersectoral articulation	Most countries have formulated sectoral plans for CC adaptation (Argentina, Bolivia, Chile, Colombia, Ecuador, Peru) and 2 countries have specific institutions for multisectoral articulation at national level (Intersectoral Commission on Climate Change, Colombia; High Level Commission on Climate Change, Peru). In addition, 2 countries have sectoral planning tools at the subnational level (Bolivia and Colombia).	A major challenge is the consolidation of multisectoral platforms at the national level and the concrete application of these instruments to solve the recurrent challenges of articulation in CC adaptation between key sectors with historical contradictions such as environment and agriculture. Several national or subnational CC policies have been built around an integrating transversal sector (water, forests, or sustainable agriculture), which represents an opportunity for articulation. However, an emphasis on forest ecosystems poses a challenge in terms of incorporating a more integrated perspective on mountain landscapes (including other nonforest ecosystems, such as high-elevation grasslands and wetlands).
Social participation	All countries mention social participation in their national climate policies as a guiding principle. This is achieved through citizen consultation mechanisms (Argentina, Chile), territorial planning (Bolivia), or subnational coordination tables (Colombia, Ecuador). An innovative experience is, for example, the creation of Peru's Indigenous Peoples' Platform for Climate Change.	The biggest challenge is the effective implementation of platforms and mechanisms for involving civil society in decision-making processes. Potential opportunities that promote the effective articulation of civil society include water summits in Bolivia, biosphere reserves, and model forests, among others. In addition, a key opportunity is to enhance coproduction processes of technoscientific and local knowledge about CC, both for scaling up local knowledge about CC and training on the use of technical and scientific tools.
Monitoring and evaluation	Three countries have national mechanisms for evaluating and monitoring CC adaptation measures (Argentina, Chile, Colombia), through national systems of environmental indicators, monitoring systems, or specific goals set out in their NDCs. Another advance is the ongoing construction of the National Policy of Glaciers and Mountain Ecosystems in Peru.	One major challenge is that the mechanisms are in the design stage, so there are still no concrete data. In addition, there are opportunities for regional discussion and exchange of experiences on the long-term integrated monitoring of socio-environmental indicators and the follow-up of CC adaptation measures that complement efforts at the national level (eg research agenda and platform for the integrated monitoring and analysis of socio-environmental indicators in the Andes, Consortium for the Sustainable Development of the Andean Ecoregion; Andean Environmental Technology Platform Proposal, Andean Community Environmental Charter).

TABLE 2 Continued. (First part of Table 2 on previous page.)

Dimension	Progress	Challenges and opportunities
Sustainable and adaptive productive transitions	Several countries have designed and implemented pilot management plans and land use and sustainable livestock practices that adapt production transition processes to the local scale (eg sustainable management plan for livestock grazing in Laguna de los Pozuelos, Argentina; pilot intervention plan in the rural community of Miraflores, Peru). In Ecuador, 2 municipal ordinances seek to promote an alternative model of sustainable rurality in Chocó Andino (Ordinance No. 137), and the regulation of land uses in Cayambe canton (Ordinance No. 04-CMC-2020).	A key challenge is to integrate these instruments more explicitly into CC adaptation plans and strategies formulated at the national level. In addition, it is necessary to clarify how these sustainable agricultural or livestock alternatives respond to climate threats or vulnerabilities faced by productive and livelihood systems.
Production and access to information	An illustration of progress is the construction of the Strategy for Integrated Monitoring of High Andean Ecosystems in Colombia, which aims to disseminate scientific knowledge to civil society and political actors. In Bolivia, several academic research projects encourage processes of institutionalization of ancestral knowledge on climate measurement in the Andes.	One of the greatest challenges is to better connect science and decision-making and to support the development of citizen science and participatory research. In addition, a key challenge is to support the combination of local knowledge with technoscientific systems promoted at the national level, to respond to the complexity of CC impacts related to monitoring processes.

development, as in Colombia (Ministerial Resolution 464, Strategic Public Policy Guidelines for Peasant, Family, and Community Agriculture) and Argentina (Law 27.118 of Historical Repair of Family Farming). In addition, the national instruments or commissions for intersectoral articulation around CC that have recently been created in various countries of the region (eg Intersectoral Commission on Climate Change, Colombia; High Level Commission on Climate Change, Peru; Climate Change Intersectoral Committee, Ecuador) have high potential, although their implementation at the subnational scale needs to be strengthened. Another illustration at the local level is the adoption, in the Andean Chocó of Ecuador (0°3'45.072"N; 78°40'56.3232"W), of participatory integrated farm plans, where objectives of sustainable productive systems are implemented with environmental conservation and degraded area restoration practices.

Social participation

In some cases, formal spaces have been created to promote more effective participation of civil society actors in formal decision-making and governance processes, for example in the case of protected natural areas and CC adaptation programs. Three types of social participation mechanisms are highlighted: (1) plans and management committees for protected natural areas, landscape, and biosphere reserves; (2) master plans, municipal laws, associations among several municipalities, and ordinances at the subnational level; and (3) civil society networks and participatory summits. Many of these spaces are supported by national policies related to CC or development planning more broadly. This is the case with the participatory process for the construction of a municipal law of watershed areas protection in Totora (17°44'16.908"S; 65°11'22.236"W) and Tiraque (17°24'16.416"S; 65°43'55.164"W), Bolivia, which is derived from Law 777 of the Comprehensive State Planning System, the guidelines for the elaboration of the Territorial Plans of Integral Development, and the Life Systems (a unit for development planning in Bolivia).

Monitoring and evaluation

Another important challenge for multiscale governance is the monitoring of CC adaptation programs, which often tend to be tied to time-limited international cooperation projects. Several actors mention the difficulty of institutionalizing programs at the local, subnational, or national government level to ensure their long-term monitoring and sustainability. To respond to this limitation, capacity-building efforts are being developed for municipalities and local communities. These efforts are evidenced in the cases of San José de Maipo in Chile and Laguna de los Pozuelos (22°20'28.266"S; 65°59'53.412"W) in Argentina, where several training workshops on the management of new political instruments of CC adaptation have been implemented for municipal technicians.

Challenges include sustainability over time, documentation, and monitoring of the impacts of ecosystem-based adaptation (EbA). The sustainability of conservation and restoration practices that are being implemented by local communities through international or governmental cooperation programs should be ensured. For example, in the case of the municipalities' association in Nor Yauyos Cochas (12°6'42.6132"S; 75°53'39.2568"W), Peru, and Chocó Andino, Ecuador, greater consolidation integrating several local governments is needed, as the projects have been promoted through time-limited international cooperation. There is a risk of losing interest and commitment from local communities in ensuring environmental conservation and the substitution of unsustainable and nonresilient productive practices in the face of economic instability. This is manifested in the Nor Yauyos Cochas reserve, where the Conservation and Sustainable Use of the High Andean Ecosystems of Peru Through Payment for Environmental Services for the Alleviation of Rural Poverty and Social Inclusion project is nearing completion. This presents the problem of ensuring financial assistance and technical support from the National Protected Areas Secretary of Peru for the cattle-raising pastoral communities that have begun their productive

transition. Moreover, more participatory approaches in monitoring and evaluation of EbA strategies are needed.

Sustainable and adaptive productive transitions

The identification of sustainable agricultural and livestock production alternatives for local communities is a cornerstone of most of the CC adaptation plans that are being implemented at the local level. These activities are prioritized through the design and implementation of pilot management plans and land use and sustainable livestock practices that facilitate production transition processes at the local scale (eg Sustainable Management Plan for Livestock Grazing in Laguna de los Pozuelos, Argentina; Pilot Intervention Plan in the rural community of Miraflores, Peru). Municipalities play a key role, sometimes organized through an association in alliance with local communities. Central government can also play an important role, through the Ministry of Agriculture promoting family farming or managing protected areas and natural resources. In the case of Ecuador, there are 2 examples of municipal ordinances that seek to promote an alternative model of sustainable rurality in Chocó Andino (Ordinance No. 137) and the ordinance of land uses in Cayambe canton (Ordinance No. 04-CMC-2020).

Although these local instruments could be replicated and systematized at the national level, they need to be more explicitly integrated into CC adaptation plans and strategies formulated at the national level. In addition, clarification is needed on how these sustainable agricultural or livestock alternatives respond to climate threats or vulnerabilities faced by productive and livelihood systems.

Production and access to information

Some of the greatest challenges in production and access to information are the needs to better connect science and decision-making and to support the development of citizen science and participatory research (Bäckstrand 2004; Jasanoff 2004; Llambí and Garcés 2021). An illustration of progress here is the ongoing construction of the Strategy for Integrated Monitoring of High Andean Ecosystems in Colombia, which aims to disseminate scientific knowledge among civil society and political actors (Llambí et al 2019). In Bolivia, several academic research projects (Universidad San Simón de Cochabamba) encourage processes of institutionalization of ancestral knowledge on climate measurement in the Andes. These focus on the relationship between climate and cultural and ritual practices. Research conducted at the local scale reveals the priority given by residents to community-based adaptation rather than the classical approaches of nature-based solutions or EbA often promoted by international cooperation and government-led programs (Ariza-Montobbio and Cuvi 2020). In addition, a key challenge is to support the combination of local knowledge with technoscientific systems promoted at the national level to respond to the complexity of CC impacts related to monitoring processes.

Finally, some cases show the challenges and risks in the recognition and revalorization of local knowledge at the national level, especially within formal governance spaces (Dupuits et al 2020). This is evidenced in the institutionalization process of the Kayambi Community Water Protection Area (0°2'24.72"N; 78°8'31.8516"W) in

Ecuador. This resulted in the transformation of community demands according to the requirements of the public regulations (reduction of the protected area, imposition of restrictions on land uses allowed). Although the Institute of Ecology and Development of the Andean Communities contributed to producing knowledge about water resources in the Kayambi territory, the process was not recognized by government actors, who asked for more technoscientific evidence. This demonstrates the importance of coproduction processes between technoscientific and local knowledge (Budde and Zwartveen 2020; Miller and Wyborn 2020) to resolve the tensions between the sociocultural vision of indigenous communities and the political-legal vision promoted by government agencies. This antagonism derives from the prevalence of uses and the disparities among actors in terms of power, knowledge, political influence, and so forth.

National policies for CC adaptation should therefore provide tools and mechanisms to allow technoscientific knowledge to be better used by local actors and be articulated with their own knowledge. Some national policies for CC adaptation do include the recognition of the communities' cultural vision of natural resources and the assessment of their knowledge to analyze the impacts of CC on their adaptive capacity. For example, in 2020, Peru created the Indigenous Peoples' Platform for Climate Change as an innovative space to facilitate knowledge coproduction on CC between the state and indigenous peoples.

Recommendations for future research and policy on CC adaptation in the Andes

The analysis presented in this paper emphasizes how the implementation of national CC adaptation policies on the ground often lacks articulation and coherence with local governance tools and platforms mostly used by local authorities, civil society organizations, and communities. We highlighted various local initiatives in response to this limitation. Several examples across the Andes illustrated interesting processes of multiactor and multiscale cooperation. They also showed the tensions and opportunities that can arise for an effective integration of stakeholders and governance scales. Based on the results of our normative and sociopolitical analysis, we now propose some key recommendations aimed at the different stakeholders. These could inform the development of an agenda for multiscale and multiactor CC adaptation governance in the region.

A first priority is to develop and enhance spaces, processes, and mechanisms of participatory and territorial construction of national policies for CC adaptation. These should capitalize on the normative tools mostly used by local actors (eg municipal ordinances and laws, land use planning, disaster risk reduction strategies, community or municipal conservation areas) and the most relevant sectoral policies (eg guidelines to address forestry and agroforestry in national adaptation plans, Food and Agriculture Organization of the United Nations [FAO]). These tools would facilitate the inclusion of the specificities of mountain socio-ecosystems as a crosscutting axis of CC adaptation policies in the region. This would be achieved by providing

effective spaces for collaboration in the field and by responding to the effects of CC on these ecosystems. In addition, it is essential to document and systematize subnational tools and spaces that adopt an intersectoral and ecosystem approach to inform and influence national public policies as well as their effective implementation. Local and subnational governments, as well as representatives of civil society organizations, should be key actors in this process of replication and scaling up.

A second priority is to design strategies for monitoring and evaluating the tools, spaces, and practices developed within programs of international cooperation to transition toward practices of sustainable and adaptive rural development and conservation by local communities. For this, regional political platforms such as the Andean Mountain Initiative have a particularly important role to play as a bridge among international actors and agreements and the continuity of public policies at the national and subnational level. A way to address this and promote more active participation of local stakeholders would be to incorporate participatory monitoring across CC adaptation initiatives. This would strengthen capacities at the local and landscape levels and tie the generation of relevant knowledge to local actors' specific needs for maintaining and restoring ecosystem functioning. This can be complemented by the construction of integrative platforms of indicators for the sociopolitical monitoring of CC adaptation measures, which could complement the hydrometeorological and environmental dimensions more commonly monitored.

A third priority is linked to the construction of mechanisms and spaces for coproduction between technoscientific knowledge and local and ancestral knowledge on CC adaptation (Young and Lipton 2006; Cueva and Groten 2010; Ariza-Montobbio and Cuví 2020). For this, researchers can play a key role, along with local and indigenous leaders, in fostering transdisciplinary approaches to knowledge coproduction (Steger et al 2021). This can link local and ancestral knowledge with national public policies and, in turn, evaluate environmental sustainability, adaptive value, and disaster risk reduction potential in CC scenarios of traditional management practices and strategies (design of participatory action–research methodologies; Grundy 1988). In addition, international and regional initiatives or funds focused on research on community-based CC adaptation should be promoted. The implementation of international or governmental cooperation programs should support the institutionalization of ancestral practices of assessment of or adaptation to CC. Their impacts in CC scenarios and their value should be analyzed in the context of promoting resilience and reducing vulnerability of livelihoods and productive strategies (eg United Nations University Nairobi Work Program; Training in Sustainable Management of Mountain Areas led by the Secretariat of the Alliance for Mountains of the FAO). Conversely, tools should be promoted so that technoscientific knowledge is better used and appropriated in territorial management by local actors. Processes of knowledge coproduction and innovation should be generated by integrating diverse knowledge perspectives through an effective dialogue guided by participatory approaches to problem-solving and governance at multiple spatial scales.

Finally, it should be recognized that, within and across groups and actors, there are likely to be diverse perspectives,

capacities, and knowledge systems. These can generate tensions, lack of trust, misunderstandings, or lack of effective participation from the early stages of implementation of CC adaptation strategies. These can then impede knowledge coproduction and undermine coherent action on CC adaptation. Finding ways to reach consensus or compromise among alternative knowledge systems, worldviews, perspectives, and priorities through more problem-oriented policy design, monitoring, and research should be a priority goal to promote more effective dialogue processes among stakeholders.

ACKNOWLEDGMENTS

The authors would like to thank the Andean Forests Program and Adaptation at Altitude Program, financed by the Swiss Agency for Development and Cooperation (SDC), for their financial support. The authors also thank the teams at CONDESAN for their support (in particular María Arguello, Alexandra Garcés, Karen Price, Geovanna Lasso, Ana C. Benitez, and Alejandra Melfo), as well as the many experts and institutions working in Andean mountain socio-ecosystems and climate change adaptation programs and policies for their invaluable contributions to the study.

OPEN PEER REVIEW

This article was reviewed by Catherine M. Tucker and Manuel Prieto. The peer review process for all MountainAgenda articles is open. In shaping target knowledge, values are explicitly at stake. The open review process offers authors and reviewers the opportunity to engage in a discussion about these values.

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