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Mountain social-ecological resilience requires transdisciplinarity with Indigenous and local worldviews

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Addressing the shocks of global crises requires that scientists, policymakers, and Indigenous Peoples and Local Communities work together to enable communities to withstand and adapt to disturbances. On the basis of our experiences in the Andes, we propose the ‘10-step cycle of transdisciplinarity’ for designing projects to build social-ecological resilience in mountains.

Mountain social-ecological resilience

Mountains are archetypal social-ecological systems in which reciprocal contributions between people and nature can be fostered, because they represent critical sources of water, food, energy, minerals, biodiversity, leisure, spirituality, and cultural identity [1]. This is the case of the Andes mountains in South America, where Indigenous Peoples and Local Communities (IP&LC)[†]

have adapted to and shaped their environments through a long history of mutual interactions, resulting in dynamic and resilient social-ecological systems. ‘Mountain social-ecological resilience’ (SER) refers to the ability of mountain social and ecological systems to withstand and adapt to disturbances while maintaining their functional properties that ensure the well-being and health of mountain societies and environments [2]. SER is expressed in Indigenous and local worldviews and knowledge systems that result from a continuous learning process as a response to socioeconomic changes, demographic shifts, land-use transformations, and other dynamics. Building mountain SER encompasses strengthening livelihood strategies, social cohesion, and local governance structures [1]. This effort is all the more critical in the Andes, where some of the largest tracts of well-conserved and managed ecosystems, biodiversity hotspots, centers of food crop origin and diversification, and Indigenous territories spatially co-occur, and many of these produce the resources lowland societies and major cities are dependent upon [3,4].

The United Nations (UN) proclamation of an International Year of Sustainable Mountain Development (2022), the target 15.4 of the Sustainable Development Goals (‘Ensure Conservation of Mountain Ecosystems’), as well as the declaration of the Decade of Ecological Restoration (2021–2030), reflect the political and economic efforts from UN signatories, including all seven Andean countries, to jointly identify and develop innovative pathways to build mountain SER. To achieve this goal, we argue that there is a need to bridge policy, science, and societies through transdisciplinary research and action, with a special focus on engaging with the worldviews and knowledge systems of IP&LC. For this, we propose the ‘10-step cycle of transdisciplinarity’ for

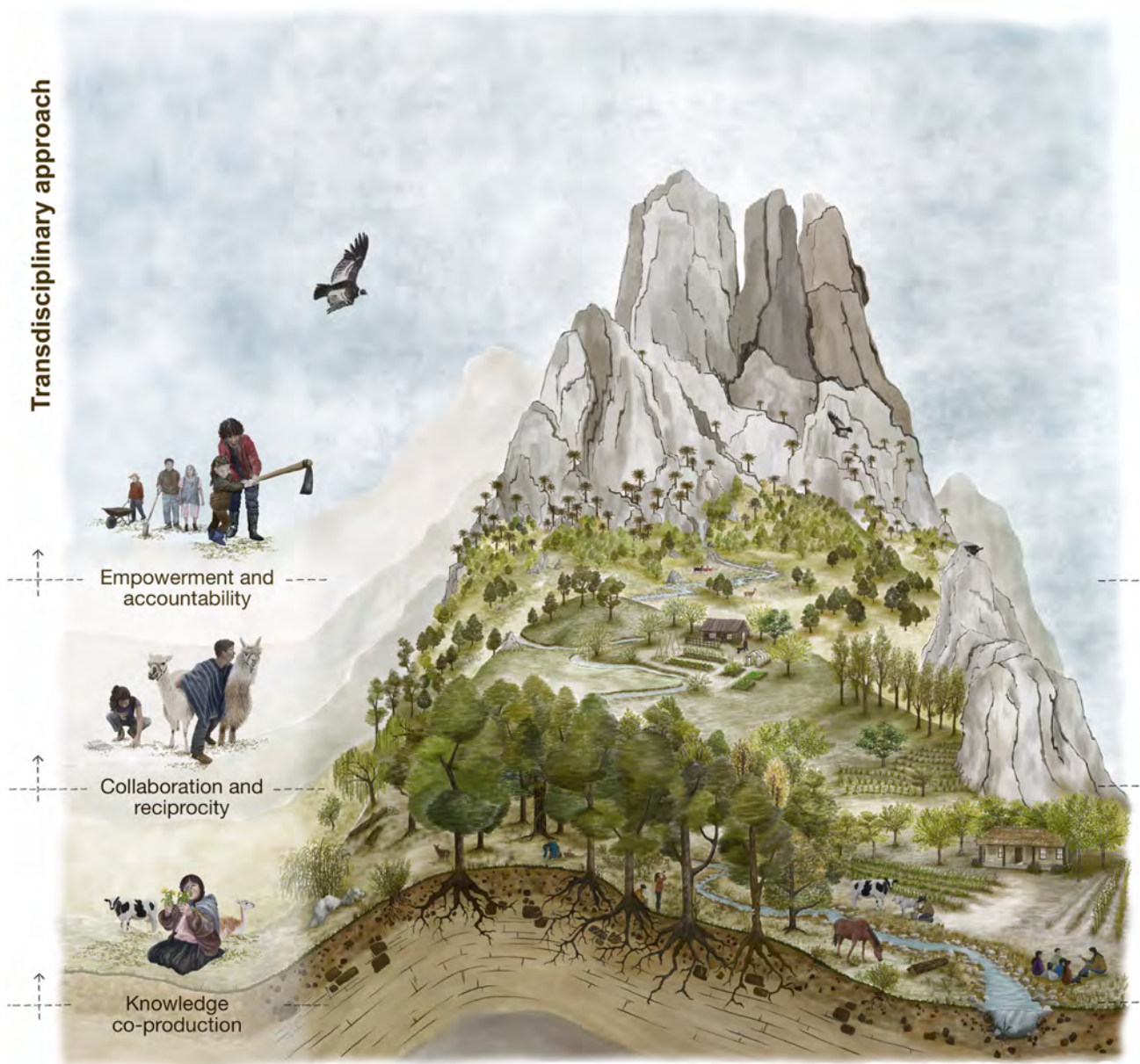
designing and implementing projects to build mountain SER with and for IP&LC.

Mountain policies in Andean countries

Over the past 15 years, several Andean countries have designed policies aimed at mountains, some of them including Indigenous and local worldviews by recognizing nature as a subject of rights or by including Indigenous concepts of well-being. These policies are needed to protect fragile Andean ecosystems, address climate change impacts, ensure water and food security for both mountain societies and downstream populations, strengthen cultural and Indigenous heritage, promote sustainable tourism, and establish efficient governance frameworks [1,3].

In 2016, for instance, the Chilean state promoted the formulation of a national policy on sustainable mountain development for 2030; but, after the first stage of formulation with an erratic citizen participation agenda, the process was interrupted. Both Chile and Peru are currently elaborating national policies on glaciers (which, in the case of Peru, is encompassed within a broader policy for mountain ecosystem conservation), acknowledging the key role of Andean social-ecological systems for the countries’ sustainable development. Ecuador and Bolivia have incorporated the rights of Mother Earth (*Pachamama*) into law for over a decade (Constitution of Ecuador of 2008, Bolivian Law of Mother Earth of 2010) and developed institutional support for ecological transitions in mountains and beyond. Both countries also adopted Andean Indigenous communities’ concept of ‘living well’ or *Sumak Kawsay* into their governmental goals, which is a holistic approach to life that emphasizes the harmonious coexistence of humans with nature, community well-being, and the fulfillment of human potential [5]. Although all these policies and legal

[†] We refer to both Indigenous peoples and other traditional and local communities which may not fall under the International Labour Organization (ILO) definition of ‘Indigenous Peoples’. We use the acronym ‘IP&LC’, instead of the most common one ‘IPLC’, because the latter has been criticized by Indigenous movements for undermining their interests.



Trends in Ecology & Evolution

Figure 1. Alexander von Humboldt climbed Mount Chimborazo in the Andes of Ecuador. During his expedition throughout the Americas, Humboldt developed the idea that Nature is a web of life and sketched the ‘Painting of Nature’ or Naturgemälde. Inspired by this art and ecological piece, here we suggest that a transdisciplinary approach can contribute to building social-ecological resilience in mountains with and for Indigenous Peoples and Local Communities. Illustration by María Medina.

frameworks in place may be seen as going in the right direction, they are not sufficient to secure Andean mountain SER in the face of global socioeconomic and environmental crises. Even in countries such as Bolivia and Ecuador, with

Andean worldviews incorporated into their legal frameworks, an extractivist development model prevails in practice [5]. Indeed, pressing drivers such as water scarcity and deforestation are resulting in growing pressures on mountain ecosystems, generating

social unrest and political instability [6]. How can these current social-ecological crises and political contexts be seized as opportunities to shift the way policy, academia, and IP&LC work together in building mountain SER in the Andes?

The contribution of transdisciplinarity

Transdisciplinarity is an adaptive and problem-focused approach that requires the input of different stakeholders and rights holders to address complex social-ecological problems. The relevance of transdisciplinarity has long been recognized as a convergent, integrative approach encompassing diverse disciplines [7]. It lies at the core of the ‘montology’ school of thought, which focuses on the integrative study of mountains [8]. However, transdisciplinarity also emphasizes the involvement of actors from outside academia to integrate multiple perspectives on knowing, acting, and being [7,8]. Deeply engaging with the worldviews and knowledge systems of IP&LC in transdisciplinary processes is imperative, because (i) understanding complex social-ecological problems in mountain contexts demands ‘knowledge co-production’ because the latter explicitly recognizes the multiple ways of knowing and doing to produce context-specific knowledge and pathways toward resilient mountain futures; (ii) a problem-solving focus requires ‘collaboration and reciprocity’ between scientists, IP&LC, and other stakeholders and rights holders, respecting ethical protocols and local priorities; and (iii) transformation strategies toward mountain SER, guided by IP&LC goals, creates ‘empowerment and accountability’ (Figure 1).

In the Andes, a dialogue between scientific knowledge and other worldviews and knowledge systems has led to more resilient livelihoods, including the design of mountain slopeland agroforestry and pastoralism initiatives [8], the maintenance of agrobiodiversity and traditional foods [4], and the identification of sacred sites and sentient mountains for the strict protection of certain areas in community-based tourism strategies [9]. Another important challenge that transdisciplinary research has helped address is integrating local knowledge about vernacular taxonomy of species, along with IP&LC’s descriptors of mountain features, in conservation management initiatives (e.g., migration routes, altitudinal zonification, geology, and flora and fauna) [10]. Transdisciplinary approaches have been implemented in decolonizing and social-ecological approaches to environmental education and biocultural revitalization, creating opportunities for biocultural expression and development [11] (Box 1), such as to value camelids and pastoralism in IP&LC territories [12]. In the domains of human and animal health in the Andes, transdisciplinary approaches have proved to be highly relevant culturally, ecologically, and economically, given the prevalence of traditional medicine and therapeutic practices in mountain societies [13]. Finally, learning processes involving researchers and IP&LC have contributed

to increase the latter’s adaptive capacity to climate change [14,15].

Steps for a transdisciplinary project to build mountain SER

To build mountain SER with and for IP&LC, we describe 10 steps for a transdisciplinary project (Table 1). However, it is important to emphasize that the specific implementation of such a project will vary on the basis of its context, scale, and objectives.

Toward a meaningful involvement of IP&LC through transdisciplinarity

Organized civil organizations as well as global and regional institutions[‡] are increasingly calling for the inclusion of the worldviews and knowledge systems of IP&LC into research and political agendas. For instance, since 2017, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services has systematically engaged with IP&LC to receive their inputs in all its chapters, organized dialogue workshops, and integrated contributions from different worldviews. However, we acknowledge that participatory processes that engage IP&LC in meaningful ways are often challenging because they question the foundations of Western science and society. In this perspective, decolonizing and Indigenous approaches could undoubtedly make important contributions to the growing field of transdisciplinarity.

Box 1. The project ‘Listening to Elders’ in the southern Andes of Chile, coproduced with rural schools, developed a transdisciplinary approach for building resilience and biocultural revitalization in Wallmapu, the ancestral land of the Mapuche Indigenous People

The ongoing disconnection of children from nature, known as the ‘extinction of experience,’ may lead to adverse effects on the care for mountain social-ecological systems. Factors such as rural exodus, rapid technological advancements, and sedentary lifestyles have contributed to this shift, resulting in a detachment of children from their mountain territories. To address this problem, the initiative called ‘Listening to Elders’ developed a transdisciplinary approach for building resilience and for biocultural revitalization in rural schools of IP&LC in the southern Andes, Chile. Mountain forests and birds served as the foundation for local narratives, collected by children, about long-term territorial changes. The initiative encouraged children to engage in social-ecological monitoring, facilitated intergenerational dialogues between children and elders, and developed artistic activities. The latter allowed children to give meaning to their collected narratives as they created contemporary artifacts (memes) to communicate their experiences within and beyond communities. During and after the project’s implementation, evaluations and reflections of the transdisciplinary steps and of the project as a whole were conducted. Reflections served to project future initiatives for building resilience in other components (e.g., food and health systems, agrobiodiversity and small-scale farming, wild edibles, wetlands and rivers, or wildlife) of local social-ecological systems [11].

The shock of global crises (e.g., environmental, climatic, socioeconomic, and health) must be turned into opportunities to promote new ways of coproducing knowledge among policymakers, academia, and IP&LC. The 10-step cycle of transdisciplinarity that we propose can

[‡] For example, the United Nations (UN), the International Satoyama Initiative (ISI), the Organization for Economic Cooperation and Development (OECD), the Intergovernmental Panel on Climate Change (IPCC), the Consortium for the Sustainable Development of the Andean Ecoregion (CONDESAN), and the Andean Mountain Initiative (IAM).

Table 1. The 10-step cycle of transdisciplinarity^a

Step		Description
1	Problem identification and framing	Clearly define, with participating IP&LC, the problem related to mountain SER. Consider the specific challenges, vulnerabilities, and opportunities that mountain regions face in terms of their human societies and ecological systems. Respect and genuinely include local worldviews, perspectives, and practices in the project.
2	Formation of a transdisciplinary team	Assemble a diverse team of experts from relevant disciplines, such as ecology, sociology, economics, geography, climatology, and anthropology, always including IP&LC. This step will ensure representation from different perspectives and expertise.
3	Building a common language and understanding	Foster a shared understanding of key concepts related to mountain SER. Develop a common language that enables effective communication and collaboration among team members from different areas.
4	Establishing common goals and objectives	Design and implement spaces aimed at facilitating discussions among team members. Establish shared goals and objectives for building mountain SER. Define the desired outcomes and impacts for social and ecological systems in mountain regions.
5	Data collection and analysis	Collect data on social, ecological, and IP&LC perspectives on mountain systems, using a mix of quantitative, qualitative, and IP&LC methods. Analyze the data to gain insights into the dynamics, interactions, and feedback between human and other-than-human actors in the system (e.g., IP&LC, policymakers, other institutions, biodiversity, climate, water, soils, habitats, etc.), as well as on transformative pathways toward mountain SER.
6	Collaborative problem-solving	Engage team members in collaborative problem-solving activities, considering potential scenarios for mountain social-ecological systems. Promote knowledge sharing, complementarity, and synthesis across perspectives to understand the complex interactions and potential solutions to problems in mountain regions.
7	Iterative feedback and refinement	Regularly seek feedback from team members, participating IP&LC, stakeholders and rights holders, and external experts to refine project methodologies, approaches, and findings. Iteratively improve the project based on this feedback.
8	Synthesis and integration of findings	Integrate the findings from social-ecological and Indigenous research to develop a comprehensive understanding of mountain SER. Identify synergies and trade-offs between different dimensions of resilience and propose strategies for enhancing mountain SER.
9	Communication and dissemination	Communicate the project findings, insights, and recommendations to mountain communities, scientists, policymakers, and practitioners. Use a range of communication formats and channels to ensure broad dissemination and engagement, including publications, multimedia, reports, policy briefs, workshops, and community events (see [11] for an example; Box 1).
10	Reflectivity: evaluation and projection	Evaluate the project's trajectory, outcomes, impacts, and lessons learned. Reflect on the effectiveness of the transdisciplinary approach in enhancing mountain SER. Identify areas for improvement and apply these insights to current and/or future projects.

^aThis can be used as a roadmap to design and implement projects with and for IP&LC with a specific focus on mountain SER.

contribute to designing and implementing projects in view of building mountain SER with and for IP&LC. However, beyond innovating knowledge production practices through this type of transdisciplinary approach, it is also necessary to fully incorporate them into longer-term governmental, development cooperation, and research and education programs.

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Declaration of interests

The authors have no interests to declare.

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