TITLE: Resilience requires change. Assessing Pehuenche responses to climate change impacts in Southern Chile.

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KEYWORDS: Climate Change; Resilience; Indigenous People; Adaptation; Policy; Chile.

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Abstract

Indigenous peoples are one of the most vulnerable groups to climate change. Although many communities are already responding to these impacts, inequitable structures impose barriers to their capacity to recover and adapt. Through the case of the Pehuenche people of Southern Chile, this article addresses the question of what is the relationship between resilience and adaptation to climate change. From an ethnographic approach, the article characterizes the construction process of the contextual vulnerability of Pehuenche communities and evaluates their responses to cope with climate change impacts. Fieldwork was conducted in two stages between 2017 and 2019. Results show that current Pehuenche vulnerability to climate change is an ongoing process influenced by the state rather than a consequence of this phenomenon. Although Pehuenche communities are responding to climate change impacts, their resilience is constrained by the incidence of state policy. Identifying themselves as herders, Pehuenche responses aim to restore the conditions for livestock instead of changing the factors that make them vulnerable. Most of their responses can be considered maladaptation because they reinforce vulnerability by reproducing practices that damage their social capital and cause more pressure on the territory. A critical review and reformulation of the policy implemented at the local level are mandatory to strengthen community resilience.

Key words: climate change; resilience; indigenous people; adaptation; policy; Chile.

Introduction

Indigenous peoples are one of the most vulnerable to climate change impacts.[1] Their high vulnerability originates in their strong interdependence to their environments.[2] But above all, in inequitable structures that have excluded them from decision making processes and pushed communities to inhabit territories with extreme geographic and climatic conditions,[3] many of which are also disproportionately affected by environmental liabilities.[4] For centuries, indigenous societies have elaborated coping strategies, and some of them are already adapting to climate change.5 Nevertheless, inequality, coloniality dynamics[6] and the speed of the changes7 impose barriers to their resilience.

1IWGIA, "Conference on Indigenous Peoples and Climate Change. Copenhagen, 21 – 22 February 2008. Meeting Report. Submitted by the International Work Group for Indigenous Affairs (IWGIA)" (New York: Permanent Forum on Indigenous Issues Seventh session, 2008), https://www.ipcc.ch/apps/njlite/ar5wg2/njlite_download2.php?id=10166#:~:text=Indigenous%20peoples%20are%20affected%20by,and%20reductions%20in%20rainfall%20in.

2Colburn, Lisa, Michael Jepson, Changhua Weng, Tarsila Seara, Jeremy Weiss, and Jonathan Har. "Indicators of Climate Change and Social Vulnerability in Fishing Dependent Communities along the Eastern and Gulf Coasts of the United States." Marine Policy 74 (2016): 323–33.

3Rebecca Tsosie, "Indigenous People and Environmental Justice: The Impact of Climate Change," *University of Colorado Law Review* 78 (2007): 1625–77.

4Denise Humphreys Bebbington y Anthony J. Bebbington, "Extracción, territorio e inequidades: el gas en el Chaco boliviano", *Umbrales. Revista del Postgrado Multidisciplinario en Ciencias del Desarrollo*, 2010, 127–60.

5E. N. Ajani, R. N. Mgbenka, and M Okeke, "Use of Indigenous Knowledge as a Strategy for Climate Change Adaptation among Farmers in Sub-Saharan Africa: Implications for Policy.," *Asian Journal of Agricultural Extension, Economics & Sociology* 2 (2013): 23–40; Gyampoh, Benjamin, S Amisah, Monica Idinoba, and Johnson Nkem. "Using Traditional Knowledge to Cope with Climate Change in Rural Ghana." Unasylva 60 (2009): 70–74; R.A.B. Kpadonou, Y. Adégbola, and S. D. Tovignan. "Local Knowledge and Adaptation to Climate Change in Ouémé Valley, Benin." African Crop Science Journal 20 (2012): 181–92.; Douglas Nakashima, Kirsty Galloway McLean, Hans Thulstrup, Ameyali Ramos Castillo, and Jennifer Rubis. *Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* (Paris: Darwin: UNESCO; UNU-IAS, 2012); Nancy Turner and Helen Clifton., "'It's so Different Today': Climate Change and Indigenous Lifeways in British Columbia, Canada," *Global Environmental Change* 19 (2009): 180–90, doi:https://doi.org/10.1016/j.gloenvcha.2009.01.005.

6Nick Bernards. "'Latent' Surplus Populations and Colonial Histories of Drought, Groundnuts, and Finance in Senegal," *Geoforum*, October 2019, S0016718519302969, doi:10.1016/j.geoforum.2019.10.007.

7Álvaro Fernández-Llamazares, Isabel Díaz-Reviriego, Ana C. Luz, Mar Cabeza, Aili Pyhälä, and Victoria Reyes-García. "Rapid Ecosystem Change Challenges the Adaptive Capacity of Local Environmental Knowledge," *Global Environmental Change* 31 (March 2015): 272–84.

Resilience is a key concept in climate change discussions,[8] yet a controversial one. It has focused largely on the ability of social-ecological systems to cope with stress and recover the integrity of previous functional relationships.[9] This approach diverts the discussion about the structural causes that promote vulnerability at the local level,[10] ignoring the question of why certain communities are more vulnerable than others.

Vulnerability to climate change can be understood as a result of historical processes, institutions and political structures.[11] That is, a context in which climate change occurs, rather than a result of this phenomenon. This contextual vulnerability limits the communities' range of action; oftentimes they do not see any other way out than to reproduce those activities that make them vulnerable, such as the cultivation of unsustainable crops.[12] Climate change, along with other non-climate pressures, could push people to poor planning[13] and to make decisions whose benefits in the present are outweighed by negative effects in the long term.[14] Those responses have the potential to increase vulnerability, and are understood as maladaptation.[15] For example, maladaptation can occur when the main responses to climate

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8Bimo Nkhata, "Climate Change and Water Resources in Southern Africa: A Resilience Perspective," in *The Palgrave Handbook of Climate Resilient Societies*, ed. Robert Brears (Cham: Palgrave Macmillan, 2020), https://doi.org/10.1007/978-3-030-32811-5_98-1.

9Roberto Barrios, "Resilience: A commentary from the vantage point of anthropology", *Annals of Anthropological Practice* 40, no 1 (2016): 28–38.

10Roberto Barrios, "Resilience: A Commentary from the Vantage Point of Anthropology," *Annals of Anthropological Practice* 40 (2016): 28–38.

11Karen O'Brien et al., "Why different interpretations of vulnerability matter in climate change discourses", *Climate Policy* 7, no 1 (2007): 73–88.

12 Nick Bernards. "'Latent' Surplus Populations and Colonial Histories of Drought, Groundnuts, and Finance in Senegal." Geoforum, (2019) S0016718519302969. https://doi.org/10.1016/j.geoforum.2019.10.007.

13Michael Mason, "The Ends of Justice: Climate Vulnerability beyond the Pale," in *The Governance of Climate Change*, ed. David Held, Marika Theros, and Angus Fane-Hervey (Cambridge: Polity, 2011), 162–82, http://eprints.lse.ac.uk/36656/.

14Mark Pelling, *Adaptation to Climate Change: From Resilience to Transformation* (London and New York: Routledge, 2011).

15Jon Barnett and Saffron O'Neill, "Maladaptation," *Global Environmental Change* 20 (May 2010): 211–13, doi:10.1016/j.gloenvcha.2009.11.004; Sirkku Juhola et al., "Redefining Maladaptation," *Environmental Science & Policy* 55 (January 2016): 135–40, doi:10.1016/j.envsci.2015.09.014; Alexandre Magnan and Gaëll Mainguy, "Avoiding Maladaptation to Climate Change: Towards Guiding Principles," *S.A.P.I.EN.S [Online]* 7 (2014): 12; I.R. Noble et al., "Adaptation Needs and Options," in *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part A: Global and Sectoral Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change [Field, C.B., V.R. Barros, D.J. Dokken, K.J. Mach, M.D. Mastrandrea, T.E. Bilir, M. Chatterjee, K.L. Ebi, Y.O. Estrada, R.C. Genova, B. Girma, E.S. Kissel, A.N. Levy, S. MacCracken, P.R. Mastrandrea, and L.L. White (Eds.)]*. (Cambridge, United Kingdom and New York,

change aim to reduce its impacts on household economies, ignoring the necessary reflections and actions to reduce vulnerability in the long term. Such is the case of communities in San Felipe, Mexico, where temporary employment programs have become the main adaptation strategy.[16] Or poor communities affected by floods and rainstorms in Ilorin, Nigeria, whose first coping mechanism is to resort to loans or family savings.[17]

Considering this, resilience is determined by multiple factors, such as material and human capital, which can be translated into organizational capacity and autonomy to make decisions,[18] but also by historical processes and people's relationship with their territory. Because the event a society recovers from is part of its social dynamics, resilience must point to questioning the systems that determined vulnerability[19] and, ideally, change them through "adaptive processes that facilitate the social system's ability to reorganize, change and learn in response to a threat."[20] These processes must be socially and environmentally sustainable, but most importantly, they should aim to reduce vulnerability from a social[21] and environmental justice approach that addresses socio-ecological inequality and strengthens local capabilities.[22]

NY, USA: Cambridge University Press, 2014), 833–68; E. L. F. Schipper, "Maladaptation: When Adaptation to Climate Change Goes Very Wrong," *One Earth* 3 (2020): 409–14.

16Denise Soares y Isabel Gutierrez, "Vulnerabilidad social, institucionalidad y percepciones sobre el cambio climático: un acercamiento al municipio de San Felipe, Costa de Yucatán", *CIENCIA ergo-sum : revista científica multidisciplinaria de la Universidad Autónoma del Estado de México* 18, no 3 (2012): 249–63.

17Siri Eriksen et al., "When not every response to climate change is a good one: Identifying principles for sustainable adaptation", *Climate and Development* 3, no 1 (2011): 7–20, https://doi.org/10.3763/cdev.2010.0060.

18Caroline Moser, "The asset vulnerability framework: Reassessing urban poverty reduction strategies", *World Development,* 1, no 26 (1998): 1–19.

19Barrios, "Resilience: A Commentary from the Vantage Point of Anthropology."

20Susan L. Cutter et al., "A Place-Based Model for Understanding Community Resilience to Natural Disasters", *Global Environmental Change* 18, no 4 (octubre de 2008): 599, https://doi.org/10.1016/j.gloenvcha.2008.07.013.

21Eriksen et al., "When not every response to climate change is a good one: Identifying principles for sustainable adaptation"; O'Brien et al., "Why different interpretations of vulnerability matter in climate change discourses".

22Amartya Sen, *Commodities and Capabilities* (Amsterdam: North-Holland, 1985); David Schlosberg y David Carruthers, "Indigenous Struggles, Environmental Justice, and Community Capabilities", *Global Environmental Politics* 10, no 4 (2010): 12–35.

In Chile, indigenous communities are one of the most vulnerable to climate change,[23] especially those who live in the mountains.[24] Furthermore, due to the lack of policies that address their specific vulnerability, the latter has increased in the last decade.[25] This article aims to address the question of what is the relationship between resilience and adaptation to climate change through the case of Pehuenche people of Southern Chile. To achieve this goal, and from an ethnographic approach, this article identifies the incidence of the state in the construction of the Pehuenche contextual vulnerability to climate change, and assesses Pehuenche resilience by evaluating their responses to climate change impacts.

Material and Methods

a. Lonquimay and its Mapuche-Pehuenche population

Lonquimay is located in a high intra-Andean valley in Southern Chile, at an average altitude of 925 m a.s.l. (figure 1). It is the second poorest commune in the poorest region of Chile; La Araucanía. Autonomous household income per capita income barely reaches 104 USD per month, and 64.4% of its population live in multidimensional poverty –a percentage which has increased in the last years.[26] Besides, in Chile, mountain communes show indicators of quality of life lower than those of the rest of the national population.[27]

23Consuelo Biskupovic, Macarena Sepúlveda, and Rosario Carmona, "Ley Marco de Cambio Climático y Pueblos Indígenas En Chile. Elementos Para Su Incorporación" (Serie Policy Papers, CIIR., 2020), http://www.ciir.cl/ciir.cl/wp-content/uploads/2020/03/policy-paper-UPP-n%C2%BA-7-2020.pdf.
24Carla Marchant, "Factores Que Afectan La Sustentabilidad de Las Comunas de Montaña. El Caso de La Comuna de Lonquimay, Región de La Araucanía, Chile," *Revista de Historia y Geografía* (2011): 55–73.
25Elvis Parragez, Jonathan Barton, and Gabriela Raposo-Quintana, "Impacts of Climate Change in the Andean Foothills of Chile: Economic and Cultural Vulnerability of Indigenous Mapuche Livelihoods," *Journal of Developing Societies* 32 (2016): 454–83.
26MIDESO, "Encuesta de Caracterización Socioeconómica Nacional CASEN" (Ministerior de Desarrollo Social. Gobierno de Chile, 2015); MIDESO, "Encuesta de Caracterización Socioeconómica Nacional CASEN" (Ministerior de Desarrollo Social. Gobierno de Chile, 2017).
27Marchant, "Factores Que Afectan La Sustentabilidad de Las Comunas de Montaña. El Caso de La Comuna de Lonquimay, Región de La Araucanía, Chile."

Lonquimay has a population of 10,251 inhabitants, of which 63.1% is rural and 56% is indigenous,[28] Pehuenche.[29]

Lonquimay has a cold steppe climate, with very cold and wet winters –snow can reach three meters and the temperature -20˚C. As a mountain territory, Lonquimay is highly sensitive to environmental changes.[30] Projections indicate that the 0ºC isotherm will rise in this area between 300 and 500 meters.[31] This situation will increase runoff from the basins and winter flooding of the rivers, reducing water storage in the mountains and decreasing summer flows, making Lonquimay highly vulnerable to drought.[32]

b. Methods

Data construction

The data were constructed through a qualitative ethnographic methodology in two stages between September 2017 and November 2019. The research protocol was approved by the Ethics Committee of the Academia de Humanismo Cristiano University in Chile, and we asked the participants for prior informed consent. Documentary research was conducted to assess the contextual vulnerability of Pehuenche communities from a historical perspective.

This study used a purposive sampling technique to interview 30 actors involved in the implementation of indigenous policy in Lonquimay: ten were officials of the Ministry of Agriculture in charge of implementing indigenous policies; ten were Pehuenche officials who live in a community in Lonquimay and work in the municipality supporting the

28INE, "Censo" (Gobierno de Chile, 2017).
29The Pehuenche are a subgroup of Mapuche people who inhabit the area of the Andes characterized by the presence of the monkey puzzle tree (*Araucaria araucana*). This tree is called Pehuen by local inhabitants. In Mapuche language, Pehuenche means People of Pehuen.
30Bruno Messereli and Jack Ives, eds., *Mountains of the World: A Global Priority* (New York and Carnforth: Parthenon Publishing, 1997).
31MMA, "Plan de adaptación al cambio climático del sector silvoagropecuario" (Ministerio de Medio Ambiente, 2013).
32(CR)2 y Ministry of Environment, "Atlas de Riesgos Climáticos para Chile" ((CR)2 and Ministry of Environment, 2020), https://arclim.mma.gob.cl/.

implementation of these policies; and ten were Pehuenche leaders, who live in a rural community and are beneficiaries of these programs. Participants ranged in age from 30 to 50 years old. All respondents were asked about: i. the main livelihood activities in Lonquimay; and ii. the function and scope of the policies implemented in indigenous communities. Additionally, indigenous participants were asked about: i. perceptions of changes attributed to climate change during the last thirty years; ii. impacts of these changes on Pehuenche livelihoods; iii. Pehuenche reflections, organization and responses around these impacts; iv. objectives and scope of the responses; and v. barriers to these responses. Also, the implementation of policies was observed in the field. Officials were accompanied and observed how they interacted with the indigenous population, both in the municipality, in community meetings and in the homes of the Pehuenche.

Data analysis

Content analysis was carried out assisted by ATLAS.ti. The contextual vulnerability of the Pehuenche communities was assessed according to socioeconomic indicators, and evaluating the level of Pehuenche dependence (high, medium, low) on land resources and state aid. Deductive coding was applied to interview responses based on the following categories: main Pehuenche livelihoods; dependence on land resources; incidence of state policy on Pehuenche economies; environmental changes attributable to climate change; impacts of these changes on livelihoods; Pehuenche responses to these impacts; objectives of such responses; and barriers of theses responses.

The climate change impacts affecting local livelihoods that were mentioned more than once were organized into three categories: i. water; ii. weather; iii. flora and fauna. We analyzed responses refereeing to the impacts of these changes in Pehuenche livelihoods through economic losses or limiting the transmission of local knowledge.

The resilience of the Pehuenche was evaluated based on their potential to adapt to climate change impacts. Adaptation requires actions that ensure their sustainability[33] and reduce adverse impacts.[34] Conversely, responses that increase the causes of vulnerability are considered as maladaptation.[35] We evaluate how Pehuenche responses address or reinforce contextual vulnerability by analyzing how these responses relate to the factors that produce vulnerability (e.g. welfare, degradation). The responses that try to address or change the factors that produce contextual vulnerability, and which do not cause negative effects, were classified as potential adaptation. While responses that attempt to return to previous conditions, but either reinforce the factors that produce vulnerability or their benefits are outweighed by negative effects, were classified as potential maladaptation.

Results

The construction of the Pehuenche contextual vulnerability

Lonquimay origin dates back to the processes of Pacification of Araucanía in Chile and the Conquest of the Desert in Argentina,[36] which had the objective of expanding agricultural and livestock frontiers through indigenous dispossession and territorial emptying.[37] Several Mapuche families from the valleys of central-southern Chile, and the

33Neil Adger, Nigel Arnell, and Emma Tompkins."Successful Adaptation to Climate Change across Scales Nigel W. Arnella,c, Emma L. Tompkins," *Global Environmental Change* 15 (2005): 77–86; Barry Smit et al., "An Anatomy of Adaptation to Climate Change and Variability," *Climatic Change* 45 (2000): 223–51; Barry Smit, Olga Pilifosova, I Burton, B Challenger, S Huq, and R.J.T. Klein. "Adaptation to Climate Change in the Context of Sustainable Development and Equity," in *Climate Change 2001: Impacts, Adaptation and Vulnerability, Contribution of Working Group II to the Third Assessment Report of the Intergovernmental Panel on Climate Change*, ed. J. J. McCarthy et al. (Cambridge: Cambridge University Press, 2001), 877–912.

34Smit et al., "Adaptation to Climate Change in the Context of Sustainable Development and Equity."

35Pelling, *Adaptation to Climate Change: From Resilience to Transformation*.

36José Bengoa. *Quinquén. Cien Años de Historia Pehuenche* (Santiago: Ediciones Chile América CESOC, 1992).

37Héctor Alimonda. "La Colonialidad de La Naturaleza. Una Aproximación a La Ecología Política Latinoamericana," in *La Naturaleza Colonizada. Ecología Política y Minería En América Latina*, ed. Héctor Alimonda (CLACSO, 2011), 21–60.

Andean valleys of central Argentina, took refuge in Lonquimay among the former Pehuenche inhabitants.

The characteristics of Lonquimay soil, volcanic and erosion-prone, prevent the development of intensive agriculture. Since 1881, the economy was promoted through extractivism and livestock.[38] The native forest was exploited through slash-and-burn,[39] and currently, the territory is highly deforested and eroded. Today, the native forest is protected by the Forest Law, but forests continue to be exploited for the extraction of non-timber forest products, especially the pehuen (*Araucaria araucana*) pine nut. Since the 1990s, the state has promoted reforestation with exotic species –contorta and ponderosa pines–, which have been subsidized thanks to the 701 Decree.[40] According to most of the Pehuenche participants, these plantations have led to biodiversity loss and drought.

Deforestation facilitated animal husbandry. The state has promoted livestock through policies and also by influencing the Pehuenche cultural identity: the municipal coat of arms depicts a goat. Pehuenche identify themselves as herders. Lack of planning has led to overgrazing, which, added to the population increase, has reinforced deforestation and erosion. Besides, as agricultural activities are mostly destined to feeding livestock, crop diversity has decreased. Conversely, livestock profits do not cover production costs – Lonquimay does not have a slaughterhouse, so animals are not sold for high prices in regional

38Peralta, 1980 in Marchant, "Factores Que Afectan La Sustentabilidad de Las Comunas de Montaña. El Caso de La Comuna de Lonquimay, Región de La Araucanía, Chile."

39Luis Otero. *La Huella Del Fuego. Historia de Los Bosques Nativos. Poblamiento y Cambios En El Apisaje En El Sur de Chile* (Santiago: Pehuén, 2006).

40 This decree has fostered forestry as an extractive activity. The social and environmental impacts of forestry over the Mapuche territory have been widely discussed (see José Aylwin, Nancy Yáñez, and Rubén Sánchez, *Pueblo Mapuche y Recursos Forestales En Chile: Devastación y Conservación En Un Contexto de Globalización Económica* (Santiago de Chile: Observatorio Ciudadano - IWGIA, 2013); Pablo Camus, "De La Panacea a La Tragedia. Bosques, Erosión y Forestación En Chile. Siglos XIX y XX," *Revista de Historia Iberoamericana* 7, no. 2 (2014): 10–19; Pablo Camus Gayan, *Ambiente, bosques y gestión forestal en Chile 1541-2005* (Santiago de Chile: Dirección de Bibliotecas, Archivos y Museos, Centro de Investigaciones Diego Barros Arana, 2006); Eduardo Mondaca, "La Re-Existencia Mapuche Frente al Extractivismo Forestal En Un Contexto de Neoliberalismo Armado," in *Ecología Política Del Extractivismo En América Latina: Casos de Resistencia y Justicia Socio-Ambiental*, ed. Gian Carlo Delgado (Buenos Aires: CLACSO, 2013), 19–41; Robinson Torres-Salinas et al., "Desarrollo Forestal, Escasez Hídrica y La Protesta Social Mapuche Por La Justicia Ambiental En Chile," *Ambiente & Sociedade* 19, no. 1 (2016): 121–46).

markets. And since 2012, due to a changing climate, livestock production has started to decrease.[41]

The Pehuenche mentioned that they do not know what other activity they could do. Sustain livestock requires state aid, which is implemented by the municipality and the Institute for Agricultural Development (INDAP) of the Ministry of Agriculture. Bonds and subsides represent 30% of the family income. However, this aid has strengthened dependence on welfare.

Since the 1990s, indigenous policies aimed at socio-economic development complement state assistance. These policies have not been efficient; they do not have clear targets, are subject to constant reformulations, have multiple management problems and do not measure effectiveness and quality.[42] This failure goes back to its design, which omits indigenous participation or reduces it to mere consent, and is reinforced by its implementation, which lacks a coordinated multisectoral approach. Furthermore, these policies reduce indigenous situation as a poverty problem,[43] and address it from a multicultural perspective.[44]

The indigenous policies that have had the most impact in Lonquimay are those aimed at purchasing land and foster agriculture and livestock. The purchase of land is regulated by the Indigenous Law 19,253 through its Land Fund. Although the main objective of this fund is to transfer public lands, the mechanism has led to the purchase of private lands,[45] leading to

41RIMISP, CORFO, Fundación superación de la pobreza, CNID, FACSO, USACH, and BID. "Informe Territorio Funcional Lonquimay Región de La Araucanía" (RIMISP, 2017), http://rimisp.org/prototipodeinnovacionsocial/wp-content/uploads/2018/03/Lonquimay.pdf.
42Isabel Aninat and Andrés Hernando. "Mapeando El Laberinto de La Política Pública Indígena En Chile," *Estudios Públicos* 153 (2019): 7–56.
43Francisca de la Maza. "Construir El Estado En El Espacio Rural e Indígena: Un Análisis Desde La Etnografía Del Estado En La Araucanía, Chile," *RURIS - Revista Do Centro de Estudos Rurais* 6 (2012): 239–66.
44Enrique Antileo. "Nuevas Formas de Colonialismo: Diáspora Mapuche y El Discurso de La Multiculturalidad" (Magíster en Estudios Latinoamericanos, Universidad de Chile, 2013).
45Mayarí Castillo. "Socio-Ecological Inequality and Water Crisis: Views of Indigenous Communities in the Alto Loa Area," *Environmental Justice* 9 (2016): 9–14, doi:10.1089/env.2015.0023.

speculation and overvaluation. This situation, added to budget shortages, has promoted community division, resource competition and illegal land seizures.

The most relevant policy is the Indigenous Territorial Development Program (PDTI) of INDAP, which is not well evaluated neither by the state[46] nor the participants. Through the support of cattle handling and cultivation of pastures, this program has reinforced homogenous agriculture and livestock systems. Along with technical support, the PDTI imparts training activities, which, despite being in high demand, have not improved local economies. Furthermore, the PDTI is based on a loan system that promotes family projects, diluting collective responsibilities. By configuring new boards, the PDTI has also damaged the traditional modes of organization.

As it can be observed, state policy has regulated the relation with the territory, prescribing specific activities and controlling what people do and their access to the natural resources.[47] On the other hand, by encouraging competition for resources and limiting biodiversity, these policies have promoted Pehuenche vulnerability and dependence on state aid.[48] In this context, the Pehuenche face a series of climatic changes[49] that rebound on their contextual vulnerability.

Climate change impacts and Pehuenche responses in Lonquimay

All participants reported many impacts on Pehuenche livelihoods, which were attributed to climatic changes that are interrelated. The Pehuenche expressed uncertainty and concern, they are dealing with a complex scenario. The officials mentioned the changes are accelerating, limiting the communities' capacity to respond.

46Aninat and Hernando. "Mapeando El Laberinto de La Política Pública Indígena En Chile."
47Robert D Sack, "Human Territoriality: A Theory", *Annals of the Association of American Geographers* 73, no 1 (1983): 55–74.
48Elvis Parragez, Jonathan Barton, and Gabriela Raposo-Quintana. "Impacts of Climate Change in the Andean Foothills of Chile: Economic and Cultural Vulnerability of Indigenous Mapuche Livelihoods."
49ARClim, "Atlas de Riesgos Climáticos Para Chile" (Chile: MMA, 2020), https://arclim.mma.gob.cl/.

i. Changes in water

The major environmental change perceived in Lonquimay is the decrease of fresh water, due to deforestation and increasing temperatures. All participants mentioned that precipitations have decreased, augmenting the frequency and intensity of drought and leading to water scarcity, especially for the most dense, deforested and degraded communities.

To cope with water scarcity, families request the municipality to distribute water through cistern trucks. Around 30% of them depend on this water in summer.[50] This measure means unprecedented municipal spending. And participants agree that water has poor quality and is insufficient. Besides, it reinforces the communities dependence on the government.

All participants agree that forest restoration is necessary to address drought. But families cannot afford this project by themselves and institutional support is required. Some families have asked support to close the springs areas to prevent the passage of livestock. This measure improves water availability, however, it still encounters resistance because it restricts the livestock area. Some communities ask support from the Ministry of Agriculture's Forestry Corporation to reforest with native species. This measure requires nurseries and high care for the seedlings. Unfortunately, due to the lack of coordination, the results have not been successful and many projects have been abandoned.

Drought also impacts livestock feed. Natural grasslands are decreasing, so the Pehuenche have turned from crops for human consumption to crops for animal consumption. Before, the main crops were wheat, oats and beans. Today, they buy these foods from the market and produce mainly alfalfa, which is treated with a huge amount of pesticides. Neither is there enough water to irrigate these sown grasslands, which have also become less productive due to rising temperatures. Food shortage starves livestock and increases mortality rates, pushing families to invest in fodder at times where, previously, it was not required.

50Oscar Samuel Cayul and Daniel Quilaqueo. "Cambio Climático En Lonquimay: Conocimiento Científico y Conocimiento Local Mapuche-Pehuenche," *Revista Austral de Ciencias Sociales* 37 (2019): 123–38.

Some families organize themselves to cover the costs together, nevertheless, most families ask for aid from the municipality and INDAP. Others end up selling the animals earlier and cheaper than planned. Although this measure reduces overgrazing, it increases contextual vulnerability since cattle are considered “the saving of the Pehuenche.” All Pehuenche agree that livestock is unsustainable, but they do not visualize other options yet.

ii. Changes in the seasons

According to the participants, the rhythm of the seasons to which they are accustomed has been altered, disturbing the ecological balance. Temperatures have increased, transition seasons disappeared and the weather is unpredictable.

Winter is perceived warmer and drier than before. But also longer because blizzard episodes have increased and spring minimum temperatures have decreased. The prolongation of winter increases livestock disease and mortality rates. Furthermore, females are giving birth earlier, and many of them do not produce milk. Illness decreases animal prices, as well as the availability of meat and milk for human consumption. These changes demand new investments, from milk replacement formula to the construction of sheds and shelters. To access more revenue, families with no debts with INDAP apply for loans, while the majority migrate north during summer to work in temporary jobs. These jobs offer precarious working conditions and demand great family effort and travel expenses.

Summer has also changed and takes weeks to stabilize. Maximum temperatures have increased and the sun is more intense. These changes hinder agricultural planning, labor and production. Many species that were staple foods cannot be produced anymore, such as potatoes and quinoa. To cope with food scarcity, families relay on markets, which are difficult to access in winter. Moreover, frost episodes that burn crops have increased, installing further fodder expenditure.

Taking advantage of rising temperatures, many families have made gardens and, those who have the means, have built greenhouses, where they introduced new species such as lettuce and tomato. Although both activities are affected by climate, they represent an opportunity to strengthen food sovereignty and to revitalize agroecological practices, such as the use of smoke to control frost and ash as fertilizer.

The participants reported increases in summer rains, which, coming from higher altitudes, are colder and more intense. These rains have increased the occurrence of landslide episodes, which in turns increments erosion and hazards. The frequency of dry thunderstorms has also increased, augmenting fires. By strengthening their organizational and associative capacity, the Pehuenche created their own brigade to prevent these fires. However, the lack of infrastructure, institutional support and capacities limits their success.

Changes in the seasons impact Pehuenche culture. Climate variability makes forecasting difficult. And forecasting inaccuracies make local knowledge less reliable and decrease its transmission. The loss of knowledge is a matter of great concern among the Pehuenche, as they consider that it diminishes autonomy and increases dependence on the state. Pehuenche leaders are organizing community meetings to discuss how to strengthen cultural and spiritual values. However, due to individualism promoted by policy, there are obstacles to summon families for these meetings.

Some families have asked institutional support to INDAP to develop tourism as an economic alternative. Tourism has had positive effects such as environmental care and appreciation of Pehuenche culture. For example, communities offer excursions where they explain the cultural relevance of the territory and share Pehuenche dishes. These tours end with a meeting around the fire where they explain Mapuche worldview and history. Notwithstanding, tourism also produces negative impacts: it increases pollution –garbage management has not been improved accordingly– and local inequality, since most families

find bureaucracy barriers and do not have enough resources or adequate sanitary conditions to receive visitors.

iii. Changes in flora and fauna

Regarding flora, most of the reported changes relate to grasslands (mentioned above), herbs and trees. Participants noted fewer *lawenes* (medicinal herbs), which impacts traditional health system, making the Pehuenche dependent on conventional medicine.

Native trees are perceived as weaker and sicker. All the participants mentioned that the trees broke due to the snow weight, increasing deforestation and erosion. This weakness is read as a bad omen and is attributed to a plague or disease that the Pehuenche have not yet been able to identify. The most emblematic case is that of the pehuen tree, participants said "the pehuen is getting sick, it is dying." Pehuen disease has modified the pine nut production, affecting regeneration. Besides, the participants perceive that the pehuen is more affected by lightning than before and is catching fire quicker.

The pehuen disease has affected the Pehuenche economy –the pine nut is called "Pehuenche gold"–, as well as their culture and identity. The Pehuenche wonder whether they can still be considered as Pehuenche if they stop eating pine nuts. On the other hand, the situation has opened a national debate on the conservation status of the pehuen.[51] The Pehuenche know that if the conservation status changes, the state will introduce more restrictions. Therefore, they have organized to contribute to the elaboration of a national conservation plan, nevertheless, they perceive that their culture and knowledge are not taken seriously.

To cope with the economic losses, and although few recognize it, the sale of firewood continues to be the quickest way to access cash. Nevertheless, this practice is illegal and

51Currently classified as vulnerable.

socially condemned. Conflicts have arisen between those who continue to extract firewood and those who try to protect the forests.

Regarding fauna, some native species have diminished or changed their behavior. Participants claim to have seen the condor only a few meters away. And the puma is coming closer to the residential areas, attacking domestic animals. The only response reported is the decrease in the rearing of domestic animals.

As can be seen (table 1), Pehuenche responses can be considered multi-strategic. They range from ecological restoration projects to applying for more state aid. High rates of poverty and damage to social capital impose significant barriers to the success of responses that address contextual vulnerability, even in the case of community meetings. On the other hand, more than half of the responses do not address the factors that produce vulnerability or generate negative effects. Pehuenche identification as herders determines that their responses primarily aim to restore conditions for livestock, which, everyone admits, is not sustainable. Mechanisms to access more resources have an impact on the territory, like logging, and on social capital, such as temporary work. And unequal access to new opportunities like tourism risks reinforcing local inequalities.

Discussion

Our analysis shows that the resilience capacity of the Pehuenche is constrained. Although they have the capabilities to respond to climate change, their possibilities of adaptation are limited by the same structures that make them vulnerable, such as inequality and lack of participation. This finding is consistent with previous researches[52] that link socio-economic indicators to barriers for sustainability in Lonquimay. More than half of the

52Marchant, "Factores Que Afectan La Sustentabilidad de Las Comunas de Montaña. El Caso de La Comuna de Lonquimay, Región de La Araucanía, Chile"; Parragez, Barton, and Raposo-Quintana, "Impacts of Climate Change in the Andean Foothills of Chile: Economic and Cultural Vulnerability of Indigenous Mapuche Livelihoods."

Pehuenche responses do not address the causes of vulnerability and generate negative effects, which is why they can be considered maladaptation.

The Pehuenche contextual vulnerability is an ongoing process that goes hand in hand with the violation of their rights. It has its origins in the internal colonization processes that left many Pehuenche without lands, and has been reinforced by policies that promoted homogenization of the agro-livestock systems and shaped the relation with the territory. Inequality reduction from a poverty perspective, state assistance and development policies have reinforced dependence and damaged the social capital.

Currently, the Pehuenche perceive many climatic changes, which are in line with previous studies.[53] These changes can be mainly attributed to an average increase in temperatures. This data was corroborated by the Municipal Environment Office –the 0ºC isotherm has risen 200 meters– and matches the projections made by the Ministry of the Environment.[54] Such changes are generating impacts on their socio-economic systems, ranging from loss of knowledge to significant economic losses. These impacts will likely increase in duration and/or intensity[55] in the Andes region,[56] further increasing vulnerability[57] and requiring ongoing adaptation strategies.[58]

It is worth mentioning that these climatic changes are complex because they are intertwined and they enhance each other.[59] Their drivers are also multiple and diverse.[60]

53Cayul and Quilaqueo, "Cambio Climático En Lonquimay: Conocimiento Científico y Conocimiento Local Mapuche-Pehuenche"; Parragez, Barton, and Raposo-Quintana, "Impacts of Climate Change in the Andean Foothills of Chile: Economic and Cultural Vulnerability of Indigenous Mapuche Livelihoods."
54MMA. "Plan de Adaptación al Cambio Climático Del Sector Silvoagropecuario" (Ministerio de Medio Ambiente, 2013).
55ARClim, "Atlas de Riesgos Climáticos Para Chile"; MMA, "Plan Nacional de Adaptación al Cambio Climático [National Climate Change Adaptation Plan]" (Ministerio de Medio Ambiente, 2014).
56Adapt-Chile. "Adaptación Urbana al Cambio Climático. Propuesta Para La Adaptación Urbana al Cambio Climático En Capitales Regionales de Chile." ((Unpublished report). Ministry of Environment., 2014), https://cambioglobal.uc.cl/images/proyectos/Documento_041_Proyecto-Adaptacin-Ciudades-Final-MMA_CCG-CEDEUS-ADAPTChile.pdf.
57Parragez, Barton, and Raposo-Quintana, "Impacts of Climate Change in the Andean Foothills of Chile: Economic and Cultural Vulnerability of Indigenous Mapuche Livelihoods."
58Jorge Rojas, "Society, Environment, Vulnerability, and Climate Change in Latin America: Challenges of the Twenty-first Century", *Latin American Perspectives* 43, no 4 (2016): 29–42.
59Ibid.

Furthermore, Pehuenche measures are not exclusively oriented to recent climate events, but to long-standing climatic and non-climatic pressures.

Pehuenche respond to climate change impacts locally, however, building resilience requires socio-political changes at broader scales. As mentioned above, responses fostering adaptation focus beyond biophysical impacts, thus promoting a different relationship with the territory and challenging the current development model (e.g. revitalization of local agro-ecological practices). Besides, these responses strengthen social capital, Pehuenche culture, participation and collaboration with institutions, such as the Pehuenche brigade. In order for these responses to enable adaptation, a major institutional transformation is required.[61] For example, to overcome water scarcity, in addition to territorial redeployment, a reformulation of current legislation is needed.[62] Similarly, many of Pehuenche responses demand further planning. Such as tourism, which could become a sustainable economic alternative provided local inequalities are addressed, environmental education is strengthened and municipal waste management is improved. On the contrary, measures that only seek access to more resources have impacts on Pehuenche families and communities, as is the case of temporary work. Moreover, unequal access to these resources risks reinforcing local inequalities.

By understanding vulnerability as a result of historical processes, institutions and political structures,[63] we could identify the socio-economic barriers that constrain resilience and limit adaptation. This allows us to rethink and reformulate existing practices,[64] but also, to address these barriers from an environmental justice approach when designing future

60Lisen Schultz, Carl Folke, Henrik Österblom, and Per Olsson. "Adaptive Governance, Ecosystem Management and Natural Capital," *PNAS* 112 (2015): 7369–74.
61Karen O'Brien y Linda Sygna, "Responding to climate change: the three spheres of transformation", en *Proceedings of Transformation in a changing climate* (Transformation in a changing climate, Oslo, Norway: University of Oslo, 2013), 16–23; Pelling, *Adaptation to Climate Change: From Resilience to Transformation*.
62Robinson Torres-Salinas et al., "Desarrollo forestal, escasez hídrica y la protesta social Mapuche por la justicia ambiental en Chile", *Ambiente & Sociedade* 19, no 1 (2016): 121–46.
63O'Brien et al., "Why different interpretations of vulnerability matter in climate change discourses".
64Sumetee Pahwa Gajjar, Chandni Singh, and Tanvi Deshpande, "Tracing Back to Move Ahead: A Review of Development Pathways That Constrain Adaptation Futures," *Climate and Development* 11 (March 16, 2019): 223–37, doi:10.1080/17565529.2018.1442793.

climate policies. To date, climate policies do not effectively include indigenous people participation and knowledge.[65] Predominant discourses position them as victims of climate change[66], that is, the object of policies that generally omit their cultural and symbolic relationships with their territories[67] and inequitable structures that make them vulnerable.[68] If these constraints are not addressed, climate policies also risk restricting indigenous peoples' resilience and increasing their vulnerability.[69]

Indigenous peoples have denounced this situation. Participation has been at the heart of their international demand for climate justice since the First World Climate Conference in 1979.[70] Today, thanks to the consistent advocacy of diverse indigenous leaders,[71] the consideration of indigenous peoples is increasingly promoted by science[72] and the United

65Mikael Granberg y Leigh Glover, "Adaptation and Maladaptation in Australian National Climate Change Policy", *Journal of Environmental Policy & Planning* 16, no 2 (3 de abril de 2014): 147–59, https://doi.org/10.1080/1523908X.2013.823857; Douglas Nakashima et al., *Weathering uncertainty: traditional knowledge for climate change assessment and adaptation Weathering Uncertainty: Traditional Knowledge for Climate Change Assessment and Adaptation* (Paris: Darwin: UNESCO; UNU-IAS, 2012).

66Candis Callison, "Climate Change Communication and Indigenous Publics", en *The Oxford Encyclopedia of Climate Change Communication*, ed. Matthew Nisbet et al. (Oxford: Oxford University Press, 2017), 1–26, https://oxfordre.com/view/10.1093/acrefore/9780190228620.001.0001/acrefore-9780190228620-e-411.

67Neil Adger, Nigel Arnell, y Emma Tompkins, "Successful adaptation to climate change across scales Nigel W. Arnella,c, Emma L. Tompkins", *Global Environmental Change* 15 (2005): 77–86.

68Ella Belfer, James D. Ford, y Michelle Maillet, "Representation of Indigenous Peoples in Climate Change Reporting", *Climatic Change* 145, no 1–2 (noviembre de 2017): 57–70, https://doi.org/10.1007/s10584-017-2076-z.

69Ameyali Ramos-Castillo, Edwin J. Castellanos, y Kirsty Galloway McLean, "Indigenous Peoples, Local Communities and Climate Change Mitigation", *Climatic Change* 140, no 1 (enero de 2017): 1–4, https://doi.org/10.1007/s10584-016-1873-0; Justine Townsend, Faisal Moola, y Mary-Kate Craig, "Indigenous Peoples Are Critical to the Success of Nature-Based Solutions to Climate Change", ed. David Lesbarrères, *FACETS* 5, no 1 (1 de enero de 2020): 551–56, https://doi.org/10.1139/facets-2019-0058.

70Pasang Dolma Sherpa, "The Historical Journey of Indigenous Peoples in Climate Change Negotiation", 2019, https://www.iucn.org/news/commission-environmental-economic-and-social-policy/201912/historical-journey-indigenous-peoples-climate-change-negotiation.

71Deborah Delgado, "La participación de los pueblos indígenas en la Convención Marco de las Naciones Unidas sobre el Cambio Climático. De actores 'tradicionales' a actores frente al Antropoceno" (Documentos de Trabajo no 22 (2a época), Madrid, Fundación Carolina, 2019).

72D Green, J Billy, y A Tapim, "Indigenous Australians' knowledge of weather and climate", *Climatic Change* 100, no 2 (2010): 337–54.

Nations Framework Convention on Climate Change.[73] To analyze this process and enrich this discussion, further research is required on how the participation of indigenous peoples in climate change processes translates into climate policies aimed at local, regional and national levels.

Conclusion

Resilience to climate change requires changing inequitable structures. Otherwise, adaptation possibilities will be restricted by the same causes that generate vulnerability in the first place.

Lonquimay history illustrates how climate vulnerability is an ongoing process rather than a product of climate change. And the Pehuenche responses demonstrate that resilience is not a return to a previous state, nor is it static. Resilience depends on multiple social and historical factors. As well as present and future possibilities, such as a critical review and reformulation of the policies that regulate the relationship with the territory. Without addressing the factors that constrain resilience, adaptation to climate change will not be feasible.

To change inequitable structures, it is necessary to recognize indigenous peoples not as victims of climate change or mere recipients of policies, but as subjects of rights, protagonists of their development processes and the recovery of their territories. This calls for policies that address socio-ecological inequality as a matter of justice. And the creation of indigenous peoples' rights-based mechanisms that enhance resilience by strengthening local

73UNFCCC, "Local Communities and Indigenous Peoples Platform. Draft conclusions proposed by the Chair.", 2018, https://unfccc.int/documents/184766; UNFCCC, "Statement, International day of the world's indigenous peoples.", 2006, http://unfccc.int/files/press/news_room/statements/application/pdf/20060808_rk_indigenous.pdf.

capabilities and ensuring effective participation and inclusion of local knowledge at all stages of decision-making processes. Consequently, not only local adaptation processes will be facilitated, but also the socio-political transformation required to face climate change.