

PILLANMAPU GEOPARK PROJECT: LOCAL GOVERNANCE STRATEGIES FOR RESILIENCE IN THE FACE OF MULTI- HAZARD SCENARIOS IN CENTRAL CHILE

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INTRODUCTION

Approximately 272 km south of Santiago de Chile is the Maule region, a territory with great mountain range geodiversity, being an object of scientific interest, particularly in the San Clemente commune – 4,504 km² in area and 41,366 inhabitants – for hosting important volcanoes, which although for more than 5 decades they have been without variations (or on green alert) represent a high associated risk (Descabezado Grande #19, Quizapu #10 according to the Specific Risk Ranking of the SERNAGEOMIN Volcanic Surveillance Network).

Contrasting with them is the instability present in the Laguna del Maule Volcanic Complex (CVLdM, #27 Specific Risk Ranking), which allows us to affirm that it is above its baseline, being one of the three volcanic Yellow Alerts in Chile during 2021. The main access to this commune is given in an easterly direction by the paved Route CH-115 or Pehuenche International Pass, where the entire Region is traveled to the border with the Republic of Argentina. The foregoing makes this commune a key territory, along with 5 others (Romeral, Curicó, Colbún, Molina and Linares), to be recognized as a UNESCO World Geopark.

Given its multi-threat nature, the consolidation of the Pillanmapu Geopark project (Fig. 1) allows the development of a territorial management model that establishes a baseline of actions, consecrating the development of a 'Science-Society' governance model, which integrates the actors key in both the public and private sectors, reaching decision makers at the local and regional level, thus promoting resilience and sustainability in the Mountain territories of the region.

GLOBAL CONTEXT

Chile is located on an active margin, in the Pacific Ring of Fire; long and narrow enough to present mountainous and coastal ecosystems, arid, semi-arid and forested territories. It is prone to desertification, drought, loss of biodiversity and air pollution, and is highly susceptible to socio-natural disasters. All characteristics that, combined, place Chile in 25th place in the Global Climate Risk Index (Eckstein et al. 2021).

Added to this is the unequivocal anthropogenic influence for at least the last 170 years, which has generated irreversible impacts on our planet on a human scale (IPCC, 2022), given that human wealth is based on the use and consumption of natural resources, and the continuous increase of this fact and the environmental impacts related to it can have various negative effects that lead to ecological crises and threats to security. For this reason, the sustainable use and management of natural resources have gained prominence and have been the subject of numerous political debates over decades, beginning with the Environment and Development Summit in Rio de Janeiro in 1992 (Moll et al., 2005).

The current context of the Global Environmental Crisis reinforces the need to accelerate direct and effective action strategies, under a territorial perspective that allow the development of "Bottom up" strategies, an issue that has been raised since Local Agenda 21 (United Nations, 1992). These principles were reaffirmed at the United Nations Conference on Sustainable Development – Rio+20 – held in 2012, valuing local action to generate sustained changes and adjust governance strategies under a sustainable perspective.

Likewise, instruments such as the Hyogo Framework for Action and its successor, the Sendai Framework, present among

their priorities for action strengthening the Governance of Disaster Risk Management by investing in it to aim at greater resilience, all of which is also subscribed within of the Sustainable Development Goals in most of its 169 targets.

LOCAL CONTEXT

On the one hand, the geological activity of the Maule Andes brings with it a record of volcanic events manifested in its geological diversity (Geodiversity), positioning sectors such as the Pehuenche Pass as a model that accounts for the risk of disasters in mountain territories. While, on the other hand, Geodiversity converges with other inseparable dimensions for integrated land management, since it sustains a biodiversity considered one of the 25 global Hotspots for Mediterranean climate ecosystems (Andrasanu, 2006; Myers et al. 2000) and it has defined the lifestyle of pre-Hispanic human groups for 8,000 years who have used geological resources such as obsidian to make tools (Duran et al., 2004).

Additionally, and given the virtue of the Pehuenche Pass as a binational corridor that connects the Pacific with the Atlantic, an important opportunity is presented for those who make up the territory, including those who live in the San Clemente commune. In this case, the generation of knowledge under a Science-Society governance model, in which work is done in coordination with the Municipality and the community, makes it possible to generate a territorial management model from a sustainable perspective that allows influencing public policies. at the local level, developing functional and replicable models at the regional and national level (aligned with the 2030 Agenda).

This route has important implications for an integrated development of the community, providing comparative advantages to carry out research and scientific development, allowing

the integration of different areas of knowledge, generating a sense of belonging and local identity, creating a story that unites science, history, culture and tradition. This generates positive externalities in its environment (spillovers), such as the increase in human, technological and social capital, development of universities and other research centers, exchange of technology transfer experiences, creation of new ventures and development of tourism, among others. others (Aguilera and Larraín, 2016).

Consequently, the Commune of San Clemente, and in particular the Paso Pehuenche Bi-Oceanic Corridor, constitutes one of the best models known at the national level to address the issue of disasters in Andean territories, as they are exposed to possible threats to be found both in the north of Chile as in the southern zone. This gives the territory versatility to be comprehensively approached as a natural laboratory of any kind (Aguilera and Larraín, 2018), with an emphasis on socio-natural disasters, in addition to its link with other types of natural laboratories.

LOCAL HERITAGE

The complementarity between the variety of Geological elements present as a record of the evolution of the Earth, the flora and fauna in the territory, make up the Natural Heritage of the Maule Region. The Geological Heritage (Geoheritage) is constituted by a set of places with geological elements of relevance and special value, which are key vestiges to reconstruct the past, understand the present and predict the future (Schilling et al., 2012), recognizing a important value in the scientific, educational, tourist and/or cultural field. The use of geological heritage in connection with other aspects of natural and cultural heritage is considered a fundamental tool to increase understanding of the main conflicts that society faces, such as the sustainable use of

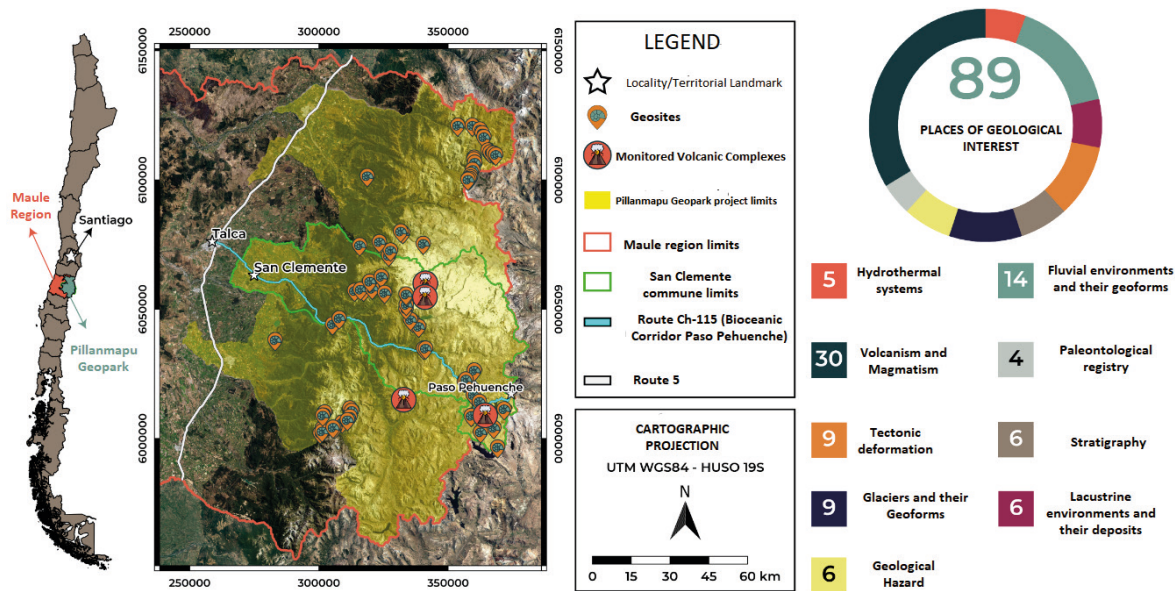


Fig. 1 – Distribution of identified and categorized geosites, and monitored Volcanic complexes, in the Commune of San Clemente, Pillanmapu Geopark Project.



Fig. 2 – Geosite of the stepped plateaus of the Valley of the Condors, San Clemente, Maule Region. Photography by Pablo Cifuentes. Pillanmapu Geopark Project.

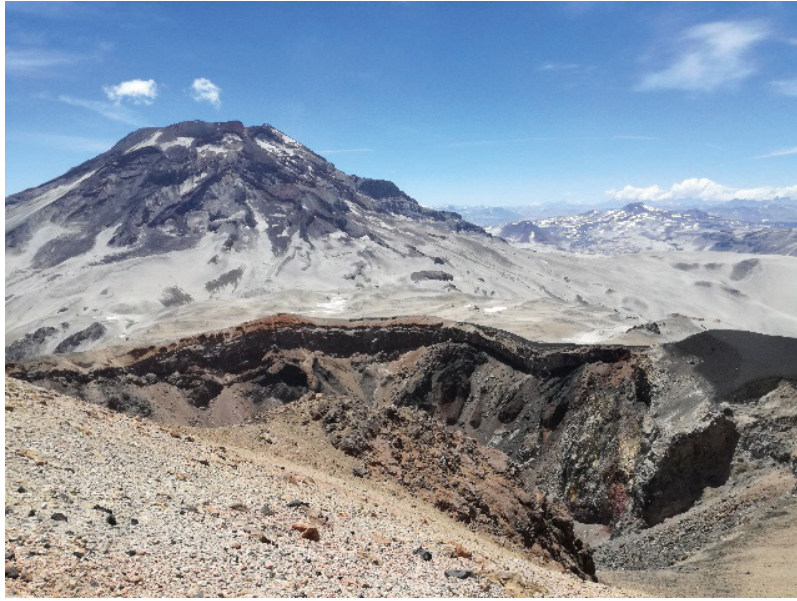


Fig. 2 – Quizapu Volcano Crater., San Clemente, Maule Region. Pillanmapu Geopark Project.

resources, mitigation of the effects of climate change and the reduction of the impact of disasters (UNESCO, 2017).

This intersection in the Natural Heritage, of biological and geological sciences, is enhanced by incorporating a comprehensive perspective and focused on innovation, where there is a coordination of expert voices, which place research beyond preservation, understanding that this diversity puts the territory in a highly vulnerable scenario, considering its multi-threat condition (of Geological, hydrometeorological or anthropic hazards), and the degree of exposure of those who inhabit it (whether humans or other species). These expert voices cannot come only from universities and research centers, they must come from the private world and also from the public world, as the local knowledge of the inhabitants of the territory to promote transdisciplinarity.

MULTI-HAZARD SCENARIO

Volcanic Risk is recognized as the main threat in the territory, where the Laguna del Maule Volcanic Complex (CVLdM, #27 Specific Risk Ranking) has gained some popularity in recent years, standing out for its uniqueness, being a unique case study in the world. It presents more than 40 eruptive centers (Hildreth et al. 2021), both monogenetic and polygenetic, recording explosive and effusive eruptions (Contreras, 2020), drawing the attention of different research centers at a national and international level.

Additionally, the territory is exposed to various hydrometeorological risks (Mass Removals, Floods, Snow Avalanches, drought among others) that make it vulnerable to other threats such as forest fires. Consequently, a large part of the territory along Route CH115 - Pehuenche International Pass, and the main evacuation route, is exposed to multi-hazard scenarios that require an understanding of the

processes related to the risk cycle in terms of prevention, response, recovery and mitigation (De la Llera et al. 2018 in Laboratorios Naturales para Chile de Aguilera y Larraín).

This route has been consolidated in recent years as an articulation node and emerging tourist destination at the regional level, which is evidenced in the 156,992 people who crossed the Pehuenche Border Pass (Salinas, 2017) and in the 85,996 visitors who boarded the Lo Aguirre sector in the winter season of 2019 (Government of Talca, 2019). However, the territory lacks infrastructure and information that allows the development of safe and sustainable tourism, despite having a tourist and heritage resource with the potential to position Maulino tourism in national and international markets. This diagnosis is consistent with the “Regional Innovation Strategy” (Regional Government of Maule, 2021) and the “Public Tourism Policy of the Maule Region” (Regional Government of Maule, 2020), which establish mountain tourism, and with it the Pehuenche Pass, as strategic axes of development and regional competitiveness.

THE PEHUENCHE PASS AS A NATURAL LABORATORY

NATURAL LABORATORIES ‘TYPE I’ OF ROUTE CH-115, PASO PEHUENCHE BI-OCEANIC CORRIDOR

The geographical conditions of high slopes, the location in an area threatened by 4 of the 45 volcanoes considered currently monitored at the national level and the susceptibility to water crises in the face of climate change in the basin with the highest agricultural and hydroelectric productivity at the regional level make the route to the Pehuenche International Pass a relevant case study to promote given its ability to promote applied

and transdisciplinary research, promoting the generation of new disciplinary aspects.

One of the most relevant disaster risks in recent years has been the volcanic risk associated with the CVLdM, which has attracted hundreds of researchers from all over the world to understand the implications of a global icon given its uniqueness. Another icon of the Ch-115 route corresponds to the Quizapu Volcano (Fig. 3) located on the border between the Precordillera and the Andean Cordillera, which generated the largest effusive eruption in Chile during the 19th century, and the most violent eruption in Chile during the 20th century, being the fifth most explosive in the world for the same century (Hildreth and Drake, 1992). The Quizapu eruption of 1932 generated a catastrophic environmental, social and economic impact by covering more than 90,000 hectares of volcanic material, causing the death of wild flora and fauna and thousands of cattle and goats in Argentina.

On the other hand, these volcanic processes are closely linked to other natural laboratories (Aguilera and Larraín, 2018), being that of renewable energies linked to hydroelectric production the most important. The Maule basin has the highest production of hydroelectric energy in the country through its 11 power plants, making the Maule River one of the most intervened basins nationwide in terms of the number of reservoir and run-of-the-river power plants (Carrasco, 2019). Unfortunately, the risk of a climate crisis directly threatens the sustainability of this type of energy, while the Los Cóncores, Río Colorado and Cipreses hydroelectric plants are within the polygons threatened by volcanic risk (IDE, 2021).

NATURAL LABORATORIES 'TYPE II' OF ROUTE CH-115, PASO PEHUENCHE BI-OCEANIC CORRIDOR

Resilience in mountain territories requires greater challenges considering the multi-hazard exposure (of Geological, hydrometeorological or anthropic hazards), and the degree of exposure of those who inhabit them (whether humans or other species). In this context, it is not enough to pursue the recruitment of a critical mass of researchers and entrepreneurs who generate international impact (De la Llera et al. 2018), but efforts must be devoted to attracting a critical mass of experts who can develop in a transdisciplinary way, research applied to disaster risk reduction. A relevant aspect to consider is that transdisciplinarity in the field of disaster management has the particularity of requiring the participation of public and private actors, and above all local communities, since they are the ones that are affected by the events.

The disciplinary crossing that promotes the theme of disasters allows, in turn, to constitute a catalyst for the improvement of new areas of investigation. An example of this is the link between elements of the geological and archaeological heritage, where the obsidian quarries of Laguna del Maule show that, although the volcanic complex constitutes an element of risk, it has been used since pre-Hispanic times for the development of tools, thus intersecting with the Natural Laboratory of the Population of America proposed by Aguilera and Larraín. Another example to highlight is the link with hydroelectric production in the Maule basin, which has 11 power plants in the intervention area of this initiative (Carrasco, 2019), but 4 of these are threatened by volcanic risk and the entire due to climate risk that threatens productivity. This way, the theme of Disasters presents points

of interrelation with Renewable Energies, another proposed natural laboratory (Aguilera and Larraín, 2018); which becomes relevant in a context of climate change in which progress towards sustainable development is sought in line with the United Nations 2030 Agenda.

NATURAL LABORATORIES 'TYPE III' OF ROUTE CH-115, PASO PEHUENCHE BI-OCEANIC CORRIDOR

Given the virtue of the Pehuenche Pass of being a bi-oceanic corridor that connects the Maule region (Chile) with the province of Malargüe (Argentina), the CH-115 route constitutes the main articulating node and pole of regional economic development. This route, and the Maule River basin in its Andean portions, sustain one of the largest sources of hydroelectric production nationwide through the 11 reservoir and run-of-the-river power plants (Carrasco, 2019). On the other hand, 190,000 ha of irrigation depend on this river and the maintenance of the Andean reservoirs, accessible thanks to the Pehuenche route, for the agricultural sector, the main engine of regional development (Palma, 2018). Additionally, in recent years the sector has shown an accelerated increase in tourist activity, which comes to the sector for its natural environment linked to water and snow resources, reaching a total of 156,992 visitors who accessed via route Ch-115 through of the Pehuenche Border Pass in 2016 (Salinas, 2017) and 85,996 visitors who went up to the Lo Aguirre sector in the winter season of 2019 (Government of Talca, 2019).

However, the CH-115 route presents multi-threat scenarios due to the previously mentioned disasters, threatening the way of

life of a region. In this context, this initiative seeks to propose and implement disaster socialization strategies through heritage milestones validated in a participatory manner, thus advancing towards resilient societies.

FINAL COMMENTS

The National Commission for Resilience against Disasters of Natural Origin (CREDEN) defines Resilience as the “capacities of a system, person, community or country exposed to a threat of natural origin, to anticipate and recover from its effects in a timely and effective, to achieve the preservation, restoration and improvement of its structures, basic functions and identity”. Consequently, it is necessary to incorporate R+D+i+e in the development of both technical and scientific capacities, thus understanding socio-natural disasters in their general context, together with the academic, public and private sectors. But in order to consecrate a forceful strategy, the various organizations of Civil Society must be involved, as well as the various communities that inhabit the territory, thus allowing anticipation and recovery from various events.

It is for this reason that Governance strategies at the local level must be of a transdisciplinary nature, which allows the evaluation of the impact from a collective effort of all those people involved with the territory.

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