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The Andean zinc rush: Green extractivism and climate vulnerabilities in the Peruvian highland waterscapes

Anna Heikkinen¹

University of Helsinki, Finland

Abstract

Zinc is a green mineral that is increasingly required for manufacturing low-carbon technology. This demand has been promoted mainly by the Global North-led green policies to mitigate the impacts of climate change. However, simultaneously expanding zinc mining risks further entrenching climate threats in fragile socio-ecological environments such as the Peruvian highlands. This article analyses the linkages between the accelerated green extractivism of zinc and its associated climate-related vulnerabilities in the Cunas watershed in the Central highlands of Peru. The study draws on ethnographic-oriented fieldwork in the area in 2019, and 2022 and a review of policy documents on climate mitigation and zinc mining in Peru. The analysis particularly focuses on the recently reopened Azulcocha zinc mine and its intertwined socio-ecological effects on the local waterscapes amid climate change. The analysis draws the theoretical approaches of the political ecology of green extractivism and vulnerability to disentangle the multi-scalar power dynamics embedded in the global low-carbon transition and green extractivism and how these shape climate-related vulnerabilities. The study shows that with the impacts of climate change, accelerated extractivism risks (re)producing multiple vulnerabilities in the Andean highland communities. The findings highlight the urgent need to rethink the global climate proposals in such a way that they do not deepen climate damage in the already marginalized waterscapes in the Andes and elsewhere in the Global South.

Keywords: Andes, climate vulnerability, green extractivism, Peru, water injustices, zinc

Résumé

Le zinc est un minerai vert de plus en plus nécessaire à la fabrication de technologies à faibles émissions de carbone. Cette demande a été promue principalement par les politiques vertes menées par les pays du Nord pour atténuer les impacts du changement climatique. Cependant, l'expansion simultanée de l'exploitation minière du zinc risque d'aggraver davantage les menaces climatiques dans des environnements socio-écologiques fragiles tels que les hauts plateaux péruviens. Cet article analyse les liens entre l'extractivisme vert accéléré du zinc et les vulnérabilités associées liées au climat dans le bassin versant de Cunas, dans les hauts plateaux du centre du Pérou. L'étude s'appuie sur un travail de terrain ethnographique dans la région en 2019 et 2022 et sur un examen des documents politiques sur l'atténuation du changement climatique et l'exploitation minière du zinc au Pérou. L'analyse se concentre particulièrement sur la mine de zinc d'Azulcocha récemment réouverte et ses effets socio-écologiques étroitement liés sur les paysages aquatiques locaux dans un contexte de changement climatique. L'analyse s'appuie sur les approches théoriques de l'écologie politique de l'extractivisme vert et de

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la vulnérabilité pour démêler les dynamiques de pouvoir multi-scalaires ancrées dans la transition mondiale à faible intensité de carbone et l'extractivisme vert et comment celles-ci façonnent les vulnérabilités liées au climat. L'étude montre qu'avec les impacts du changement climatique, l'extractivisme accéléré risque de (re)produire de multiples vulnérabilités dans les communautés andines. Les résultats soulignent le besoin urgent de repenser les politiques climatiques mondiales de telle manière qu'elles n'aggravent pas les dommages climatiques dans les paysages aquatiques déjà marginalisés des Andes et ailleurs dans le Sud global.

Mots-clés: Les Andes, vulnérabilité climatique, extractivisme vert, Pérou, injustices de l'eau, zinc

Resumen

El zinc es un mineral verde cada vez más necesario para fabricar tecnología baja en carbono. Esta demanda ha sido promovida principalmente por las políticas verdes lideradas por el Norte Global para mitigar los impactos del cambio climático. Sin embargo, la expansión simultánea de la minería de zinc corre el riesgo de afianzar aún más las amenazas climáticas en entornos socioecológicos frágiles como en los Andes peruanos. Este artículo analiza los vínculos entre el acelerado extractivismo verde del zinc y las vulnerabilidades relacionadas con el clima en la cuenca del Cunas en la sierra central del Perú. El estudio se basa en un trabajo de campo de orientación etnográfica en el área en 2019 y 2022 y una revisión de documentos de políticas sobre mitigación climática y minería de zinc en Perú. El análisis se centra particularmente en la mina de zinc Azulcocha recientemente reabierta y sus efectos socioecológicos entrelazados en los paisajes hídricos locales en medio del cambio climático. El análisis se basa en los enfoques teóricos de la ecología política del extractivismo verde y la vulnerabilidad para desentrañar las dinámicas de poder multiescalar integradas en la transición global hacia una economía baja en carbono y el extractivismo verde y cómo estos dan forma a las vulnerabilidades relacionadas con el clima. El estudio muestra que, con los impactos del cambio climático, el extractivismo acelerado corre el riesgo de (re)producir múltiples vulnerabilidades en las comunidades andinas. Los hallazgos resaltan la necesidad urgente de repensar las propuestas climáticas globales de tal manera que no profundicen el daño climático en los paisajes hídricos ya marginados de los Andes y otras partes del Sur Global.

Palabras clave: Andes, vulnerabilidad climática, extractivismo verde, Perú, injusticias hídricas, zinc

1. Introduction

The demand for lower-carbon infrastructures, and consequently zinc, has risen dramatically with new energy and climate change mitigation policies. Zinc has become an essential mineral for solar panels, wind turbines and as a substitute for lithium-ion batteries in electric vehicles (World Economic Forum, 2022). This demand is projected to further rise since zinc's listing as a key mineral for climate mitigation (World Bank, 2020). However, recent studies show how new and additional demands of such low-carbon minerals have accelerated the mineral 'rush', particularly in the Southern Hemisphere (Jerez *et al.*, 2021; Dorn *et al.*, 2022). In many places, this rush has deteriorated sensitive ecosystems and local livelihoods (Le Billon, 2021) and generated new socio-environmental conflicts (Lorca *et al.*, 2022; Voskoboynik & Andreucci, 2021). As such, sustainability transition and climate mitigation efforts risk deepening climate-related threats for marginalized populations of the Global South and their fragile environments (Sovacool, 2021; Verweijen & Dunlap, 2021).

Expanding resource extraction and related harm in the context of sustainability transitions has gained increasing attention in political ecology (Andreucci *et al.*, 2023; Bruna, 2022; Dunlap, 2018; Dunlap & Riquito, 2023; Ulloa, 2023). Recent studies in the field have addressed discursive and material re-making of the new green mineral frontiers (Almeida *et al.*, 2023; Dorn *et al.*, 2022) and the associated struggles and suffering of humans and non-humans in such landscapes (Sullivan 2017; Tornel, 2023). There is also an emerging interest in analyzing how climate change policies justify expanding mineral mining, new forms of accumulation, and socio-ecological depletion (Bruna, 2021; Dorn *et al.*, 2022; Odell *et al.*, 2018). Within the context of Green New Deal (GND) proposals, scholars have also questioned the inherently colonial and extractivist logics embedded in the current plans towards low-carbon societies (Dunlap & Laratte, 2022; Zografos & Robbins, 2020). However, few studies have paid attention to the less evident forms of green extractivist practices and how these intertwine with the impacts of climate change, (re)producing multiple vulnerabilities and socio-ecological conflicts in fragile environments (Sovacool, 2021; Voskoboynik & Andreucci, 2021).

This article addresses such multi-scalar processes related to zinc extractivism and production of climate vulnerabilities in the Peruvian Andes. Drawing on the recurring literature on the political ecology of green

extractivism (Dunlap, 2019; Bruna, 2022; Tornel, 2023), the study explores the less visible ways the emerging zinc rush in Peru is advanced by the global low-carbon agenda and how Peruvian highland residents' experience its implications amid ever-more tangible climate threats. For this purpose, the study applies the concept of 'indirect green extractivism' to disentangle the multi-scalar extractivist practices including environmental policies, actions, and discourses that aim to secure minerals for climate mitigation schemes (Dunlap & Riquito, 2023: 5). I focus on how green extractivism is advanced in less explicit ways, through unrelated climate mitigation and mining policies across multiple scales. The analysis on how ambiguous policies 'invisibilize' extractivism follows Davies' (2019) account of extractivist practices that permit invisibilization of environmental degradation and ignore the resulting vulnerabilities.

In the Andean highlands, extractive operations have long records of contaminating surrounding rivers and soils (Li, 2015; Perreault, 2013). At the same time, climate extremes are increasingly altering highland water supplies (Vicuña *et al.*, 2013). Nevertheless, there is growing evidence of the extractivist expansion into sensitive waterscapes, posing new threats to the local water ecosystems and people's access to water (Bustos-Gallardo *et al.*, 2021; Jerez *et al.*, 2021). In Peru, zinc mining has been associated with high pollution in sensitive highland headwaters, risking the well-being of local residents and their living environments (Custodio *et al.*, 2020). Despite this evidence, zinc mining is increasing in Peru, particularly due to its growing demand in Europe and China (MINEM, 2022). This zinc rush is expected to further accelerate due to its growing role as a key low-carbon mineral (World Bank, 2020). Peru is one of the leading zinc producers in the world (MINEM, 2022), which is experiencing increasing pressure due to global demand.

Currently, most of Peru's zinc mines are located in the Andean highlands, classified as highly vulnerable ecosystems to the impacts of climate change (Castellanos *et al.*, 2022). Moreover, the Andean mining regions are the socio-economically poorest in Peru due to their historical and current exclusion in resource governance (Heikkinen, 2021; Lynch, 2018; Stensrud, 2019). Despite these multiple vulnerabilities faced by the Andean residents and their living environments, zinc mining is promoted in Peru with claims of responsible and sustainable mining (Heikkinen *et al.*, 2023). Zinc mining, moreover, poses threat to water. This study therefore focuses on analyzing how accelerated extractivism transforms sensitive waterscapes in the context of climate change and how people inhabiting them interpret and experience these shifts in their everyday lives. This is done drawing on Ribot's (2022) multi-scalar vulnerability approach to examine how social, and political-economic structures on multiple scales (re)produce uneven accumulation and distribution of climate harms. The analysis centers on green extractivist procedures, including practices and discourses that permit expansion of zinc mining, while ignoring water-related vulnerabilities amid climate change.

The article draws on ethnographic-oriented methods and document analysis to explore green extractivist procedures through the case of the Azulcocha zinc mine in the Cunas watershed in the Peruvian Andes. While many studies have examined uneven governance processes in mineral mining for low-carbon infrastructures, such as lithium (Dorn & Gunderman, 2022; Saleth & Varov, 2023), copper (Dunlap, 2019b), cobalt (Sovacool, 2019) and nickel (Andreucci *et al.*, 2023), zinc mining remains understudied (Veltmeyer & Petras, 2014). Considering zinc's strengthening role as a key 'green' mineral and Peru's leading role in its production, an urgent need exists to study its effects in the Andean highlands. This article seeks to fill this research gap.

The article is organized as follows: The next section elaborates a conceptual framework based on the political ecology of green extractivism and climate vulnerability. The second describes the methods and context of the study. The third discusses the invisibilized practices of green extractivism and politics of vulnerabilization in the Peruvian Andes. The fourth analyzes how accelerated zinc extractivism exacerbates Cunas residents' susceptibility to multiple vulnerabilities amid deepening climatic shifts. The final section discusses how the multi-scalar forms of green extractivism threaten to (re)produce vulnerabilities in the socio-ecologically fragile waterscapes of the Global South.

2. Political ecology of green extractivism and climate vulnerability

Extractivism is expanding at an unforeseen pace and scale (Kröger, 2020; Nygren *et al.*, 2022). This development is interlinked to the international agreements outlined in the 2012 Sustainable Development Summit in Rio and the 2015 Paris Agreement to mitigate the impacts of climate change. These agreements laid the ground for new imaginaries and discourses on green growth, green economy, and clean technology, which

international organizations such as the United Nations (UN), the Organisation for Economic Co-operation and Development (OECD), the European Union (EU), and the like have since promoted (Bustos-Gallardo *et al.*, 2021; Brand & Lang, 2019). At a discursive level, these institutions claim an inclusive and just sustainability transition in which "no one is left behind" with particular emphasis on supporting the Southern countries (UN, 2022). However, recent studies show that the low-carbon policies have strengthened global power asymmetries through accelerated extractivism and have been accompanied by the accumulation of climate threats in socio-ecologically marginalized environments (Sovacool, 2021).

The new dynamics of extractivism have received increasing attention in political ecology and related fields (Arboleda, 2020; Dunlap, 2019a; Nygren *et al.*, 2022; Veltmeyer & Petras, 2014). In particular, recent debates have sought to conceptualize the expanding global scale of extractivist practices and how they transform socio-ecological and non-human relations (Ye *et al.*, 2019). Chagnon and colleagues (2022: 8) propose the term "global extractivism," pointing to "a scale of planetary significance" of the current extractivist procedures to capture the cross-scale impacts of extractivism. Others have extended the analysis to ontological dimensions of extractivism, moving beyond overexploiting nature (Willow, 2018) toward how extractivist practices unearth other kinds of lifeworlds (Lassila, 2021). However, less attention has been given to how extractivism and climatic changes mutually (re)shape socio-ecologically fragile landscapes and (re)produce vulnerabilities through multiple scales (Sovacool, 2021; Mirumachi *et al.*, 2020), which is the analytical focus of this article.

The analysis pays particular attention to the global extractivist processes through appropriating natural resources to export them as raw materials (Gudynas, 2018) and how these procedures intertwine with the effects of climate change. For this purpose, in this study, the term extractivism is understood as the "overextension of natural resource exploitation, with attendant mindsets, politics, and practices" (Nygren *et al.*, 2022: 2). Moreover, the analysis builds on the wide body of literature on extractivist practices and its related socio-ecological harm and conflicts in the Andean region (Bebbington & Bury, 2013; Damonte & Schorr, 2022; Perreault, 2013). This work helps to situate the analysis on new forms of green extractivism and climate change to past extractivist development in the region, particularly the resource boom in the 2000s (Svampa, 2012).

Political ecologists have increasingly applied the concept of green extractivism to better analyze the new dynamics in extractivism related to the low-carbon transition and climate mitigation (Verweijen & Dunlap, 2021). The term emerged from the need to conceptualize the institutional promotion of environmental policies through the discursive notions of "sustainability" and the "green economy" (Sullivan, 2013). Recently, political-ecological studies have approached green extractivism as extracting emission rights (Bruna, 2022), intensifying renewable energy production to mitigate climate change (Dunlap, 2019; Ulloa, 2023; Singh, 2023), coloniality of sustainability transition (Andreucci *et al.*, 2023; Jerez *et al.*, 2022), and greening of extraction processes by presenting mining of transition minerals as climate-friendly (Kingsbury, 2021; Voskoboynik & Andreucci, 2021). Moreover, green extractivism is increasingly used as an analytical tool to disentangle how the new green deals and related discourses legitimize harmful mineral mining, portraying extractivism as necessary for sustainability transitions and "green growth" (Almeida *et al.*, 2023; Dunlap & Riquito, 2023).

This study is particularly interested in how indirect forms of green extractivism transform sensitive socio-ecological landscapes, disproportionately exposing ecosystems and those inhabiting them to climate threats. Previous work on green extractivism has mostly examined the explicit linkages between the sustainability discourses and practices and how they justify socio-ecologically harmful extractivist processes in the name of climate mitigation (Dorn *et al.*, 2022). However, extractivism and climate-related practices often produce socio-ecological threats in hidden and slowly unfolding ways (Nixon, 2011). Here, analytical attention is given to more invisibilized forms of extractivist practices and associated politics of vulnerabilization (Davies, 2019). This way, it is possible to explore how the multi-scalar power relations related to green extractivism (re)shape differentiated vulnerabilities in the fragile Andean waterscapes affected by climate change.

As Ribot (2022: 684) argues, while climate stresses might trigger climate-related damage, their origins are always "stratified by historical, social and political-economic arrangements that render some people secure and others vulnerable." Following these ideas, the study conceptualizes vulnerabilities related to climate harms as an outcome of uneven power relations (re)shaping ecological, cultural, political, and socioeconomic settings across multiple scales (Ribot, 2014). Considering extractivism and climatic changes are closely related to shifts in water (Bustos-Gallardo, 2021; Sultana, 2018), the analysis focuses specifically on vulnerabilities as multi-scalar hydro-social shifts and how the nexus of power and water mediates differentiated access to and use of

water (Lynch, 2018; Nygren, 2021). Moreover, the analysis scrutinizes the differentiated everyday place-based vulnerabilities (Nygren, 2016) and the multiple ways the Andean people relate to their living environments, especially in terms of water (Boelens, 2015; Gelles, 2000).

3. The study site and methods

This study focuses on the Cunas watershed in the Central highlands of Peru. At an altitude between 3,200 m and 4,500 m above sea level, high ecological and climatic diversity characterize the Cunas. Due to topographic variation, the Cunas landscape consists of diverse micro watersheds, small Andean plateaus, hillsides, and canyons highly vulnerable to hydrological disturbances (INGEMMET, 2014). Recently, exacerbating impacts of climate change have further altered the sensitive Cunas waterscape. At the end of 2022, the worst drought since the 1970s hit the Southern and Central Andes. Many smallholders, including those of Cunas, experienced massive losses as the harvests deteriorated and animals died due to a lack of fodder and water (La República, 2022). Moreover, in recent decades, the Cunas smallholders have suffered abnormal waves of hail and heavy rains (CIIFEN, 2018).

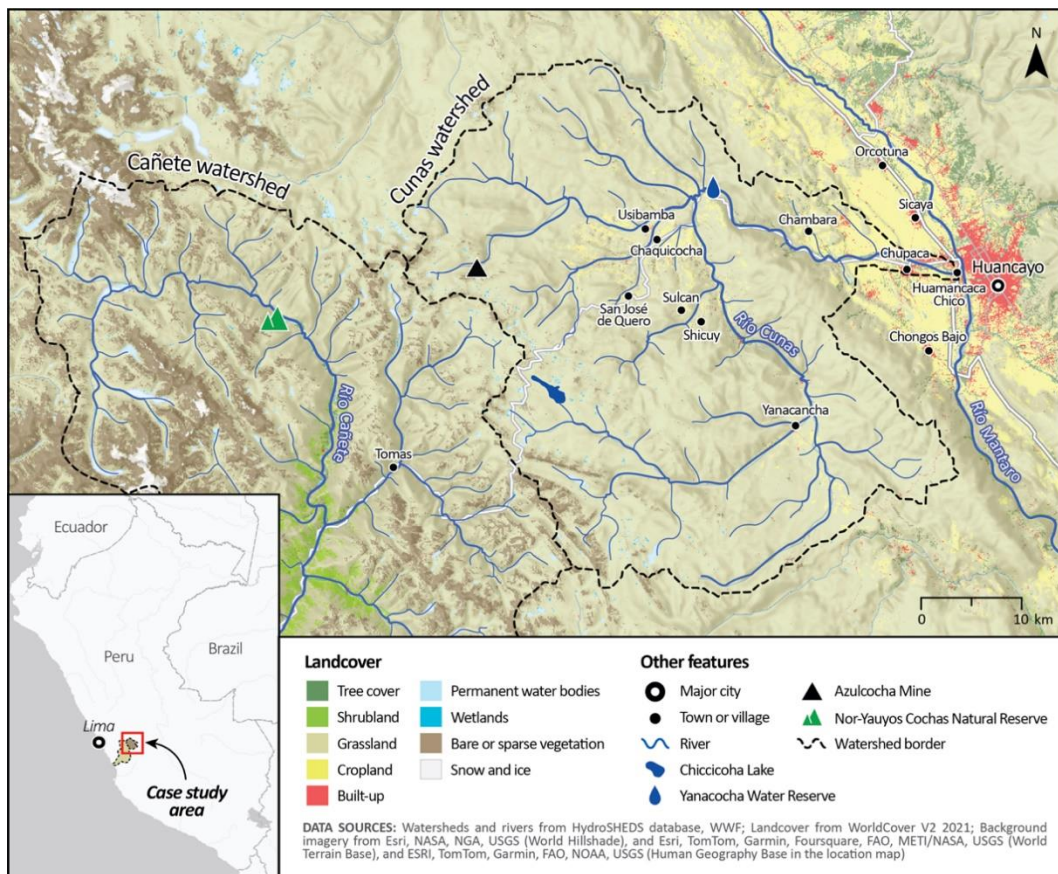


Figure 1. The Cunas waterscape. Drawn by Hanna-Maija Toivanen

Despite high environmental fragility, mining activities have altered the Cunas for over eight decades. In the late 1940s, valuable mineral reserves were discovered in the upper Cunas, establishing the Azulcocha mine at the headwaters of the Cunas River. The mine first focused on manganese mining, but since the early 1960s,

it shifted to extracting zinc, which is continuing today.² Recently, zinc extraction in the Azulcocha has further expanded despite evidence of long-term toxic pollution threatening local smallholders' and livestock herders' livelihoods and living environments (Custodio *et al.*, 2020).

This study draws on ethnographic-oriented methods to understand the linkages among the emerging zinc extractivism in Cunas, the global low-carbon transition, and the residents' deepening climate vulnerabilities. This approach included 12 months of fieldwork in the area in 2019 and 2022 and an analysis of mining documents related to the Azulcocha mine and overall zinc extraction in Peru. During the fieldwork, I conducted 44 interviews, participant observation, and workshops with residents in different parts of the Cunas watershed. In addition, I interviewed 25 state officials at central, regional, and departmental levels, NGO staff, journalists, and mining company representatives. I also participated in numerous community and regional-level meetings related to mining and water management. A review of Peruvian and international reports and media publications related to climate mitigation, low-carbon transition, and green minerals complemented these data.

During the field research in Cunas, I paid close attention to the residents' experiences of differentiated and multiple vulnerabilities related to the interconnected impacts of climate change and zinc extraction. Informal conversations with residents and observation of their daily activities in their living environments helped clarify such nuances. Meanwhile, the interviews and informal meetings with state officials, mining representatives, and other professionals helped illuminate how the multi-scalar dynamics of low-carbon transition to mitigate climate can result in invisibilized forms of green extractivism, which (re)produce vulnerabilities in the Andean waterscapes.

4. Invisibilized practices of green extractivism and vulnerabilization

Emerging zinc rush in the Peruvian Andes

Since the late 1990s, different governments in Peru have promoted a development model based on extractivist activities, particularly mining. Today, the mining sector forms the basis of Peru's economy, and the country has become a world leader in producing copper, silver, and zinc (MINEM, 2022). This development trajectory has led to considerable expanding of mining operations throughout the country; between 1991 and 2022, the total area of mining concessions grew ninefold, occupying nearly 16% of the Peruvian territory (approximately 19 million hectares) (CooperAcción, 2022). Most of these operations are in the mineral-rich Andean highland region at 3,000 meters and above. At these altitudes, the mining operations pose a high risk of deteriorating sensitive headwater ecosystems and threaten the highland residents' living environments and ways of life (CooperAcción, 2017). These threats are now strengthened by ever-more tangible impacts of climate change, such as accelerated glacier retreat (Vuille *et al.*, 2018), uncertain precipitation (Anderson *et al.*, 2011), and prolonged droughts (SENAMHI, 2022).

Despite the growing awareness of the severe socio-ecological mining-related risks in the Andean region, Peru's government is further promoting the expansion of the extractive frontiers. Such is the case also with zinc, whose production has grown steadily, and its exports have more than doubled between 2013 (1,414 tons) and 2022 (2,661 tons). Moreover, during 2023, new zinc concessions have been inaugurated with the hopes that "such mining projects will help to safeguard the country's future as a prominent mining export country" (MINEM, 2022: 17). Currently, Peru has the fourth largest zinc reserves in the world and is the second biggest global producer of zinc after China. In 2022, zinc was Peru's third major mineral exported; its main export destinations were China, Spain, and Brazil (MINEM, 2022).

The emerging zinc rush in Peru is linked to the recent global political-economic shifts in mineral markets and their connection to low-carbon transition (Sovacool, 2019). According to a recent report by the International Energy Agency (IEA, 2023), the market intensity of the key energy transition minerals has doubled over the past five years, reaching a value of US\$320 billion in 2022. While zinc still represents a modest fraction of this

² Information based on the historical Environmental Impact Assessment (EIA) documents of the Azulcocha mine obtained from Peru's Ministry of Energy and Mining. I refer to the EIA documents by pseudonymized codes due the confidential information related to the residents, mining companies, and state authorities. INRENA-OF-997-2007

market volume, its demand has grown continuously (ILZSG, 2023). This trend has been visible in development of global zinc prices, approaching a historical record of US\$4,405 per ton in April 2022—a price unseen in 15 years (CooperAcción, 2023). In a recent World Bank report (2020), zinc has been listed as one of the most essential minerals for "climate action," and the global zinc demand is forecasted to rise by over 200% by 2050. The growth in zinc demand is the highest forecasted increase among low-carbon minerals after iron and aluminum, which is particularly affected by the increased use of zinc for wind energy technology.

Previous studies have discussed how governments use "green progress" as discursive tactics to legitimize extracting key energy transition minerals in the name of sustainability and climate mitigation (Dorn *et al.*, 2022; Dunlap & Riquito, 2023; Kingsbury, 2021). In Peru's case, at a governmental level, there is currently no official strategy to promote mining in the frames of low-carbon transition. Rather, the debates over opportunities in marketing Peru's mining sector via a green economy are speculative (CEPLAN, 2023). This relates to the high political volatility in the country in recent years, obstructing all initiatives to formulate coherent state policies on ecological transition (Bermeo, 2023). However, this might change in the forthcoming years. For instance, BBVA research's recent report on Peru's mining sector (2023) highlights the attractiveness of the country's mineral reserves concerning climate change and rising global interest in green technology. The report calculates how Peru could benefit from the global rise in zinc demand under different scenarios of the global temperature rise and related decarbonization action.

Thus, unlike in many other Latin American countries that have recently applied sustainability discourses to expand extractivism of green minerals (Dorn & Gundermann, 2022; Voskoboynik & Andreucci, 2021), Peru's government still promotes mining rather through traditional discourses of economic progress and poverty reduction it has used since the 1990s (MINEM, 2022). However, the country's mining sector is not disconnected from the recent global shifts in extractivist expansion (Chagnon *et al.*, 2022) and its links toward a low-carbon economy. In the case of zinc, this connection is reflected in the ways that the rising global market prices of the mineral have affected the progressive growth of its production at major zinc mining companies in Peru; Peruvian-Swiss Antamina S.A. and Volcan S.A., and Peruvian-Brazilian Nexa Resources Perú. In Antamina's case, zinc production grew nearly twofold between 2013 and 2022. Volcan saw a modest rise, while Nexa Resources quintupled output between 2014 and 2022.³ These three multinational companies operate in the Central Andean departments of Ancash, Junín, and Pasco, and represent 72% of Peru's zinc production (MINEM, 2022).

Simultaneously, the prosperous zinc markets have encouraged the revitalization of smaller zinc mines in the Andes, as they "permit relatively rapid reactivation of extraction" (El Comercio, 2018). One of them is an 80-year-old Azulcocha mine in the highlands of the Cunas watershed. After having been closed for some years during the 2010s, Azulcocha was reopened in May 2019 as it was sold to a new owner, Canadian-Peruvian multinational Sierra Poli SAC.⁴ The transaction coincides with a surge in the London Metal Exchange (LME) market price for zinc since 2017 (Van Leeuwen, 2022). The new company now aims for a considerable rise in zinc extraction, while in the early 2000s, the target for Azulcocha's zinc production volume was 500 tons per day,⁵ Sierra Poli aims to grow production to 1,000 tons per day and continue increasing until reaching 5,000 tons per day (Sierra Sun Group, 2023; Rumbo Minero, 2021). Although Azulcocha is classified as a medium-sized mine and its extracted volumes are relatively small, expanding the mining operations poses a considerable threat to the local highland water ecosystems and smallholder communities (Heikkinen *et al.*, 2023).

Peru's emerging zinc rush demonstrates the inherently global character of the current expansion of green extractivism and its multi-scalar planetary connections (Chagnon *et al.*, 2022; Nygren *et al.*, 2022). While in other Andean countries global sustainability transition has been applied as a discursive tool to justify the spread of green mineral mining (Barandiáran, 2019), in Peru emerging zinc extraction has not occurred through strategic policies or explicit discourses over the "greening of extractivism" (Voskoboynik & Andreucci, 2021). Rather, green extractivism has been advanced in the frames of the Latin American (neo)extractivism since the

³ Data did not exist before 2014.

⁴ CONCESIÓN-AZULCOCHA-2018-2019/RP-2406-2019

⁵ INRENA-OF-997-2007

2000s, drawing on the promises of economic growth, productivity and modernization (Svampa, 2012). This way, as Peru's case shows, green extractivism can also emerge gradually, in less evident ways due to multi-scalar extractivist policies, speculations, and markets driven by global low-carbon transition. In the following, I discuss how such procedures of invisibilization in green extractivism are further advanced through confusing climate and mining policies, resulting in entrenched vulnerabilization in the Andean waterscapes.

Politics of vulnerabilization in the Andean waterscapes

The current low-carbon development and related climate mitigation risk producing unintended and unforeseen implications in socio-ecologically marginalized environments. This risk relates to uneven arrangements in implementing climate policies created by power asymmetries that are seldom questioned (Mirumachi *et al.*, 2020). Compliance with unequal power structures in climate policies threatens to mask the non-acute and latent environmental harms related to mining (Gamu & Dauvergne, 2018) and how these deepen vulnerabilities in the context of climate change (O'Lear, 2016). Such intertwined ambiguous climate mitigation and zinc mining procedures contribute to the politics of vulnerabilization, understood as governmental and corporate discourses and practices permitting the accumulation of environmental degradation and vulnerabilities (Nygren, 2021; Taylor, 2015). In the context of Cunas, the article demonstrates how confusing zinc mining with climate change mitigation policies advance green extractivism, meanwhile amplifying the vulnerabilities of highland residents.

The key transnational and Peruvian environmental institutions acknowledge the high vulnerability of the Andean highlands to climate change (IPCC, 2022; MINAM, 2019). The climate-induced socio-ecological vulnerabilities are also highly prioritized in Peru's climate policy agendas. Peru is renewing its current climate strategy (ENCC, 2015) to a new National Climate Change Strategy for 2050 (ENCC, 2050). According to the ENCC 2050 draft, the country is committed to protecting watersheds vulnerable to climate change and reducing any related climate impacts and risks, especially when they threaten marginalized populations. Moreover, Peru's new National Climate Adaptation Plan published in 2021 states its main objective as follows: "Reducing any kind of harm, alterations and current and future losses generated due to threats associated with climate change for all the populations and their livelihoods" (MINAM, 2021: 77).

The importance of mitigating climate change has also become more frequent in the discourses and actions of Peru's top political authorities. In January 2022, President Pedro Castillo announced a national interest in climate emergency, posing a legal obligation to mitigate climate impacts with high urgency.⁶ After Castillo's impeachment amid the political crisis in December 2022, one of the first things interim president Dina Boluarte did was to implement an urgent decree to economically support the Andean smallholders and alpaca herders suffering from the historically severe droughts.⁷ In the interviews, the governmental authorities in diverse positions recalled the necessity of placing climate change and related vulnerabilities as a key national priority, as one high-level environmental authority from the central government expressed:

Our country has an important role in the climate issues, and it [the government] is taking serious actions accordingly. I want to reiterate that this is exactly because we are a highly vulnerable country to the effects of climate change...and I think the recent legal changes are highly important to be able to protect the populations that are mostly affected by the grave consequences of climate change.⁸

The political action and discourses thus demonstrate Peru's institutional commitment to mitigate climate change and protect vulnerable populations. However, these goals have been weakly achieved and even worsened the vulnerabilities in the Andean communities (Heikkinen, 2021; Stensrud, 2021). These processes have occurred through overlapping policies, such as agricultural market arrangements that exclude small

⁶ DECRETO SUPREMO N° 003-2022-MINAM: Intéres nacional la emergencia climática

⁷ Decreto de urgencia – N° 025-2022

⁸ Interview, 5 July 2022

producers and weaken their agroecological forms of livelihood (Zimmerer, 2018). Moreover, the Andean smallholders and Indigenous people have been systematically excluded from climate policy decision-making; rather, state authorities have planted technocratic adaptation solutions in the highland communities, often resulting in adverse outcomes (Stensrud, 2019).

The climate mitigation policies striving to reduce vulnerabilities risk failure, also due to permissible mining practices in sensitive highland environments. In 2021, the Peruvian Congress debated a law project requiring the prohibition of mining activities in the highland headwater areas, but the initiative did not gain enough support to proceed.⁹ The halting of the law contradicts Peru's new climate agenda that prioritizes preserving sensitive watersheds (ENCC, 2050), especially because mining risks contaminating important headwater ecosystems that provide important water supply for highland populations (CooperAcción, 2017). Also concerning is that none of Peru's high climate policies mention the socio-environmental mining-related threats in the context of climate change. Recent studies have observed similar contradictory climate policies vis-à-vis extractivism. In Mexico, Hesketh (2022) shows how the new national development strategy rhetorically presented renewable energy production as a way to mitigate climate change, while allowing deep-sea oil drilling. Likewise in California in the US, oil production has continued in the shadows of the state's highly ambitious climate agenda, targeting widespread carbon neutrality by 2045 (Patridge *et al.*, 2020).

In Peru, ambiguous climate policies leave space for accelerated extraction of low carbon minerals, which risk further deepening climate-related vulnerabilities. Such processes can be seen, for instance, in the recent development of the Azulcocha zinc mine's concession in the Cunas watershed. On their webpage, the new company highlights itself as especially committed to protecting water ecosystems (Sierra Sun Group, 2023). However, recent studies have found alarming levels of toxic heavy metals, such as arsenic and lead, in the water and sediments in the rivers near the mining area, posing a high risk to the well-being of the residents and non-human nature (Custodio *et al.*, 2020). While the mining company has made no official statements in its operations regarding climate change, in an informal discussion with the company's director described his views on climate-mining relations:

Of course, a mine will always have an impact on the environment, but the key thing is to minimize this impact and the possible risks. After all, all human activities are affecting the planet. Think about, for example, the CO₂ emissions caused by meat production. So, mining is not any worse in that sense.¹⁰

The mining company's justification of extractivism by undermining the environmental harm is a common practice by extractive industries (Scott & Bennet, 2015). This also illustrates how politics of vulnerabilization are reproduced by corporate discourses normalizing mining-related impacts as 'manageable' and while permitting accumulation of environmental deterioration (Leifsen, 2017). In Colombia, researchers have recently urged a shift in such practices, presenting a case to Constitutional Court demanding that impacts of climate change must be included in the mining projects' Environmental Impact Studies (EIA) (Cardona, 2024).

Meanwhile procedures of vulnerabilization have been further reinforced in the Cunas watershed through the state authorities' confusing practices and statements related to climate and mining. In the past decades, several governmental institutions have conducted studies on climate impacts in the area, highlighting the exceptionally high socio-ecological vulnerabilities, particularly in the most upper and remote parts of Cunas (IGP, 2012; CIIFEN, 2018). The special vulnerability of Cunas at the departmental level was emphasized in the interviews with regional and local authorities. A high-positioned regional environmental authority described

⁹ PROYECTO DE LEY N° 585 | 2021-CR- DECLARA LA INTANGIBILIDAD DE LAS CABECERAS DE CUENCA

¹⁰ An informal discussion, 17 February 2022

the Cunas River as "one of the most critical points of the hydro-ecological system of the region"¹¹, while a director at a municipal level highlighted the socioeconomic challenges:

The population of high Cunas is considered poor. That is why we want to improve their quality of life, but it is becoming more and more difficult because sometimes, the water supplies get so low that the farmers lose everything. Due to climate change, we have more droughts, the production has lowered, [and] the land is not giving so much anymore.¹²

While these statements show that the challenges in water access due to exacerbating climate impacts in Cunas are well-known by the governmental authorities, harmful mining has been advanced. When Azulcocha was sold to Sierra Poli in 2019, there was solid evidence of long-term water pollution caused by mining operations, yet inauguration of extraction was permitted.¹³ Ignorance of the toxic legacies of extractive operations can further amplify climate risks and injustices related to low-carbon transitions (Patridge *et al.*, 2023). Although after only six months of operation the water authority (ANA) found that the mine's EIA had an outdated water management plan, mining operations were still allowed to continue.¹⁴ Water availability is crucial in mitigating climate-related vulnerabilities, and Peru's climate agendas acknowledge this (ENCC, 2050; MINAM, 2021). Yet, as the case of the Azulcocha mine shows, mining has systematically railroaded the well-being of the Cunas watershed, the residents, and the non-humans relying on it. Thus, the politics of vulnerabilization related to zinc mining and climate change have permitted what Michael Glantz calls *creeping environmental change* (Glantz, 1998), referring to an appreciation of slow-moving and cumulative degradation resulting from multi-scalar power dynamics.

Here, I have shown that climate-related harms in the Cunas watershed are reshaped by ambiguous climate and mining policies operating across multiple scales. Despite the ambitious goals of Peru's climate agendas, their inconsistent implementation leaves space for expansion of zinc extraction, promoted by corporate discourses that undermine the environmental degradation inherent to mining. These procedures are tightly connected to political-economic arrangements of global low-carbon transition that feed an emerging demand for zinc, and consequently its accelerated mining in the Andean highlands. In Cunas, green extractivism is advanced through a politics of vulnerabilization, reproduced by intertwined practices of incoherent climate mitigation policies and zinc mining. These multi-scalar green extractivist procedures have inadvertently contributed to reinforcing climate threats and (re)producing multiple vulnerabilities along the Cunas watershed (Mirumachi *et al.*, 2020; Ribot, 2022). In the following, I show how such cumulative threats of climate change and mining are experienced in the lives and living environments of the Cunas residents.

5. Lived vulnerabilities amid a shifting climate and green extractivism

People's interpretations and experiences of climate shifts are often deeply connected to context-specific lived experiences, practices, and worldviews (Straus & Orlove, 2003). Here, I approach the Cunas residents' experienced vulnerabilities through their *lived environments* in which shifting relations between the biophysical conditions, social relations, and cultural characteristics "bring such landscapes into being" (Taylor, 2015:16). In the context of the Cunas watershed, this requires careful attention to how variations in altitude, climatic conditions, ways of life, and the Andean socio-cultural characteristics shape how people relate to their environment. By focusing on how the residents know and understand the sensitive waterscapes they inhabit, the analysis aims to better understand the multiple lived vulnerabilities related to climatic changes and expanding green extractivism in the Andean highlands.

¹¹ Interview, 20 June 2022

¹² Interview, 2 April 2019

¹³ Azulcocha EIA documents 2007–2018

¹⁴ RD-ANA-071-2020

Living between climate change and mining in the fragile highland waterscape

In the most remote part of Cunas, at an altitude of 4,500 m, arid grasslands, *punas*, dominate the landscape. The grasslands form an essential part of the daily lives of the high Cunas residents, particularly the *comuneros* of the Tomas peasant community, who use the *puna* as pastures for their alpacas. The *puna* area marks the border between the Cunas and Cañete watersheds, and the *centro poblado* of Tomas is on the side of Cañete. However, the lands of Tomas extend to the *puna*, connecting the alpaca herders to the Cunas watershed, and also to Azulcocha mine concession, as part of it is located in the Tomas' territory.

For many Tomas residents, producing alpaca wool and meat constitutes their major livelihood, as crops are difficult to grow at these altitudes. During our discussions, the residents stated that the *puna*'s well-being was an elementary condition for their way of life. However, while climatic conditions in the high *punas* are naturally varied, the residents said that in recent years, the *puna* no longer recovered as it used to because the climatic shifts had become increasingly strong, as alpaca herder Luciana described:

First, it rains so much that the pasture gets leaky [and] wet. And then suddenly, the rain stops, and the heat comes with power and burns the grass. This deteriorates the forage, and it becomes hard to find good pasture for the alpacas.¹⁵

The *puna* environment is a delicate hydrological system in which water is captured, infiltrated, and preserved through highland grass *ichu*, acting as an extensive water cushion. Now, with an accelerated hydrological cycle due to climate extremes, the *ichus* could not sustain the water equilibrium (Parra, 2019). The decayed pasturelands affected the alpacas; the quality of the wool had lowered, and many animals were getting sick, even dying. The hydrological anomalies were making the Tomas residents increasingly worried about their living environment and ways of life, as alpaca herder Raúl expressed:

We want [the] well-being of our *puna* because our animals need healthy pasturelands. We have already seen what flooding does to our pastures; the water destroyed it, and we don't want that to happen anymore.¹⁶

The alpaca herders' accounts of the recent climatic shifts show the complex socio-ecological relations constituting their lived environment in the *puna* and how climate threats emerge in this specific place (Taylor, 2015). In high Cunas, the climate-related hydrological extremes manifest concerning the pasturelands, animals, and humans and how these extremes shape the ways of life in a challenging highland environment. This intimate relationship with the diverse elements of the non-human world was closely present in how the residents interpreted climate-related harm in their environment. As an elderly alpaca herder Jacinto expressed: "...a good life for me would be that my children would be well, that my animals would feel well attended, with good pastures, and that all of us would be free from suffering".¹⁷ While the high Cunas residents do not identify as Indigenous, the Andean Quechua people drawing on "living well together amongst humans and between humans and non-humans" was closely present in how they experienced vulnerabilities amid the shifting climate (Ranta, 2020: 427).

While the high Cunas residents struggle with severe climate shifts, the zinc extraction at the Azulcocha mine has been expanding nearby. Mining activities do not directly affect the *puna*, located above the concession area, however, its operations occur within the relational highland environment in which climate and socio-ecological processes are intrinsically connected. The mine's concession extends to the border of a protected Nor-Yauyos Cochabambas Natural Reserve consisting of an exceptionally vulnerable highland environment.¹⁸ In the

¹⁵ Interview, 11 March 2022

¹⁶ Interview, 3 April 2019

¹⁷ Interview, 11 March 2022

¹⁸ Decreto supremo No 033–2001–AG–La Reserva Paisajística Nor Yauyos-Cochas; INGEMMET, 2022

early 2000s, Peru's environmental authorities expressed numerous concerns about expanding mining in this unique Andean ecosystem with fragile wetlands, flora, and fauna.¹⁹ In the ecologically important areas sustaining ecosystems, extractivist activities have a high risk of deteriorating environments that help stabilize the impacts of climate change and people's vulnerabilities (Dunlap & Riquito, 2023). In Nor Yauyos-Cochas, the conserved area is essential in regulating the hydrological balance of the Cunas, as it hosts the few glaciers left in the region, contributing to the water flow of the Cunas River. In recent years, rising temperatures have accelerated glacier retreat (INGEMMET, 2022). Moreover, studies on the Andean glaciers show that nearby mining activities risk enhancing glacial melting through dust emissions from extractive processes (Gilardoni *et al.*, 2022). In Chile, mining deposits and the construction of roads near the glaciers have already altered their recession (Brenning & Azócar, 2010).

Furthermore, the glaciers of Nor Yauyos-Cochas have important symbolic meanings for the residents. Pariaca, the region's largest glacier, is considered a sacred entity, and the myths related to *Apu Pariaca* are essential in configuring the surrounding highland environment. Thus, with the highland lakes, pastures, mountain paths, and rivers, the Pariaca Glacier shapes the residents' cultural identities and their sense of belonging (Ccente *et al.*, 2009). Studies from other parts of the Andes show how glacial retreat can cause intense feelings of emotional loss for residents living near the glaciers (Gagné *et al.*, 2014; Rasmussen, 2016). While the high Cunas residents do not live near the Nor Yauyos-Cochas glaciers, they do represent a critical element in their lived environments and how they interpret environmental change within them, as livestock herder Aurelio described:

Before, you could see all those high parts were white—full of snow. But now, the *cordillera* has disappeared. This year, you could no longer see any drop of snow. It's a question of nature, and I think that is why we are having less and less water.²⁰

Aurelio's comment shows how glacier formation is intimately connected to the Andean understanding of the water cycle. As Gelles (2000) describes, in the Andean cosmivision, the mountains provide water, which flows through the diverse highland micro-hydrological floors, supplying human and non-human needs. While the high Cunas residents did not discuss the spiritual connections and rituals related to the mountains and water—an essential part of being in the world for many Andean Indigenous communities (Paerregaard, 2017)—knowing the hydrological cycle through mountains was central in how they interpret and explain shifts in their living environment. Other studies from the Andean region similarly show, how residents experience hydrological threats shaped by climate change and mining within such multiple water worlds (Stensrud, 2016), consisting of the "modern" and "non-modern" ways to exist and think of nature (Ranta, 2020).

Interrelated effects of climate change and mining

Recently, expanding zinc extractivism at Azulcocha has further altered the Cunas watershed, particularly through toxic pollution. The mine's EIA show long-term evidence of the accumulation of heavy metals in the waters and sediments of the Cunas River and its tributaries.²¹ However, although the hydro-social fragility of Cunas is well-known, this information has been systematically ignored by confusing corporate practices and state policies. The risks of mining-related pollution are further heightened with intensifying climate extremes. Recent studies show an alarming rise in heavy metal concentrations in the rivers and sediments in the upper Cunas close to the mining site, particularly during the Andean dry season when water levels are low (Heikkinen *et al.*, 2023). Moreover, the extreme rains pose a risk for the mining tailings to overflow from the wastewater discharge pools.²²

¹⁹ INRENA-OBS-TEC-2007

²⁰ Interview, 1 April 2019

²¹ Information based on the Azulcocha mine's EIA documents and reports by ANA and OEFA between 2010 and 2019.

²² RP-OEFA-12-2015

These threats were especially present in the upper Cunas communities below the *puna*, where most residents are dedicated to animal husbandry. The intertwined effects of climatic changes and mining pollution regarding water access were often present when the residents described the challenges in their daily lives. Carmen, an elderly livestock herder, lamented that sometimes her cows did not have enough to eat because the pastures were turning "yellow," and the drinking water was questionable because she believed the rivers flowing through her pasturelands could be contaminated.²³ Other residents, such as Edwin, a livestock herder, expressed their concerns on the interrelated effects of climate shifts and mining even more clearly:

We don't have enough water, and that is because of climate change and contamination. There are mines up there where the Cunas River is born, and that's why the water is no longer adequate for any kind of use.²⁴

Dunlap & Riquito (2023) show in their study on the green extractivist expansion in Portugal how residents' concerns about the mutual effects of climate change and extractivism have been bypassed with the rhetoric of "climate-friendly mining". While such discourses have not been explicitly used in the Azulcocha's case, the mining harms have been overshadowed by celebrating the prosperous economic benefits of zinc, which can be connected to expanding global low-carbon mineral markets (Diego *et al.*, 2023). Meanwhile, recent water and sediment analyses show that especially in the high Cunas, heavy metal and metalloid concentrations keep exceeding the Peruvian and international permissible levels multiple times (Heikkinen *et al.*, 2023).

The heavy metals in the rivers can also travel long distances and accumulate into sediments for long periods with uncertain effects (Miller *et al.*, 2007). Concerns for such pollution-related uncertainties were present in the residents' everyday lives, even in low Cunas, 70 kilometers away from the mining site. This was illustrated in a conversation with Lidia, a smallholder who first described her concerns related to droughts and the lack of irrigation water for her potatoes and *choclos* (Peruvian corn) but then she suddenly said:

But you know, there is also this other thing...The other day, my husband came home, and he told me that the water was coming with [an] orange color; he knows these things and said this is not normal. They [the mining company] say that the mine will not affect us, but we talked with my husband, who said it must be the mine throwing their contamination into the river. And do you know how the contamination affects the *chacra* and the animals? I'm asking if it will poison everything.²⁵

The residents' concerns about water-related changes across Cunas show how extractivism and climatic changes increasingly affect water flows and deepen water disparities (Bustos-Gallardo, 2021; Sultana, 2018) across multiple scales. Lidia's comments on the lack of water for her potatoes and *choclo* and her uncertainties on how pollution will affect the animals and the *chacra* (agricultural plot) also show how residents experience the multi-scalar effects of pollution amid climate change through their intimate connections with humans and other-than-humans. This reflects the relational thinking of the Andean worldview, referring to the multiple ways humans and other beings can relate (Li, 2015; For a more nuanced discussion, see de la Cadena, 2010). With intensifying climatic shifts in the Andean communities, the related environmental changes happen and are felt through this interdependent world (Stensrud, 2016). Recently, the deepening material and symbolic water-related vulnerabilities the residents were exposed to in their lived environments caused increasing feelings of injustice, leading to the escalation of water-related conflicts.

²³ Interview, 2 March 2022

²⁴ Interview, 1 April 2019

²⁵ Interview, 28 February 2022

Escalating water struggles amid climate change and mining

In many parts of the world, expanding green extractivism has generated new or escalated socio-ecological struggles (Andreucci *et al.*, 2023; Diego *et al.*, 2023; Lorca *et al.*, 2022). Also, mining-related conflicts have grown alarmingly in Peru in recent years. According to a recent report of Peru's Observatory of Mining Conflicts (OCM), at the end of 2023, the number of socio-environmental conflicts in Peru was the highest in seven years, reaching 220 cases, of which 67% were related to mining activities (OCM, 2023). The Peruvian NGO CooperAcción has argued that these conflicts have been disconnected from the context of climate change and the country's decreasing water supply. For instance, on 19 September 2023, Peru's Congress declared a state of emergency for 60 days due to a hydrological deficit, mainly in the Andean region. Nevertheless, large mining projects have been advanced in the areas, where crucial water supplies are formed; such is the case with a new mega copper mine, Ariana, in the highlands of Lima (CooperAcción, 2023).

Similar interrelated concerns for mining amid climate change have recently led to multiple water-related struggles across the Cunas waterscape. The Azulcocha mine's re-opening in 2019 generated a new socio-environmental conflict as some upper Cunas residents demanded the mine's closure (Defensoria del Pueblo, 2019). This demand was due to the residents' disappointment with the long-term ignorance of pollution by the previous companies who had operated at Azulcocha. The residents no longer believed the new mining company would be any different, especially as it had criminalized their peaceful protest in June 2019 when the mine was about to inaugurate its operations. The conflict remains unsolved, as the mining company keeps neglecting the residents' feelings and claims over water injustices (Defensoria del Pueblo, 2023).

Another water-related conflict concerning the construction of a Yanacocha water reservoir has recently escalated in the Cunas waterscape. It was initially a state-led project that started in the early 2000s to improve irrigation in low Cunas allowing more extensive agricultural activities. As the Yanacocha was planned to be built in the middle Cunas, which would only benefit some of the residents, it has faced resistance from upper Cunas communities for decades (Heikkinen, 2021). However, with exacerbating climatic impacts, the tensions around the reservoir have further inflamed in recent years. The upper Cunas residents facing increasing droughts and the effects of mining-related pollution found it unjust there were no initiatives to improve their water access. As part of the planned reservoir was in their lands, the project needed their acceptance, which they refused to give. Simultaneously, the low Cunas residents suffering from prolonged droughts desperately needed more irrigation water. These dynamics produced a confrontation in which both sides allied with powerful actors such as politicians and diverse state authorities to claim their grievances regarding diminishing water access. While Yanacocha's struggle concerns improvements in irrigation amid droughts, it is inherently connected to the residents' battles with mining-related pollution, as the different discussions in 2019 and 2022 with Walter, an upper Cunas resident, show:

We will not accept the installation of the mine anymore; we must look for other alternatives to help the *campesino* – for agriculture and animal husbandry. The water from the highlands is the only water that passes through our communities, and we will no longer accept its contamination.²⁶

There is no water; as you can see, everything around here has dried out. We urgently need solutions to the water situation – not Yanacocha – but a reservoir that would benefit all of us in Cunas.²⁷

The recent escalation of the diverse water-related conflict across the Cunas waterscape reflects how green extractivism alters essential water resources and deepens local communities' water grievances in the

²⁶ Discussion, 4 July 2019

²⁷ Discussion, 28 July 2022

context of climate change (Bustos-Gallardo *et al.*, 2021; Jerez *et al.*, 2021). While in the Cunas, accelerating zinc mining is not explicitly promoted as "green mining," it is connected to a surge of low-carbon technologies as a climate solution, creating new extractivist zones in the Global South (Andreucci *et al.*, 2023). As shown here, in the socio-ecologically fragile environments, such as the Cunas waterscape, the acceleration of green extractivism risks considerably entrenching the residents' existing vulnerabilities, resulting in new water-related conflicts as the impacts of climate change keep strengthening.

6. Conclusions

This study has analyzed the links among the expanding zinc rush, the global low-carbon policies, and the associated vulnerabilities in the socio-ecologically fragile Andean waterscapes in the context of climate change. The analysis focused on the Cunas watershed in the Central highlands of Peru to explore how green extractivist procedures (re)shapes uneven power relations and multiple vulnerabilities by entrenching existing socio-political struggles and susceptibility to climate risks. By drawing on the political ecology of green extractivism and climate vulnerability, the study shows how the global low-carbon transition drives the expansion of extractivism in socio-ecologically fragile environments, sometimes in less visible ways—(re)producing and accumulating multiple vulnerabilities with exacerbating climatic shifts.

Peru's emerging zinc rush demonstrates the inherently global character of green extractivism's current expansion and multi-scalar planetary connections (Chagnon *et al.*, 2022; Nygren *et al.*, 2022). In the Cunas waterscape, these procedures do not occur through strategic policies and explicit discourses over the "greening of extractivism" (Voskoboynik & Andreucci, 2021), but rather, extractivism has emerged gradually and in less explicit ways due to multi-scalar policies, speculations, and markets driven by global low-carbon transition. Such processes of invisibilization in green extractivism have been further advanced through confusing climate and mining policies in Peru, resulting in entrenched socio-environmental deterioration in the Andean waterscapes. These procedures have occurred through the politics of vulnerabilization in which ambitious climate policies to protect vulnerable populations and highland ecosystems are systematically repealed by permissible and harmful mining practices.

The confusing policies related to green extractivism have (re)produced and amplified the Cunas residents' susceptibility to climate threats in the fragile waterscapes they inhabit. Across Cunas, the residents expressed their experiences of the intertwined impacts of zinc mining and climate change, particularly through alteration of the water cycle. While most of them were concerned how such alteration would affect their water access, essential for their agricultural, livestock and *alpaca* herding livelihoods, the shifts in water supply were also interpreted through the biophysical conditions, social relations, and cultural characteristics constituting the waterscapes they inhabit. While the mining did not have direct impacts in all parts of the watershed, its operations occur within such relational highland environment in which climate and socio-ecological processes are intrinsically connected. In this specific socio-cultural highland context, the residents' experienced vulnerabilities related to climatic extremes and mining pollution were sensed not only as material losses but also through symbolic meanings and intimate connections between humans and non-humans. Recently, the residents' experiences of multiple vulnerabilities shaped by climatic changes and mining were causing increasing feelings of injustice, escalating into numerous water-related struggles.

This study has contributed to the literature of political ecology of green extractivism and vulnerability by exploring how accelerated extractivism transforms the socio-ecological landscapes in the context of climate change, disproportionately exposing the ecosystems and people inhabiting them to environmental harms. The analysis has shown how, with the deepening climatic impacts, accelerating extractivism driven by low-carbon transition threatens to (re)produce particular water-related vulnerabilities across multiple scales. In the fragile Andean highland waterscapes, the green extractivist expansion further escalates existing and new water related conflicts as the impacts of climate change strengthen. The study thus emphasizes the urgent need to rethink the global climate proposals in a way that does not deepen climate harms in marginalized waterscapes in the Andes and elsewhere in the Global South.

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