THESIS

ENACTING ENVIRONMENTAL JUSTICE: COMMUNITY-BASED WATER RESEARCH AND RESISTANCE IN HIGHLAND ECUADOR

Submitted by

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Gradute Degree Program of Ecology

In partial fulfillment of the requirements

For the Degree of Master of Science

Colorado State University

Fort Collins, Colorado

Summer 2025

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ABSTRACT

ENACTING ENVIRONMENTAL JUSTICE: COMMUNITY-BASED WATER RESEARCH AND RESISTANCE IN HIGHLAND ECUADOR

In the highland parish of Pintag, Ecuador, community members face declining water quality and governance failures despite the country's progressive constitutional framework recognizing the Rights of Nature, the human right to water, and the principles of Buen Vivir. This thesis presents a community-based, interdisciplinary research project developed in collaboration with an Indigenous collective in Pintag, to investigate water quality conditions and governance dynamics in the region. Using a mixed-methods approach that combined water sampling, interviews, and participant observation, the research examines both biophysical indicators of water contamination and lived experiences of water access, management, and injustice.

Findings reveal that gravel mining and institutional neglect contribute to sedimentation and microbial contamination in waterways. However, many of the most pressing issues stem not from extractive activity alone, but from deeper systemic problems: regulatory gaps, underfunded institutions, and top-down structures that marginalize Indigenous and rural communities, leading to injustices. Despite constitutional protections, state institutions often fail to meaningfully engage with or support local water governance efforts. Community members report persistent procedural and recognitional environmental injustices, including lack of consultation, inaccessible data, and devaluation of Indigenous knowledge and autonomy.

In response, communities are reclaiming power over local water governance through grassroots organizing, alternative development models, and resistance to extractivist logics. This thesis contributes to environmental justice literature by highlighting how state failures produce uneven water governance outcomes, and how communities are building decolonial alternatives rooted in reciprocity and self-determination.

ACKNOWLEDGEMENTS

I would like to thank my committee - Heidi Hausermann, Andrea Baudoin Farah, Joel E. Correia, and Jacqueline Gerson, as well as Matt Ross - for all the invaluable feedback you've given me through this process. A huge thank you to the Center for Collaborative Conservation for believing in us and this work and for trusting communities in funding structures. Thank you to the Graduate Degree Program in Ecology and the department of Anthropology/Geography for providing funds for this work. Many thanks to the labs that provided services to evaluate water quality data, including CSU's Analytical Resource Core (RRID: SCR_021758), especially the invaluable help of Jacqueline Chaparro. Thanks to CSU's School of Advanced Materials Discovery Core Center for access to equipment. I am also especially thankful to the Universidad San Francisco de Quito's Core Lab for Environmental Sciences, including Melany Ruiz Urigüen, Natalia Carpintero Salvador, and Erika Llumiquinga, for all the work and support you've put into this project, and for continuing work with Pintag Amaru. To Hope, thanks for making it possible for me to do this work at all, and being a constant source of support. Thanks to Heath, Evains, and Gabe for the help in the field. Thanks to my friends at CSU and beyond for adding so much joy to my life through this time, and thank you to my family for always being there for me. Most importantly, thank you to everyone in Pintag Amaru, and all the host families who welcomed us into their homes. This project is by and for you, and it has been a privilege to share this work with you. Thanks for trusting us to share part of your story.

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1 Introduction

In summer 2022, researchers from Colorado State University began discussions with Pintag Amaru, an Indigenous collective based in the rural parish of Pintag, Ecuador, to co-develop a community-driven research project. Members of the community organization expressed water quality concerns, particularly the potentially detrimental effects of gravel mining. They viewed corporations as environmentally harmful and operating without local accountability.

Drawing from community concerns, this project was developed to query socio-environmental impacts of gravel mining in the region. We took a community-based approach to prioritize Pintag Amaru's concerns and incorporate Indigenous knowledge into project design and methodology. While initially focused on water quality and other environmental changes, especially from mining, our results reveal broader governance failures impacting community members' lives. State policies – despite a radically revised Constitution granting rights to nature – privilege economic interests at the expense of Indigenous well-being (Baudoin Farah, 2025; Riofrancos, 2020; Rodriguez, 2020; Valladares Boelens, 2019). Water quality issues thus result from institutional structures and regulatory gaps rather than solely from direct pollution by mining industries.

This research contributes to environmental justice and decolonial studies by examining how Pintag Amaru residents experience and respond to water insecurity, and highlighting the importance of collaborative, co-produced research. We argue that: a) despite progressive legal frameworks, the state fails to ensure water protection and access for rural Indigenous communities; b) formal governance structures inadequately uphold regulatory standards; and c) local communities assert water sovereignty through grassroots governance and resistance. We examine these arguments through an environmental justice framework, focusing on decolonial and Indigenous interpretations (Alimonda, 2019; Correia Galeana, 2025; Gilio-Whitaker, 2019; Gudynas, 2011; Pulido, 2017; Rodriguez, 2020; Simpson, 2017) and situate the research in Ecuador's long history of coloniality and extractivism, where nature and Indigenous rights are routinely subordinated to state-led capital accumulation (Acosta, 2013; Bebbington et al., 2008; Riofrancos, 2020; Svampa, 2015).

2 Background and Theory

2.1 Ecuador Context and Buen Vivir

Ecuador has a long history of socio-environmental struggle. Spanish colonization drastically reshaped its landscapes and societies, dispossessing Indigenous peoples of land and rights while establishing forced labor systems and racial hierarchies (Rodriguez, 2020). One of the most enduring legacies was the hacienda system, which expanded the agricultural frontier through deforestation (Bates, 2008) and exploited Indigenous labor via debt peonage and mobility restrictions (Isacovici Rodríguez, 1999; Rivadeneira, 2023). Though agrarian reform laws in the mid-20th century redistributed some land to laborers, legacies of dispossession from identity, land, and power remain (Rivadeneira, 2023; Rojas Rodriguez, 2023).

Ecological degradation and the marginalization of Indigenous communities have continued under extractivist economic models. Oil and mining intensified in the 20th and 21st centuries, producing widespread harms such as water contamination, deforestation, displacement, and cultural erosion (Coral et al., 2024; Lessmann et al., 2016; van Teijlingen Hogenboom, 2016). Such outcomes are incongruous with many Indigenous ontologies in Ecuador, which often recognize animals, waters, forests, and other components of natural landscapes as having as much personhood as humans (de la Cadena, 2015; Escobar, 2020; Noroña Aguinda, 2025). Such tensions have propelled wide-scale resistance efforts through Ecuador's history, often spearheaded by Indigenous and campesino communities (Bebbington et al., 2008; Conde, 2017; Coral et al., 2024; van Teijlingen Hogenboom, 2016). The Mirador Copper mine in southern Ecuador serves as an example of this conflict. The large-scale, open-pit project has displaced Indigenous Shuar and campesino people, contaminated local waterways, and caused deforestation in protected areas, all amidst ongoing protest (van Teijlingen Hogenboom, 2016).

Responding to increasing social unrest and political movements in the late-1990s and early-2000s, some a direct response to neoliberal extractivism, Rafael Correa ran for president under a leftist, post-neoliberal campaign (Arsel, 2012). After Correa's election in 2007, Ecuador became the first country to enshrine Buen Vivir [1] and 'Nature's Rights' into its 2008 constitution. Framed as an alternative to capitalist development, Buen Vivir emphasizes equitable living standards, resource access, and environmental integrity (National Development Plan 2009-2013). The Constitution also establishes frameworks promoting community involvement in environmental decision-making and management autonomy (Articles 95, 398).

Despite nominal alignment with Indigenous ideals, the state's interpretation of Buen Vivir has also been used to justify continued resource extraction under the narrative of promoting 'good living' through economic growth. This is exemplified with the adoption of the New Mining Law (2009), which increased mining operations in the country (Roy et al., 2018). Contradictions between extractive development and principles of Buen Vivir become especially evident around water, which is not only essential for human life and extractive industries, but also holds deep cultural and spiritual significance for many Indigenous peoples in Ecuador. For example, Kichwa communities often understand water as a living being, interconnected with territory, ancestry, and reciprocity (Noroña Aguinda, 2025). While Buen Vivir enshrines the nature's rights and well-being of communities, continued expansion of mining and oil projects – often near headwaters and sacred sites – directly undermines these values. Both scholars and activists have critiqued the contradictory ideals encompassed in the Ecuadorian state's version of Buen Vivir, claiming that acts as a form of neo-extractivism – a state-led model promising redistribution and economic diversification through resource extraction, but in practice reinforcing extractive dependency and harm (Svampa, 2015; Valladares Boelens, 2019). Water is thus a crucial element of contestation in Ecuador's Buen Vivir political landscape.

Water management in Ecuador

Water governance in Ecuador blends Western legal traditions and Indigenous customs, though approaches have shifted through time. In the late 20th century, the country moved from centralized state control to "decentralized" neoliberal approaches (Boelens et al., 2015). Under President

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[1] Translated from Kichwa, Sumak Kawsay. English meaning "life of plentitude" or "good living"

Correa, a hybrid polycentric system emerged, symbolically elevating Indigenous priorities and expanding local water associations' autonomy. As in many post-colonial contexts, hybrid legal frameworks blending western and Indigenous law often claim to recognize customary practices, but can distort or dilute underlying Indigenous values (Bosch Gupta, 2023).

Ecuador's 2008 Constitution also introduced major reforms to water policy. It recognized the human right to water and emphasized the protection of water as a human and ecological resource (Article 12). Since then, several legislative documents have reinforced the importance of safeguarding water resources for environmental integrity and human use [2]. All water resources are property of the Ecuadorian state and prohibited from privatization (Article 318). The state is responsible for approving water use allocations and permits, through MAATE [3], which absorbed (SENAGUA) [4] in 2021. While Ecuador's water governance model is supposed to distribute power to communities, permitting and authority remain highly concentrated in the state, an irony that is often noted by scholars of neoliberalism (Bakker, 2007; Harvey, 2007; Hausermann, 2012; Ribot et al., 2006).

Water use is prioritized in the Organic Law on Water Resources, Use, and Exploitation of Water (LORHUyA) [5] as follows: human consumption, irrigation (for the "guarantee of food sovereignty"), ecological flow, and other productive activities (LORHUyA). Though the state owns all water resources, various competences are delegated to different agencies and organizations. Drinking water and sanitation are managed by municipalities or local water use associations, such as juntas de agua potable (drinking water) and juntas de agua [de] riego (irrigation water). Water use associations are officially supposed to register with the government, though some exist informally. Any organization seeking water use rights must apply for permits through the state or

[2]Some laws include the Código Orgánico del Ambiente (Organic Code of the Environment), the Plan Nacional de Riego y Drenaje (National Irrigation and Drainage Plan), and the Texto Unificado de Legislación Secundaria del Medio Ambiente (Consolidated Text of Secondary Environmental Legislation).

[3]Ministry of Environment, Water, and Ecological Transition

[4]National Water Secretariat

[5]Ley Orgánica de Recursos Hídricos Usos y Aprovechamiento del Agua

the Autonomous Decentralized Governments of Ecuador (GADs), which operate at the provincial, cantonal, and parish levels. The Agencia de Regulación y Control del Agua [6] (ARCA) is responsible for enforcement, regulation, and sanctions surrounding water use, including monitoring water quality.

The decentralized nature of Ecuador's water governance system has benefits and drawbacks. On the one hand, it allows for greater community autonomy in water management. However, it can also create jurisdictional confusion and overlapping competences, leading to potential conflict and less effective management (Pinos, 2020; Wingfield et al., 2021). Though several laws emphasize community management, water quality control, and protection of water resources, evidence shows these goals are not consistently met. Extractive industries degrade natural resources and water quality in several regions, and inadequate infrastructure and municipal systems, such as leaks and poor sewage treatment, further undermine water access and quality (Martínez-Moscoso, 2023; Wingfield et al., 2021). Before presenting our mixed methods results on lived experiences of water quality and governance in Pintag, we situate this work in an environmental justice framework.

2.2 Environmental Justice Framework

The environmental justice (EJ) movement and scholarship began as activist work [7], aiming to combat contamination issues disproportionately impacting black communities in the United States (Bullard, 1983; Chowkwanyun, 2023; Schlosberg, 2013). Early EJ emphasized distributional concerns, such as unequal exposure to environmental harm, but has since expanded to examine underlying social and political structures driving injustices (Pellow, 2007; Pulido, 2015; Schlosberg, 2013; Walker, 2009). EJ practitioners often adopt an "inside-out" strategy, appealing to both formal institutions and community groups to illicit change (Chowkwanyun, 2023).

Some EJ scholars critique approaches appealing to the state, arguing it ultimately reinforces racial capitalism. Pulido (2017) argues that because capitalism inherently produces negative exter-

[6] National Water Regulation and Control agency.

[7] The Environmental Justice movement began in the 1980s in Warren County, North Carolina, in response to the proposal of a hazardous waste landfill.

nalities, justice cannot be fully realized within its structures. This critique resonates with both Latin America and Indigenous EJ traditions, which arise from histories of colonization, environmental racism, and environmental degradation (Correia Galeana, 2025; Rodriguez, 2020). Because state priorities operate within settler colonial logics, appeals to the state for justice are incongruous with Indigenous sovereignty and relational ontologies (Alimonda, 2019; Gilio-Whitaker, 2019; Leff, 2015; Rodriguez, 2020; Simpson, 2017). This is demonstrated in cases from Ecuador and Bolivia, where although constitutional rights have been granted to Nature, environmental injustices remain pervasive (Baudoin Farah, 2025; Kauffman Martin, 2017).

Latin American EJ scholarship underscores the interconnectedness of environmental outcomes, socio-economic conditions, and colonial histories (Carruthers, 2008; Correia Galeana, 2025; Hernández Vidal et al., 2023; Rodriguez, 2020), and activists and scholars demand decolonial approaches to justice (Alimonda, 2019; Álvarez Coolsaet, 2020; Leff, 2022). This requires understanding that coloniality persists in modern governance and development models, and demands an emphasis on Indigenous relational ontologies and recognitional justice for marginalized communities in response (Correia, 2023; Escobar, 2020; Rodriguez, 2020; Ulloa, 2017). Therefore, Indigenous and Latin American EJ emphasizes relational repair between people, non-human beings, ecosystems, and across generations, as essential to achieving justice (Schlosberg Carruthers, 2010; Simpson, 2017; Ulloa, 2017; Whyte, 2020).

While not always framed in EJ terms, movements calling for ‘alternatives to development’ (Acosta, 2018; Gudynas, 2011), socioambientalismo [8] (Carruthers, 2008; Santilli, 2005), resistance to extractivism (Martinez-Alier et al., 2016),and recognition of Indigenous ways of relating to nature (Escobar, 2020; Ulloa, 2017) all reflect EJ emerging from Latin America. Moving beyond distributional concerns, justice involves allowing communities to shape futures aligning with their own epistemologies and identities (Leff, 2015; Rodriguez, 2020).

[8]“Social-environmentalism” – a term emerging in the late 20th century in Latin America connecting environmental struggles to political and social justice movements

It is important for scholars to engage with these decolonial and relational forms of EJ. While academic institutions face some criticism as settler-colonial spaces with inherent power imbalances (De Leeuw Hunt, 2018; Hope Alkon, 2011; Kovach, 2021; Tuck Yang, 2014), progress can still be made by thoughtfully engaging with communities throughout - and beyond - the research process (Correia Galeana, 2025; De Leeuw Hunt, 2018; Rodriguez, 2020; Tuck, 2009). This can be aided by practicing reflexivity (Hope Alkon, 2011; Kovach, 2021) and prioritizing community-identified needs and goals (Gardner-Vandy et al., 2021; Smith, 2014). Community-based participatory action research (CBPAR) in particular has been shown to produce stronger EJ outcomes (Shepard, 2002; Wong-Parodi, 2022; Perz et al., 2022). Considerations surrounding decoloniality, relationality, and community-engaged study in EJ scholarship inform this study and research approach, as discussed further in section 4.1.

Furthermore, water has become key for advancing our understanding of EJ struggles; it is essential to all life and ecological integrity, socially and culturally important, and often deeply political and contested. Governed by multiple institutions, water management reflects complex, layered, and historic power dynamics. Scholars have conceptualized overlapping social, ecological and hydrological relationships as hydrosocial territories (Boelens et al., 2015; Hoogesteger et al., 2017). This framing further illustrates how broader systems, histories, and relationalities shape environmental outcomes, and that water issues are always social as well as ecological (Merlinsky, 2017).

Water is also a largely uncontainable entity. It is continually used, recycled, and moved through space, carrying other materials with it. Perreault (2013) describes how mining causes “accumulation by dispossession” and “dispossession by accumulation” as contaminants spread and settle in soils and bodies. Hydrosocial territories, then, are inherently relational and context-specific, shaped by histories, ecologies, governance, and cultural practices—and often produced through unequal power relations (Swyngedouw, 2007).

3 Study Site and Methods

3.1 Pintag Amaru and community-based research design

Pintag Amaru is a small Indigenous community organization in the broader parish of Pintag, Ecuador (Figure 1). The organization consists of approximately 25 people, including adults and youth, most of whom live in two barrios of Pintag [9]. Many households in this region, including those of most Pintag Amaru members, obtained land through agrarian reform policies enacted in the mid-20th century. These reforms dismantled the dominant hacienda system, redistributing land to former laborers. While many of those laborers have Indigenous ancestry, their descendants have often identified as mestizo – a result of dispossession from cultural heritage and enduring stigmas tied to racial hierarchies (Blosser, 2017) and more than 80% of the broader Pintag parish identify as mestizo (Gobierno Autónomo Descentralizado de la Parroquia Pintag, n.d.).

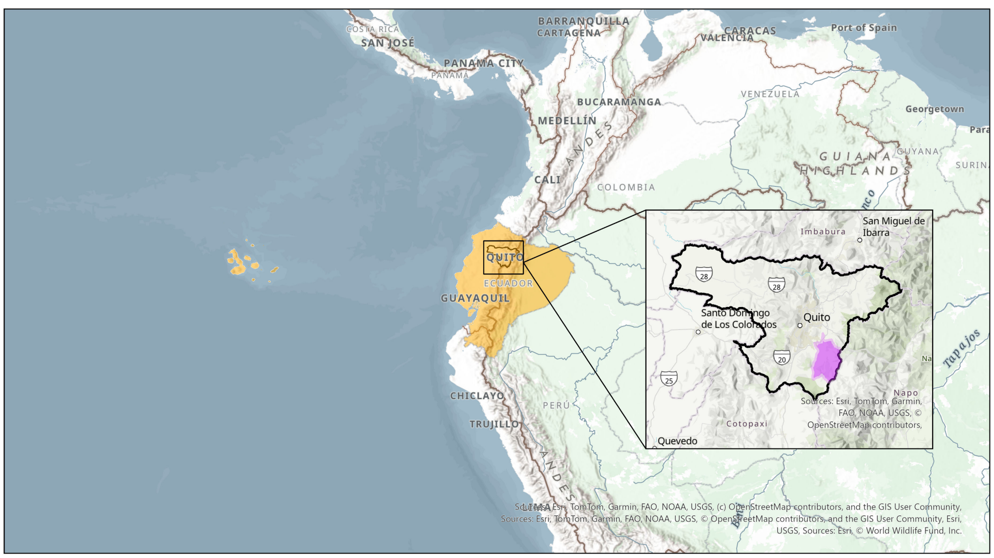

Figure 1: A map showing the general study location. Ecuador is shown highlighted in orange. The Pichincha province is outlined in black, and the Pintag parish is shown in pink. Pintag Amaru members live in neighborhoods within Pintag, and they have built their community center there.

[9]Pintag consists of 38 barrios

Pintag Amaru members make an active effort to reclaim that Indigeneity [10] (Radford, 2024). Most identify as Kichwa and seek to restore ancestral values and lifeways, including reciprocal relationships with water – practices that should be upheld by Ecuador's Constitution. The organization has a community center, Casa Amaru, which serves as a hub for meetings, seed-saving initiatives, permaculture projects, and decolonial art, particularly focused on engaging and empowering youth (Radford, 2024). Members of Pintag Amaru reject capitalist and neoliberal development models, instead practicing Indigenous forms of knowledge, sustainability, and relational care.

In this research, we prioritized community concerns from initial grant proposals through site selection, data collection, and result dissemination. Starting in fall 2022, we held regular online meetings with community members to identify research priorities and methods. The community dubbed the project Proyecto Pi – or "Project Water" – blending Spanish with pre-Incan vocabulary native to the region (reflected in names like Pichincha and Pintag).

Through these conversations, community members expressed concern about potential water contamination from gravel mining operations, alongside broader environmental issues such as deforestation, climate change, and frustration with institutional priorities. While water emerged as the most immediate and measurable concern, these broader socio-environmental issues informed our approach. Drawing from community-based participatory research ethos (Perz et al., 2022; De Leeuw Hunt, 2018) and grounded in EJ frameworks emphasizing relationality and decolonial praxis (Alimonda, 2019; Correia Galeana, 2025; Escobar, 2020), we employed an interdisciplinary, mixed-methods strategy. This included water quality monitoring, interviews, and participant observation.

Community members encouraged this approach, as pulling from diverse knowledge forms (i.e., Indigenous, scientific) tells a more complete story of environmental change. While quantitative environmental data is vital for understanding how environmental injustices occur on a landscape, it is critical to co-produce knowledge with local communities, as failure to do so can create 'blind

[10] See Radford, 2024 for a more thorough discussion of Pintag Amaru members' relationship with Indigeneity

spots' and serve elite interests rather than affected communities (Checker, 2007; Fischer, 2000; Mah, 2017).

While in Ecuador for eight weeks in summer 2023, we held weekly meetings at Casa Amaru to discuss Proyecto Pi [11]. When not doing research or attending community meetings, we helped with farm labor, learned about ancestral gardening, made humitas [12], and spent evenings around campfires, drinking manzanilla (chamomile) tea and sharing knowledge. These practices were vital to building meaningful relationships with community members that reflected respect, reciprocity and dialogue (Tuck and Yang, 2014; Gardner-Vandy et al., 2021; Tuck 2009) [13] Sharing space in this way also created opportunities for ongoing feedback, allowing us to adapt research questions, clarify interpretations, and ensure the results and dissemination aligned with community understandings and goals.

While most of the methods described below were carried out in summer 2023, we returned to Ecuador for three weeks in Summer 2024 to share initial water findings with Pintag Amaru (Figure 2). We met with community leaders and residents to discuss results, reflected together on implications, and considered future directions. Additionally, observations and early water quality data from summer 2023 fieldwork led to new questions about water policy and governance. Thus, in addition to sharing and discussing results with community members, interviews with state officials and water managers were also carried out in 2024.

3.2 Biophysical and landscape context

Pintag Amaru exists within the broader parish of Pintag, a rural parish in Ecuador, about 30 km southeast of Quito. Pintag has a mountainous, heterogeneous landscape with elevations spanning 2,400 – 4,500 m above sea level, featuring predominantly east-west slopes. It is framed to the

[11] We also discussed other community projects, such as youth outreach, hosting foreign students, and land stewardship

[12] Traditional Andean dish comprised of fresh corn and other fillings wrapped in corn husks and cooked, similar to a tamale

[13] In addition to research presented here, Proyecto Pi also helped create and fund several community-developed initiatives, including biofiltration and water catchment systems and reforestation projects.

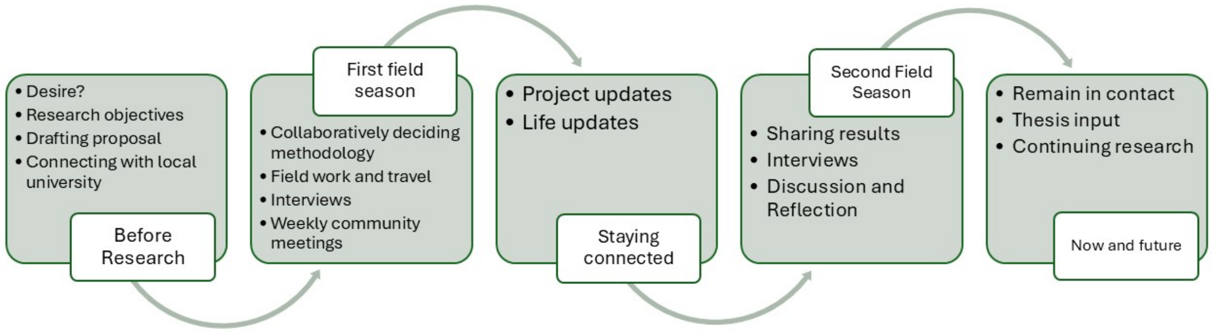

Figure 2: An overview of our process and timeline working with Pintag Amaru, highlighting continued communication and relationship building throughout the process to co-produce research.

south by volcanoes Antisana, Pasochoa, Sincholagua, and Cotopaxi. [14], [15] While much of the land has been converted to pasture, forest patches and páramo habitat remain at higher elevations.

Pintag has a subtropical highland climate, and conditions vary based on elevation and seasonality. Monthly average temperatures range from 5 to 25°C. Annual precipitation fluctuates between 638-1,456 mm, with a distinct dry season (June-September). Water from the region is a major source of Quito's water supply. The Pita and Guapal rivers, which are important to Pintag Amaru, are micro-basins within the larger Guayllabamba River Basin. [16] Pintag Amaru and adjacent communities receive piped water from the Empresa Pública Metropolitana de Agua Potable y

[14] All Volcanoes fall outside of the boundaries of the Pintag Parish but impact the region's geology and hydrology.

[15] The region's geology is shaped by volcanic, glacial, and colluvial, alluvial, fluvial, and lacustrine formations and deposits, and is predominantly characterized by sandy loam and loamy soils that are generally well-drained, with neutral to moderately acidic pH (Gobierno Autónomo Descentralizado de la Parroquia Pintag, n.d.).

[16] Several important lakes, including Muertepungo and Laguna de Secas, also originate here. Laguna de Secas provides most of Pintag's drinking water.

Saneamiento de Quito (EPMAPS), the municipal water company. Irrigation water stems from the headwaters of the Río Guapal and is managed by local juntas de aguas.

Many residents rely on agricultural activities, such as livestock, agriculture, forestry, and fishing for household subsistence (Gobierno Autónomo Descentralizado de la Parroquia Pintag, n.d.). Crop production is largely irrigation watered, and ranges from large-scale haciendas to small-scale huertas (family gardens) and greenhouse cultivation. Crops include beets, potatoes, habas (fava beans), tomate de árbol (tamarillo), lettuce, blackberries, and choclo (maize). Ganadería (cattle raising) largely for dairy production is also economically important. Many families keep pigs, guinea pigs, chickens, horses, and llamas, and some operate trout fish farms.

While deforestation occurred extensively in the colonial era as haciendas drove agricultural encroachment into the Andes (Bates, 2008), processes of deforestation and de-vegetation continue, driven by urban expansion and land conversion to pasture or timber sales for supplemental income. Many households maintain diversified livelihoods, combining agriculture with activities like manufacturing, construction, and retail trades (Gobierno Autónomo Descentralizado de la Parroquia Pintag, n.d.).

3.3 Water Quality Sampling

Site selection: Aligning with community concerns around water quality issues, including concerns about mining contamination (see Figure 3 for gravel mine map) and agro-chemicals, we sampled water in the Río Pita, Río Guapal and acequias (irrigation canals) in summer 2023. We chose twelve water sampling sites with community collaborators following a group mapping activity focused on regional land-use. Sites were selected in Río Pita (n=5), Río Guapal (n=3), and acequias (n=4), based on possible sources of contamination (Table 1; see supplemental tables for identified land use at each site). We sampled each site four times in summer 2023: first between June 3rd-15th, second between July 4th-7th, third between July 11th-17th, and fourth between July 19th-24th. We repeated sampling for redundancy and to obtain average site values. Because all samples were taken during one summer, results only show a snapshot of water quality conditions and may differ in rainy seasons.

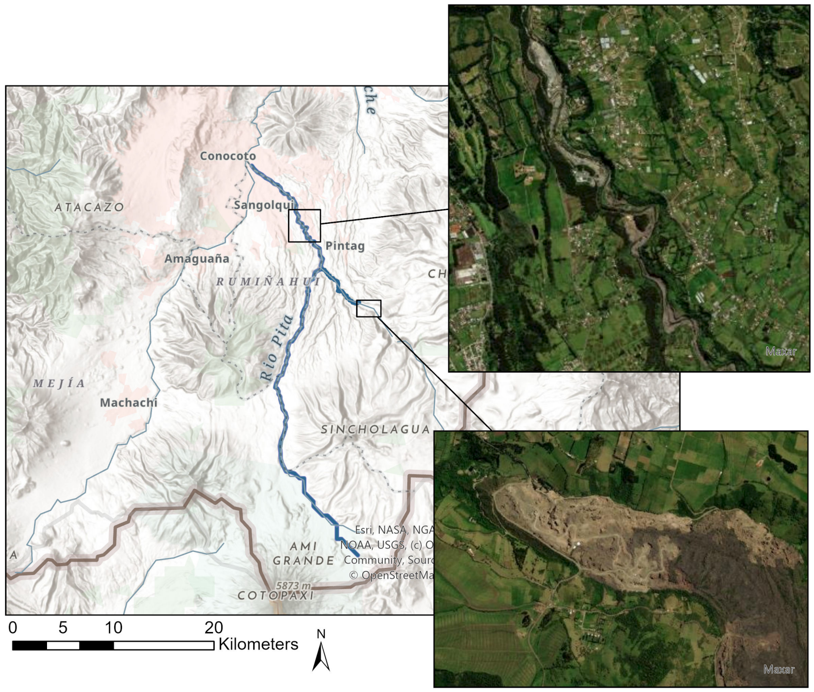

Figure 3: A map showing the two gravel mines community members identified as concerning to water sources. The 'upper mine', higher in the watershed, mines from a lahar of Antisana and sits above groundwater feeding the Río Guapal, and is shown on the bottom. The 'lower mine', lower in the watershed, is an instream gravel mine in the Río Pita, and is shown in the top image.

Sites in the Río Pita, Río Guapal, and, to a lesser extent, acequias moved along an elevational gradient, with high elevation river sites acting as proxies for uncontaminated conditions, since they are in protected areas. Because community members identified in-stream gravel mining in the Río Pita as a major concern, we also chose sites upstream and downstream of that mine. For analysis, sites were assigned to one of four categories: upstream of Pita gravel mine, downstream of Pita gravel mine, acequias, and Río Guapal.

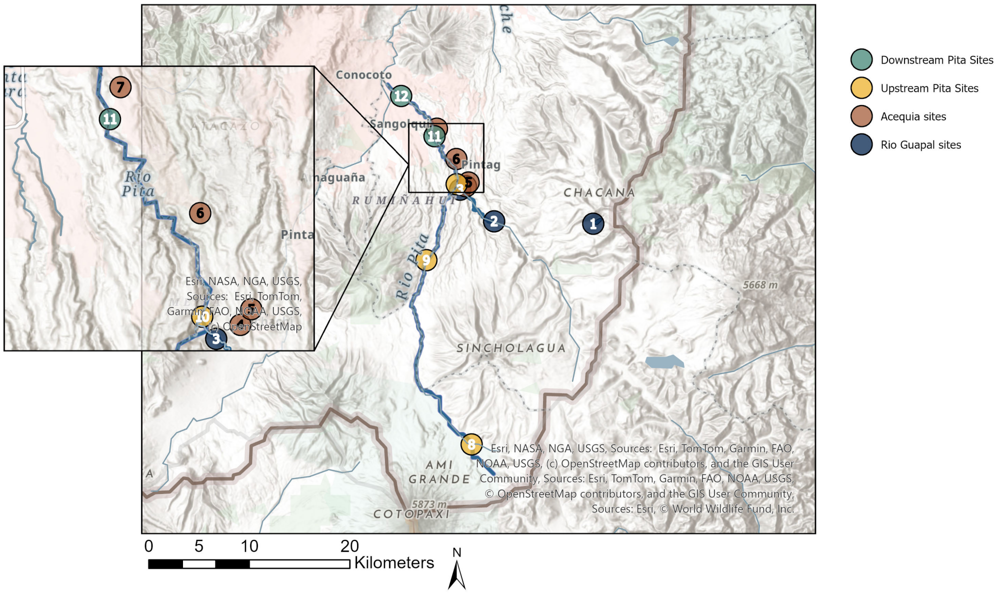

Figure 4: Map showing locations of water quality sampling sites in the Río Pita, Río Guapal, and acequias. Site numbers are indicated, and categories are color.

Site Number	Site Name	Site Category	Elevation (m)	Latitude (S)	Longitude (W)
1	Muerte Pungo	Rio Guapal	3970	-0.422517	-78.273558
2	Guapal Headwaters	Rio Guapal	3032	-0.420153	-78.362102
3	Guapal Pita confluence	Rio Guapal	2705	-0.389018	-78.396218
4	Highest Acequia	Acequia	2933	-0.388822	-78.387252
5	Mid-high Acequia	Acequia	2916	-0.385437	-78.384902
6	Mid-low Acequia	Acequia	2778	-0.364618	-78.395923
7	Lowest Acequia	Acequia	2641	-0.337445	-78.413177
8	Cotopaxi	Upstream Rio Pita	3873	-0.619648	-78.382213
9	Condor Machay	Upstream Rio Pita	3065	-0.454937	-78.422577
10	Pita after Guapal confluence	Upstream Rio Pita	2693	-0.387055	-78.395513
11	Pita Gravel Mine	Downstream Rio Pita	2569	-0.344312	-78.415415
12	Sangolqui	Downstream Rio Pita	2479	-0.3083858	-78.4451662

Table 1: Names, site numbers, elevations and coordinates of water sampling sites.

Water measurement, sample collection, and analyses: We measured conductivity, temperature, and pH in-situ [17], determined E. coli and total coliform presence using rapid-testing field kits [18], and collected total suspended solids samples and later dried and weighed them in a lab [19]. We collected metal and nutrient samples in HDPE bottles [20] and stored them at 4 °C for later lab analysis. We sent samples to the Core Lab at Universidad San Francisco de Quito (USFQ) to analyze anions (fluorine, chlorine, nitrate, nitrite, phosphate, sulfate, and ammonium) [21]. We analyzed samples for metals (aluminum, arsenic, boron, barium, beryllium, calcium, cadmium, cobalt, chromium, copper, iron, potassium, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorus, sulfur, selenium, strontium, vanadium, tungsten, and zinc) at the Bioanalysis and Omics (ARC-bio) Lab at Colorado State University [22], [23].

[17] Conductivity and temperature with YSI probe; pH with an APERA AI209

[18] Roth Bioscience's R-CARD ECC-A rapid tests. We added 1 mL of water to cards in the field, incubated cards at 35±0.5°C for 20 hours, photographed cards, and counted colonies of total coliform and e. coli that formed. Values were multiplied by 100 to reach standard units for analysis (CFU/100 mL).

[19] Drying glass fiber filters at 105 °C for 48 hours then weighing.

[20] Water for metals and nutrients was filtered through 0.45 µm filters, and metal samples were preserved with 2% HNO3. Metal and nutrient samples were placed on ice in the field.

[21] Using a Metrohm 940 professional Ion Chromatograph (IC) Vario

[22] Using a NexION 350D Inductively Coupled Plasma Mass Spectrometer (ICP-MS)

[23] All QC standards were less than 20%. Detection limits were calculated as 3* (SD/slope).

Data analysis: Since data were non-normally distributed (Shapiro test), we performed non-parametric tests (Kruskal Wallis) for site and category comparison to find statistical differences between individual sites and the four site categories (table 1). For significant parameters, the Dunn post-hoc pairwise comparison was performed. We used a significance cut-off of alpha = .05. All analysis were performed using R Statistical Software (R Core Team).

3.4 Ethnographic Methods

The first author conducted 22 semi-structured interviews with adults (>18) in Spanish in summers 2023 and 2024. 15 interviews were conducted with Pintag Amaru and nearby residents. Because this work was centered around Pintag Amaru's experiences, all adult members of the collective were asked to participate in interviews, and other residents were identified through snowball sampling methods. 7 interviews were carried out with water officials and experts in 2024, as a response to themes that emerged from 2023 interviews. The latter population of participants were recruited through an academic contact in Ecuador. Interviews were audio recorded with participant consent for later transcription. Questions queried perceptions of water quality and water change, as well as relationships between land use, extractive activity, and water governance, including institutional roles and responsibilities. Transcripts were analyzed using content analysis to identify recurring themes.

Participant observation complemented interviews during 12 weeks of fieldwork. The first author lived in the community, attended meetings, worked alongside residents, and held informal conversations. These observations informed analysis, particularly regarding resistance and relational practices. Preliminary findings were shared in meetings at Casa Amaru, and community feedback refined interpretations and emphasized key themes. Insights from 2023 informed 2024 interview questions, and community responses to water data helped interpret those results. This iterative dialogue contributed to a mixed methods approach, where qualitative data contextualized water results and vice versa.

4 Results and discussion

In the following pages, we draw from data generated through these mixed methods to examine the environmental and social dimensions of water in Pintag. We argue that the state leaves rural communities vulnerable to water injustice, both from water quality contamination and from gaps in government processes. Communities combat these injustices by reclaiming Indigenous relationships and practices with water, and enacting decolonial change in their daily lives.

4.1 Buen Vivir not realized via institutional failures and regulatory gaps

Ecuador passed Constitutional laws enshrining Buen Vivir, including the right to water, food sovereignty, and Indigenous autonomy. However, it has failed to create necessary "secondary laws and institutions" to uphold these principles, resulting in weak enforcement (Kauffman Martin, 2017). Again and again, we heard from community members and state officials that water-related projects and infrastructure are chronically underfunded. Lack of funding and oversight undermine effective water management and impacts water quality and monitoring. A former MAATE employee said,

> *"When I started working in the water ministry [in] 2018, most equipment was broken … the president [said], 'You cannot spend anything… your budget has to be zero.' So, all we could do was… create reports… and that's it… We couldn't buy equipment or do maintenance or calibration. So, most [water quality equipment] got damaged… "*

Inability to adequately monitor water quality also occurs at local levels. While decentralization policies are designed to give communities increased autonomy in water management, scholars have noted that the state often offloads resource-intensive responsibilities onto under-resourced water users (Boelens et al, 2015). The state therefore absolves itself of responsibility but still shapes the rules of engagement, simultaneously undermining local autonomy and increasing local burdens. Water use associations, like juntas de agua, are responsible for maintaining irrigation canals and upholding water quality standards, but they are typically volunteer-based and operate via small user fees, which are insufficient to cover operational costs.

Because both state agencies and local juntas lack resources to properly manage water and monitor quality, standards are often not met. However, state officials often overlook noncompliance, acknowledging limited resources available to communities. A representative from the Agencia de Regulación y Control del Agua (ARCA) stated:

> *"Communities... managing [water] services in rural areas are not trained to apply proper water quality treatment... because chemicals are expensive, treatments are expensive... they do not monitor sources or drinking water.... water safety management does not exist, it is very weak."*

The representative added local juntas struggle to uphold standards, given ARCA itself often lacks resources for analysis:

> *"If it is difficult for ARCA to have resources to analyze water samples, it is even worse for rural communities, like Pintag... There are certain small municipalities that don't have money... they don't have resources."*

Aside from leading to systemic regulatory gaps, inadequate state support leaves rural water users unable to accomplish needed projects. Juntas know which infrastructure projects are needed, but they face slow bureaucratic processes and insufficient resources to implement them. One former president of a local junta described frequent landslides in the region, resulting in obstructed waterways which left community members blocked from water access for extensive time periods.

Local water use associations face long waits to secure water permits and are not guaranteed adequate funding even when requests are approved. Community members speculated larger companies (e.g. mining, flower cultivators) were able to navigate bureaucratic systems with more success.

Furthermore, Ecuador's Constitution mandates strong community participation in decision-making and requires meaningful consultation with communities for matters involving environmental impact (Article 398 of Constitution; Article 87-90 of Mining Law). In practice, however, these principles are often not fully implemented. Pintag Amaru's interest in water quality research primarily rose from a lack of publicly available water quality information, something that should be guaranteed through the Escazú agreement. In addition to lack of monitoring and funding, even when water data does exist, it is not publicly accessible. A Fondo para la Protección del Agua (FONAG) [24] representative explained:

> *"Water quality data is restricted... [EPMAPS] [25] information security policies catalogue water quality as sensitive information… So it can only be open to the public if there is a formal request… students who use water quality data have to embargo theses with a promise that they will not publish the results."*

Community members also noted that when they tried to use official channels to lodge complaints, they often encounter inaction or bureaucratic roadblocks. For example, participants frequently reported leaks from municipal infrastructure. Despite notifying EPMAPS, repairs are slow or nonexistent, forcing residents to intervene themselves. An EPMAPS representative acknowledged:

> *"About 27% of our water is… wasted on leaks... The citizens say 'how come you are making us deal with shortages when you are wasting so much?' And that's one challenge for me because I said, 'listen, you only need 100l for water a day… You don't need more."*

While the municipal water company attempts to restrict rural water use and convince people they do not require much water, they ironically also admit to major losses via leakage in infrastructure. This irony is particularly striking, as community members also shared experiences of

[24] Some data are collected by FONAG (Fondo para la Protección del Agua or Fund for Water Protection), which supports conservation efforts, but these data are proprietary to EPMAPS and are only shared after formal requests and confidentiality agreements.

[25] Empresa Pública Metropolitana de Agua Potable y Saneamiento de Quito, the municipal water company.

EPMAPS water cuts (see section 5.2), pointing to ways in which water scarcity is socially constructed and unevenly enforced (Swyngedouw, 2007).

Inadequate funding, regulatory neglect, slow bureaucratic processes, lack of data transparency, and infrastructure deficiencies are examples of institutional failures experienced by communities. While language of the Constitution and other governing documents should provide a strong foundation for prioritizing environmental and community protections, these examples show that, in practice, degradations of Buen Vivir persist. Downsizing and budget cuts to environmental institutions [26] weaken the state's capacity to effectively manage and protect water resources, especially in rural areas. This can lead to unmonitored contamination, water shortages, and a lack of data, permits, and funds communities need to make informed decisions and implement water projects. In short, these failures undermine constitutional ideals of Buen Vivir, such as Nature's Rights, community autonomy, and equitable access to resources by eroding ecological conditions and political self-determination.

4.2 Perceptions and experiences of water in Pintag

Institutional gaps have tangible impacts on water outcomes. Here, we explore how Pintag Amaru and surrounding residents understand these issues. They identify structural drivers, especially related to extractive industry, infrastructure neglect, and state priorities, revealing how governance is experienced locally.

In June 2023, we set out from Pintag for water quality testing at Muertepungo, the high lake in the paramo. Antonio, a community collaborator, carefully placed his fishing equipment in the back of his truck– the lake, a two-hour drive up a rough, steep road was a trek, but there were fish there, and Antonio was excited to show us the lake. In stretches of river closer to Antonio's barrio in Pintag, he explained, fish had all but disappeared. Anna, a 32-year-old farmer and seamstress, similarly recalled when local rivers were abundant with fish:

[26] Such as the merging of the National Water Secretariat (SENAGUA) into the Ministry of Environment and Ecological Transition (MAATE)

“My brothers would go fishing and they always came with [fish] loaded in their bags... But ... [now]... you don’t catch anything... if you’re lucky, one... Yeah, there’s no life in that water anymore.”

Participants understood declining fish populations as a symptom of worsening water quality. Many remembered when river and acequia water was safe to drink and cook with. Now, it is perceived as contaminated. Carlos, a 55-year-old farmer, explained:

“I used to have cows, and I had to deworm them at least every three months because they drank this water. It was contaminated and dirty, so they would get sick... It was an extra cost for me.”

Participants perceived several causes of declining water quality conditions, both local and structural. Some cited waning environmental care among community members, pointing to trash, livestock near water, over-irrigation, deforestation, and agrochemical use. The arrival of piped water in the early 2000s was seen as a turning point. Anna recalled,

“Once we had drinking water, we didn’t take care of the irrigation ditch. ... we started throwing garbage [in it]... We damage it and it gets contaminated... When we consumed that water... the whole community took care of the water.”

Sanitation infrastructure was another concern. Untreated sewage is discharged into water bodies—an acknowledged problem in Ecuador (Borja-Serrano et al., 2020). As a barrio president explained:

"There’s no sewage system, they let the water that comes out of the toilets just go into the canals... that shouldn’t be the case."

Extractive processes also contribute to environmental degradation and changes in water quality. Gravel mining occurs in regional waterways to provide construction materials in Quito, including in the Río Pita. From the beginning, Pintag Amaru voiced concerns about mining’s visible landscape damage and perceived water contamination. As Carlos stated, *"Big [mining] companies... are destroying the Pita River. They're ruining it... All they care about is money, extracting the materials and nothing else. But they've contaminated it for us. The river is polluted with car oil, diesel fuel, everything. These companies bring in heavy machinery...change vehicle oils, and dump it all into the river. It's a disaster, and all they care about is extracting the material and sending it to the big cities."*

Figure 5: Llamas on the hill above the Rio Pita gravel mine.

Furthermore, interviewees reported mining companies began activities without community consultation and produce externalities impacting Pintag Amaru and surrounding residents. Community members petitioned against the Río Pita mine, but efforts have not halted operations. This follows a consistent theme of interview participants seeing the state as prioritizing corporate interests over following its own laws. A Pintag Amaru member stated:

“We don’t have any entity that does anything about this... if MAATE or something comes, they just bribe... and they say, "...they’re fine, they have all the permits” ... But... they’re causing a huge environmental impact there in that area.”

Concerns over water supply were also present throughout interviews. Municipal water service reached Pintag only after years of community pressure – and some nearby areas still lack formal potable water. [27] Even for households with piped water, service is unreliable. While cutting vegetables in 2023, Louisa, a 52-year-old woman, expressed relief that her water had recently been turned back on after continuous outages,

“...last week I didn’t have water.... They gave us water on Thursday. And that’s because we went to the top [of the barrio] because... the water company was coming... I complained..... and they gave us water in the afternoon... [they] give a lot of preference to the city.”

Quito’s municipal provider, EPMAPS, frequently cuts water service to homes like Louisa’s. Government representatives also acknowledged shutoffs have been an issue. Residents reported that EPMAPS intermittently cuts service due to ‘water shortages’ or late payments. [28] Officials state these shortages stem from low water flows in the dry season, driven by climate change, land conversion, and increasing population size. Participants recognized that decreasing water flows were driven by broader issues of environmental degradation, but also believed that shortages in Pintag were, at times, the result of authorities prioritizing urban water needs over those of rural communities. As Alejandro, a 31-year-old Pintag Amaru member and vice-president of his barrio, stated in 2024:

“[EPMAPS] has to ration the service, and many times when complaints are made... they say ‘no’... [Communities] must understand that tank levels are low and they have

[27] All participants had piped water access but several spoke of areas without piped water.

[28] One previous government employee mentioned that this has been a common occurrence for EPMAPS throughout their district, is considered illegal, and has caused problems for certain impoverished households in the past.

to ration water... they [EPMAPS] prefer to negotiate with certain sectors, I even feel they receive much more money for guaranteeing the service to certain sectors and obviously here, being in a rural area, they are not very interested in whether or not we have the service… it is a business of economic interests."

As Alejandro's comment suggests, water access is not only shaped by uncontrollable environmental conditions, but by political and economic priorities. Scholars have documented similar trends globally, with peri-urban communities often receiving limited or no municipal water service, including in India and the United States (Ranganathan Balazs, 2015).

While water quality and supply issues were attributed to both local actors and institutional failures, Pintag Amaru viewed both as problems rooted in broader state-driven development. Whether through environmental damage (e.g., mining) or an imposed "development mentality" (e.g., shifting local care), the state shapes behaviors to support its agenda.

These outcomes, while sometimes appearing accidental or unintended, can be viewed as a more intentional process through which the state shapes norms, behaviors, and priorities in ways that support its agenda. This highlights continuing tensions in Ecuador's environmental governance – despite constitutional provisions to create equity and environmental protection, local people still overwhelmingly feel that they suffer the burdens of extraction and state-led development, or conversely, from state neglect and abandonment. While mining concessions are permitted, other issues such as raw sewage in irrigation canals reflect a lack of investment, regulation, or enforcement.

Pintag residents' experience with the Pita gravel mine emphasizes this reality. While community members suffer consequences of a degraded riverscape they attribute to state neglect – including fewer fish [29] and landscape degradation – they do not see benefits, despite the state claiming this should aid in their development. Instead, they are faced with damaged infrastructure. Luca, a 35-year-old Indigenous man, pointed to the irony of gravel mining in Pintag:

[29] Though community members often attribute fewer fish to contamination, it could also be due to other environmental stressors, such as overharvesting or climate change.

> *"How is it possible that we have an asphalt mine right there, and we don't have a decent road? … the mine makes millions of dollars every day and doesn't give back even 1% of what it should. By law… 5% [of profits] are required to be given to the affected towns… They don't give anything, or maybe they do something, but not to us."*

Accounts of water contamination, shortages, and state inaction illustrate layered injustices. While some contamination stems from local practices, participants viewed these as influenced by deeper ideological shifts – favoring convenience and individualism over care and reciprocity. Failing to address widespread sewage contamination causes ecological harm and puts communities at risk. Continued extraction despite protest, and without adequate communication and compensation, demonstrates prioritizing economic expansion over environmental protection and community well-being.

These dynamics manifest not only as distributive injustices, but also undermine goals of decolonial EJ, as understood by Latin American scholars. While language in Ecuador's Constitution imagines a reality aligning with Indigenous understandings of Buen Vivir – where communities shape environmental outcomes and where nature is respected as a living being – in actuality, the state continues to privilege Western logics over Indigenous ontologies and relational ways of knowing.

4.3 Water quality in Pintag

Due to concerns about water quality, we tested samples for commonly assessed parameters. Community members feared contamination from mining metals, agrochemical nutrients, and sewage. Surprisingly, no metal concentrations exceeded USEPA or Ecuadorian standards at any sites, except iron (Fe) at the highest sites (Cotopaxi and Muertepungo). [30] Nutrient concentrations also

[30] High Fe concentrations have been found in other Ecuadorian rivers (Borja-Serrano et al., 2020; Vinueza et al., 2021) and are likely due to natural conditions.

fell below recommended limits. [31] Only total coliforms, E. coli, and total suspended solids (TSS) exceeded guideline levels. [32],[33]

Coliform concentrations were higher at lower elevation sites (328.6 ± 351.03 for e. coli, 241.8± 223.3 for total coliform) compared to sites higher in the watershed (1.3 ±1.2 CFU/100 mL for e. coli, 29.9 ± 22.04 for total coliform; p=.004; Figure 2). While most coliform bacteria are non-pathogenic, their presence suggests contamination pathways. E. coli specifically indicates fecal contamination, potentially from livestock or failing sewage infrastructure (Abass et al., 2016; Ortega-Paredes et al., 2019; Vinueza et al., 2021). Similar contamination has been documented in other Ecuadorian rivers, especially near Quito (Borja-Serrano et al., 2020; Ortega-Paredes et al., 2019; Vinueza et al., 2021). Inadequate sanitation systems are a primary contributor, as seen across Latin America and other regions with limited clean water access (Abasse et al 2016; Poma et al., 2016).

Fecal contamination poses serious risks to human and animal health. Studies near Quito found antimicrobial-resistant (AMR) coliform strains in rivers, likely linked to untreated sewage (Ortega-Paredes et al, 2019). AMR bacteria were also found on vegetables sold in Quito markets, likely due to irrigating crops with contaminated water (Ortego-Paredes et al 2018). Increasing presence of AMR bacteria poses environmental and agricultural concerns, as well as concerns for human and animal health (Sanderson et al 2018).

TSS was also high in the Río Pita, especially at acequia sites and downstream from the Pita gravel mine (p<.00004; Figure 3). TSS levels peaked (1814 mg/L) at the mining site during active operations. Natural and human processes—such as runoff, erosion, agriculture, and industry—can affect sediment levels, but in this case, gravel mining was likely the primary driver, consistent with findings from other mine-impacted rivers (Nasrabadi et al., 2016).

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[31] See supplemental tables.

[32] Total coliforms exceeded recreational limits in 4 river sites (1.2-10x); E. coli exceeded recreational limits in 2 river sites (7-160x) and exceeded irrigation/livestock limits in 2 acequia sites (1.5-2x); TSS exceeded aquatic life criteria in 4 river sites (4-90x).

[33] Similar results were found in 2020 and 2017 (Borja-Serrano et al., 2020; Simbaña Farinango et al., 2019).

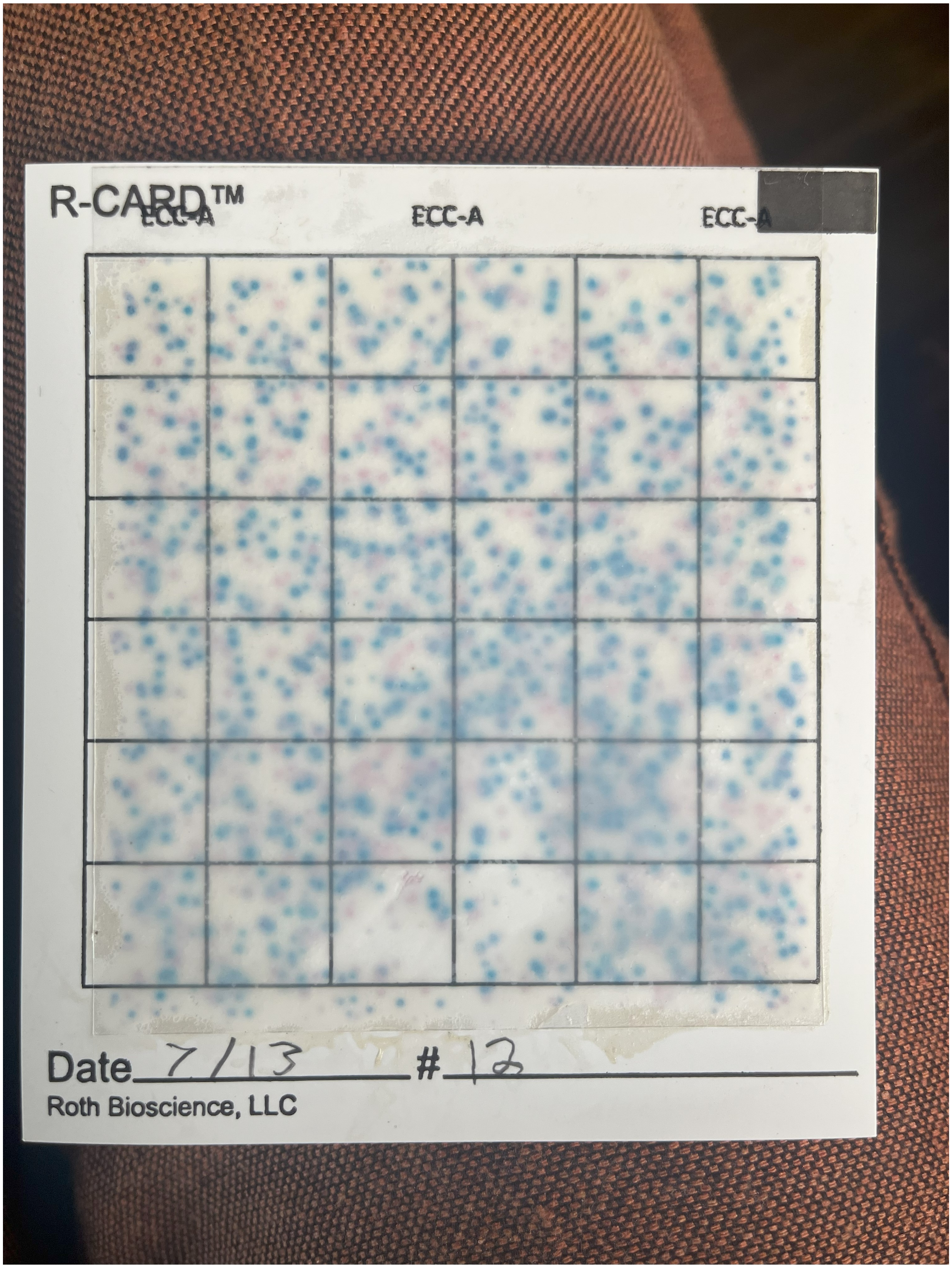

Figure 6: An example of a coliform test. Blue dots represent E. Coli, and red represent total coliforms.

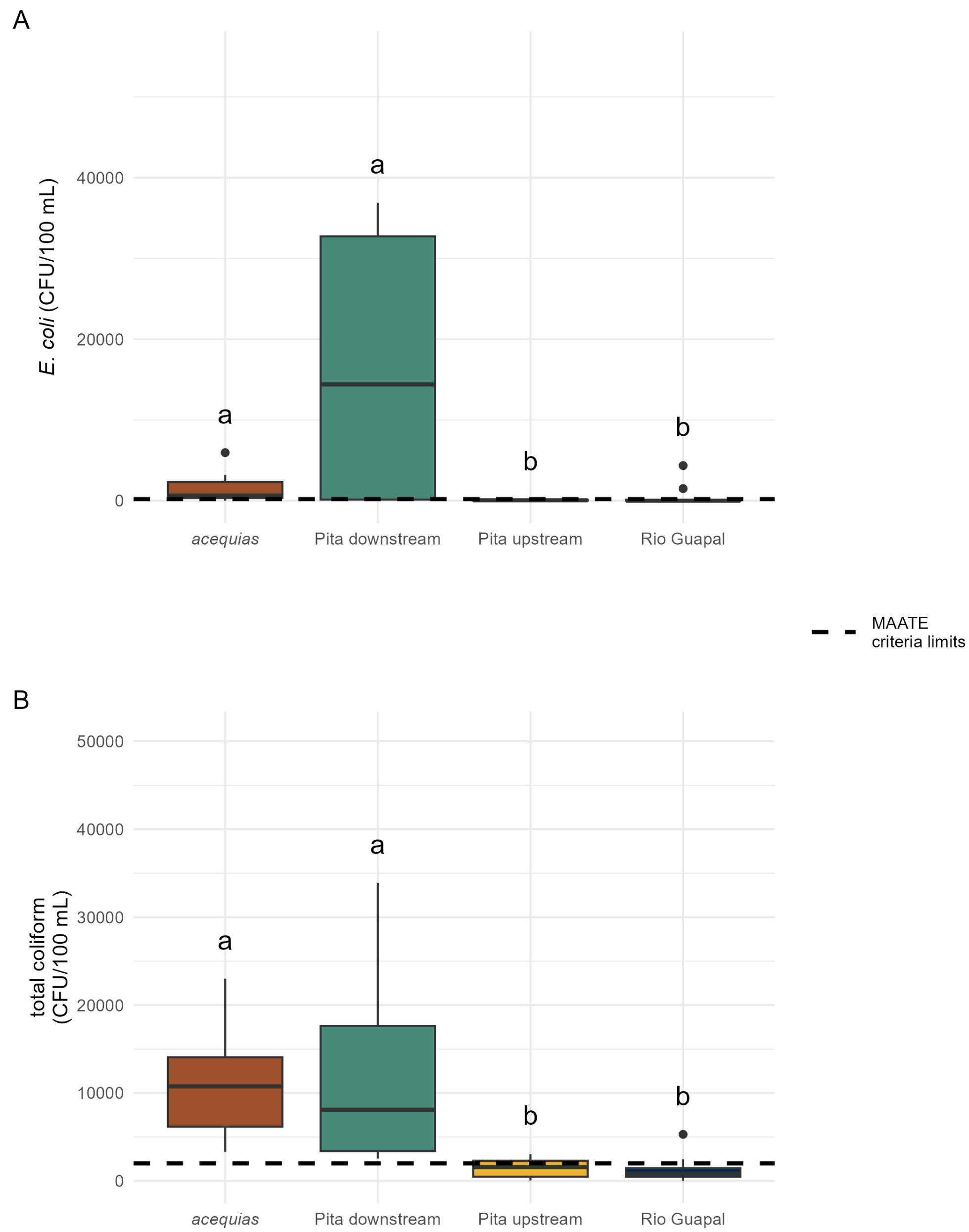

Figure 7: Boxplots show the distribution of E. coli (A) and total coliform (B) concentrations across water categories. Each box represents the interquartile range (IQR), with the horizontal line indicating the median; whiskers extend to 1.5×IQR, and points beyond are outliers. Compact Letter Displays (CLDs) above each box indicate statistically significant differences between categories (Dunn's test, = 0.05). The dashed line represents MAATE criteria limit for recreational water quality (200 CFU/100 mL for *E. coli*; 2000 CFU/100 mL for total coliforms).

High TSS can negatively impact ecosystem health. Sediment accumulation on rocky streambeds, such as those in the Río Pita, can smother invertebrate and fish habitats, preventing eggs and larvae from surviving, and potentially reducing fish habitat quality (Bilotta Brazier, 2008). This may contribute to community members' observed decline in fish populations. We were surprised metal concentrations were low despite high TSS, since TSS can bind to and transport metals in aquatic ecosystems (Nasrabadi et al., 2016). Nevertheless, if future contaminants were to enter the river, TSS could potentially increase the reach and impact of such pollutants.

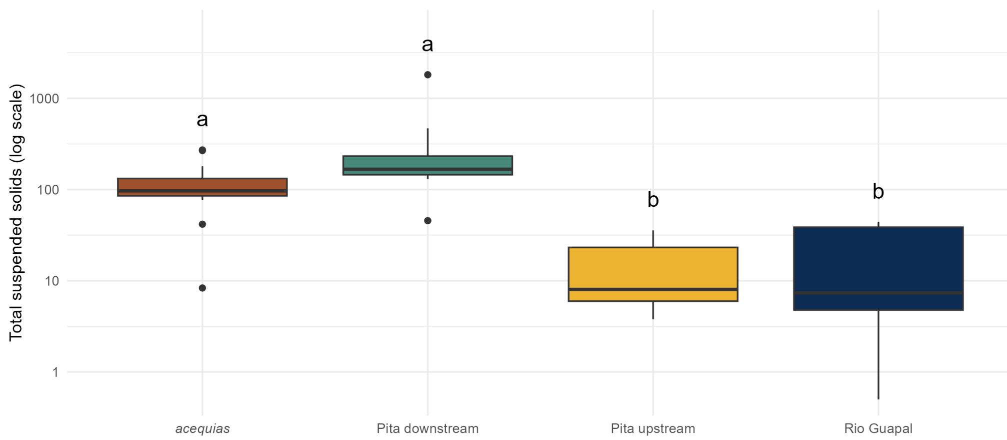

Figure 8: Boxplot showing the distribution of total suspended solids (TSS) across water categories. TSS values are plotted on a log₁₀ scale, though originally measured in mg/L. Each box represents the interquartile range (IQR), with the horizontal line indicating the median; whiskers extend to 1.5 × IQR, and points beyond are plotted as outliers. Compact Letter Displays (CLDs) above each box indicate statistically significant differences between categories (Dunn's test, = 0.05).

Although expected metal contaminants were not found, high levels of fecal bacteria and TSS raise serious concerns for livelihoods, food sources, and contaminant transport. These findings reveal important EJ dynamics in Pintag. While most metals were below WHO and national thresholds, such "acceptable limits" are institutionally defined and may not reflect community perceptions of safety (Liboiron, 2021). In contrast, coliform and TSS levels align with local concerns about poor sanitation and gravel mining, though livestock may also contribute to contamination.

These results validate community observations of degraded water quality, especially in lower-elevation areas, and reflect deeper institutional neglect. The presence of drug-resistant strains in nearby rivers and produce (Ortega-Paredes et al., 2018, 2019) further heightens public health risks and undermines rights to food sovereignty. Taken together, these biophysical and socio-political harms illustrate a recurring pattern: rural communities bear environmental burdens without receiving protections, benefits, or the ability to live in reciprocity with nature.

Figure 9: The Rio Pita gravel mining site during active mining activity.

4.4 Community action and resistance

In 2023, we arrived at Alta Pita, the river's birthplace, to take samples. That day Luca and Miguel, Pintag Amaru members, accompanied us for sampling. The sampling site was our "experimental control" for the Río Pita, which we expected to be free of contamination. As we began to pull out equipment, Luca asked us to pause, and he revealed a bouquet of lilies he had brought from his garden. Miguel began to play the pan-flute as Luca prayed to the mountain and the water, asking permission for us to collect samples and initiate this study. Eventually the music stopped, and he placed the lilies on the river's shore.

These everyday practices embody a lived version of Sumak Kawsay – not a co-opted version from the state, but one rooted in ethics of reciprocity with the Apus [34] and the water. Indigenous scholars recognize these everyday acts as crucial to resurgence: they are assertions of continued Indigenous presence, and they are a refusal to partake in colonial logics and "distractions" from the state (Simpson, 2017). In practicing everyday, anti-colonial acts, Pintag Amaru is building 'alternatives to development' (Acosta, 2018), rejecting hegemonic paradigms, and gradually replacing them with reciprocal, place-based values (Carruthers, 2008; Gudynas, 2011).

Pintag Amaru enacts this refusal through everyday actions and practices. These include those small moments of pause, hosting Indigenous workshops, implementing ancestral land practices, organizing youth events, and carrying out restoration projects on their land and water – this project included. These actions are not, for the most part, overt examples of resistance. Yet, over time, they elicit change. While community members spoke candidly about harms inflicted by the state, they emphasized hope, patience, and remained committed to creating change "poco a poco" through sustained efforts of "consciousness raising" (Radford, 2024). The night before we left Ecuador in 2024, we sat around a fire with Pintag Amaru, reflecting on Proyecto Pi. One member shared an ethic of persistence, despite state failures,

> *"We need to have hope... [but] not depend too much on institutions. If they help us, we'll applaud; if not, we'll continue [and] have no dependence on them."*

This understanding shapes management approaches. Rather than solely relying on a state that consistently lets communities down, Pintag Amaru has built their own infrastructure, including biofiltration systems, rainwater catchment structures, and reforestation efforts. These projects are

[34] Mountain spirits revered by Andes Kichwa communities

designed and carried out in collaboration with Indigenous experts trained in permaculture and ancestral construction techniques rather than appointed technocrats. In a context where water infrastructure typically requires state-approved consultants (Boelens et al., 2015), this community-driven approach is itself a form of refusal and resistance.

These projects help to address environmental injustices produced by the state at a small scale, and serve to reclaim some local self-determination in water management. Rainwater catchment systems combat dwindling water supply, and biofiltration systems reduce contaminants in acequia waters. In choosing to return water cleaner than it was received, Pintag Amaru enacts an ethic of reciprocity.

Proyecto Pi itself is part of this broader reclamation of autonomy. Faced with the absence of environmental assessments and inaccessible data, Pintag Amaru launched its own study. Though collaborations with Western institutions [35] have limitations, they also provide access to resources and broader networks. Through this project, Pintag Amaru built a lasting partnership with a university lab at USFQ in Quito, and together, they are continuing water monitoring efforts. Community-driven sampling efforts help combat data gaps left by the state and assert data sovereignty – the right of communities to own and benefit from knowledge about their territories (Hummer et al., 2021).

During our return visit in summer 2024, we presented preliminary water quality results to a gathering of community members, local colectivos, environmental and Indigenous organizations, and researchers. Notably, state representatives were invited, but did not attend. After the presentation, meeting attendees shared reflections on findings, expressed gratitude for the research, and acknowledged there was still much work to be done – including continuing working to hold the state responsible for injustices. This acted as a starting point for further action and strengthening relationships. By the end of the meeting, discussions were energized, and people were planning to reconvene and explore solutions such as expanding biofiltration systems locally and strengthening juntas de agua.

[35] Such as scientific research organizations like U.S. universities

Figure 10: Pintag Amaru's rainwater collection system

Figure 11: Pintag Amaru's biofiltration system, cleaning their gray and black water before sending downslope.

At the end of each interview, we asked participants if there was anything else they wanted to share. Nearly every person stated "agua es vida", water is life. People spoke about water with passion, fondness, and reverence. They offered childhood stories, concern for future generations, and appreciation for daily interactions and care for something so essential. Maria, a 23-year-old Indigenous Pintag Amaru member shared,

> *"We have to be aware, open our minds, open our hearts and start planting trees, start taking care and to teach little children to love nature, to take care of it, to protect it."*

Pintag Amaru continues to create moments of collective reflection, education, appreciation, and action. While perhaps small, these actions are not isolated, and over time they can lead to collectivization, slowly transforming local spaces, mindsets, and governance (Simpson, 2017). Indeed, initiatives enacted by Pintag Amaru are shaping hydrosocial relations in their community, encouraging shifts in people's thinking and behaviors, and creating new informal modes of water management. This is resistance as governance – not simply opposing dominant structures, but putting new ones in their place (Gobby et al., 2022), and focusing on relationality to nature first and foremost (Correia Galeana, 2025; Rodriguez, 2020; Ulloa, 2017). Pintag Amaru's actions embody a distinct form of Indigenous EJ, one which refuses to conform to state priorities and instead works to construct something better.

5 Conclusion

Here, we examined how water injustice in Pintag, Ecuador is shaped by a state that, despite constitutional commitments to Buen Vivir and Nature's Rights, continues to prioritize extractive development and economic growth over meaningful environmental and social protections. In this neoextractivist moment, the state's failure to uphold its own leal frameworks has left communities vulnerable to water contamination, supply insecurity, and procedural exclusion. These findings support broader critiques that justice cannot be fully realized within government systems rooted in Western economic models and colonial logics. Although Ecuador is among the countries that has begun making progress in recognizing Indigenous values in its Constitution, it has yet to implement structural changes necessary to shift away from a model founded in accumulation by dispossession and racial capitalism.

In response to these failures, efforts to manage water resources emerge. Pintag Amaru's actions – from water projects to educational efforts to acts of reciprocity – represent not only everyday resistance to hegemonic systems, but community-based governance practices aligning with decolonial EJ priorities. Participating in co-produced research furthers this enactment of justice. Their work suggests the potential for alternative development models grounded in relationality and collective well-being, and echoes resistance movements of other Indigenous peoples in Latin America. For injustices to be meaningfully addressed, the state must be held accountable to its constitutional promises and abandon capitalist, extractive, and colonizing frameworks. This demands a fundamental reorientation toward Indigenous and decolonial ontologies that center ecological care, autonomy, and justice.

Study limitations: Because this work was rooted in community priorities, it focuses specifically on the perspectives of Pintag Amaru members and nearby residents, most with direct ties to the collective. It does not aim to represent the full diversity of perceptions within the broader Pintag parish. While interviews were conducted with government officials, these were mostly interpreted in relation to community experiences, and interviews were not held with certain stakeholders, such as mining companies, based on Pintag Amaru's wishes.

Additionally, water quality sampling was limited to one season, and the study did not conduct a comprehensive assessment of broader hydrological or ecological dynamics (such as flow assessments, structure and sediment processes, aquatic life surveys, etc.).

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Supplemental Material

Table 2: Land Use and Potential Impacts at Sampling Sites

Site #	Site Name	Possible Impacts
1	Lago Muerto Pungo	Relatively little land use. May be horses, cattle, dogs, and tourism. A lake rather than a river, but the best approximation for water quality prior to Antisana mine.
2	Río Wapal Headwaters	Below Antisana mine; water here is the start of Río Wapal proper, coming from groundwater. Potentially affected by mining and upstream fishery.
3	Valencia Acequia (High Site)	Highest acequia site in Valencia. Sampled shortly after water exits a metal tube. Nearby agricultural activity and households.
4	Valencia Acequia (Casa Amaru)	At the Casa Amaru property, downstream from the upper acequia. Nearby agricultural and household activity.
5	Santa Teresa Acequia (High)	Nearby agriculture and households. Downstream of a hostel community members were concerned may be dumping sewage.
6	Santa Teresa Acequia (Low)	Located in a more densely settled part of Santa Teresa. Nearby horses and other agricultural activity.
7	Cotopaxi (Río Pita Headwaters)	Minimal land use, though some tourism and possible grazing. Best approximation for 'clean' Río Pita.
8	Río Pita – Downstream Río Chorro	Tourism and recreation area (Condor Machay). Less dense agriculture/housing, except for a larger potato farm upstream.
9	Río Wapal – Before Río Pita Intersection	Some agricultural activity and tourism in the area.

Table 2 – continued from previous page

Site #	Site Name	Possible Impacts
10	Río Pita – Downstream Río Wapal	Popular tourist site (Los Tres Cascadas nearby). Increased agricultural activity.
11	Río Pita – Downstream of Mine	Located directly after mining activities. Also affected by agricultural and household activity from Santa Teresa above.
12	Río Pita – Sangolquí	Most urban site. Río Pita as it enters Sangolquí, surrounded by manufacturing, businesses, roads, and development.

Parameter (mg/L)	Rio Wapal			Rio Pita					Aquatic Life criteria (MAATE)	Aquatic Life criteria (USEPA)
	Site 1	Site 2	Site 3	Site 8	Site 9	Site 10	Site 11	Site 12		
Al	0.0109	0.00722	0.0147	0.0236	0.0122	0.0172	0.0134	0.0197		
As	5e-6	0.0041	0.00235	5e-6	0.000255	0.00162	0.00129	0.00133		.15
B	0.0031	0.0863	0.0657	0.00486	0.0438	0.0562	0.0519	0.0549	0.75	
Ba	0.0231	0.0213	0.0273	0.0247	0.0362	0.0291	0.0308	0.0307	1.0	
Be	<LOD	<LOD	<LOD	<LOD	9.985e-6	<LOD	<LOD	<LOD	0.1	.0053
Ca	8.95	13.6	13.35	8.7	11.7	12.9	12.9	13.45		
Cd	<LOD	6.715e-6	3e-7	3e-7	3e-7	3e-7	5.55e-7	3e-7		.00015*
Co	4.21e-5	2.515e-5	0.000158	0.000129	1.925e-5	0.000169	0.000242	0.000221	0.2	
Cr	3.875e-5	8.495e-5	0.000104	5.945e-5	9.22e-5	0.000108	0.000103	9.945e-5	0.032	.01**
Cu	3.32e-5	0.00401	0.00128	8.185e-5	0.0001175	0.000931	0.000646	0.000795	0.005	.0065-.034
Fe	0.326	0.0135	0.1795	0.508	0.0791	0.212	0.254	0.251	0.3	1
K	1.875	4.74	4.945	2.625	3.85	4.66	4.665	4.94		
Li	<LOD	0.0273	0.0184	0.00468	0.0108	0.0149	0.013	0.0135		
Mg	2.73	9.535	9.405	3.44	7.22	8.73	9.17	9.71		
Mn	0.0348	0.00145	0.021	0.024	0.0024	0.0266	0.0453	0.0448		.1
Mo	0.000133	0.00217	0.00149	0.000448	0.000635	0.00118	0.00117	0.00115		
Na	3.945	14.4	12.85	6.595	11.85	12.2	12.5	14.05		
Ni	2.545e-5	2.945e-5	2.645e-5	3.075e-5	2.055e-5	2.41e-5	2.77e-5	2.84e-5	0.025	.052
P	0.00283	0.0349	0.0625	0.00569	0.0686	0.0668	0.0731	0.114		.0001
Pb	2.885e-5	2.635e-5	2.645e-5	1.465e-5	2.465e-5	2.715e-5	2.865e-5	2.835e-5	0.001	.00085***
S	0.6225	1.21	1.16	0.5675	1.085	1.105	1.095	1.12		
Se	7.995e-5	0.000119	0.000105	0.000126	0.000109	0.000114	0.000127	0.000113	0.001	.0031
Sr	0.0585	0.1325	0.1305	0.076	0.116	0.125	0.123	0.129		
V	0.00278	0.0128	0.0115	0.0051	0.01	0.0107	0.0105	0.0102		
W	1.44e-5	8.165e-5	5.91e-5	1.165e-5	1.62e-5	4.355e-5	4.475e-5	4.61e-5		
Zn	0.00263	0.00347	0.00202	0.00193	0.00371	0.00346	0.00208	0.00111	0.03	.118

Table 3: Average (median) metal concentrations at Rio Pita and Rio Wapal Sites. These are compared to criteria for Aquatic life from the Ministry of Environment in Ecuador (MAATE), and the USEPA. Those that exceed recommended criteria are boxed.

*Cd limits are based on water hardness of 50 mg/L of CaCO3, **limit for Cr VI, ***hardness dependent conversion, calculated using average hardness from all sites, of 64.1

Parameter	**Rio Wapal**			**Rio Pita**					**Aquatic Life criteria (MAATE)**	**Recreation criteria (MAATE)**
	Site 1	**Site 2**	**Site 3**	**Site 8**	**Site 9**	**Site 10**	**Site 11**	**Site 12**		
pH	8.2725	7.465	8.4025	7.5725	8.3225	8.1175	8.525	8.6375	6.5-9	
Temperature (°C)	9.895	12.5465	13.0375	8.5925	12.345	13.3825	16.01	15.9725		
Conductivity (µS/cm)	83.25	250	238	106.25	200.5	225.25	230.75	245		
TSS (mg/L)	6.385	5	41.2	6.8675	5.935	30.55	641.3218	140.9778	more than 10% the natural condition	
F (mg/L)	0.1205	0.31275	0.3	0.1925	0.28	0.2675	0.288	0.2825		
Cl (mg/L)	2.3375	8.18	6.4775	1.8225	7.77	5.53	5.9	7.15		
NO2 (mg/L)	0.025	0.04	0.0775	0.0425	0.055	0.1	0.0475	0.0825	0.2	
NO3 (mg/L)	0.0025	0.6875	0.6375	0.135	1.095	0.425	0.215	1.02	13	
PO4 (mg/L)	0	0.06525	0.035	0	0.162	0.0725	0.0325	0.0835		
SO4 (mg/L)	3.6065	17.82675	16.8455	3.069	14.0925	14.71625	14.38925	14.74275		
NH4 (mg/L)	0.023333	0.0388	0.02	0.023433	0.0314	0.043933	0.022567	0.2086		
E. coli (CFU/100 mL)	0	33.33333	1500	16.66667	66.66667	116.6667	150	32716.67		200
Total coliforms (CFU/100 mL)	566.6667	716.6667	2466.667	283.3333	1466.667	2733.333	3433.333	20750		2000

Table 4: Average in-situ and nutrient parameters at Rio Pita and Rio Wapal sites. Sites exceeding criteria set by the Ecuadorian Ministry of Environment (MAATE) and/or USEPA are boxed.

Parameter	Acequias				MAATE criteria	
	Highest (4)	**Mid-High (5)**	**Mid-Low (6)**	**Lowest (7)**	**Irrigation**	**Livestock**
pH	8.515	8.67	8.3	8.45	6.5-8.4	
temperature (C)	12.68	12.675	13.235	15.59		
conductivity (uS/cm)	190.5	190	195	202	900	
F	0.485	0.395	0.36	0.495	1	
Cl	8.67	8.57	7.555	9.085		
NO2	0.0405	0.0405	0.075	0.001	.5	.2
NO3	0.2525	0.1825	0.085	0.085	5	50
PO4	0.0075	0.0675	0.005	0.1425		
SO4	16.3645	19.2355	17.982	16.645	250	
NH4	0.005	0.047	0.019	0.002		
Al	0.009995	0.009475	0.00902	0.01625	5	5
As	0.00383	0.00344	0.00395	0.003825	.1	.2
B	0.0872	0.08605	0.08915	0.08725	.75	5
Ba	0.0233	0.02715	0.02475	0.0249		
Be	3.25e-06	3.445e-06	3.46e-06	1e-06	.1	
Ca	13.65	13.3	13.75	13.55		
Cd	1.67e-06	6.125e-07	3e-07	8.55e-07	.05	.05
Co	3.905e-05	6.245e-05	3.915e-05	6.235e-05	.01	1
Cr	7.115e-05	7.29e-05	8.02e-05	7.415e-05	.1	1
Cu	0.001855	0.001135	0.00146	0.00111	.2	2
Fe	0.0188	0.03065	0.0208	0.0269	5	
K	4.835	4.89	4.85	4.8		
Li	0.027	0.0256	0.02735	0.02655	2.5	
Mg	9.68	9.405	9.74	9.515		
Mn	0.002715	0.00508	0.002255	0.003785	.2	
Mo	0.002345	0.002305	0.0024	0.002355	.01	
Na	14.6	14.45	14.8	14.55		
Ni	2.375e-05	2.35e-05	2.31e-05	2.28e-05	.2	
P	0.0374	0.0382	0.03915	0.0434		
Pb	1.013e-05	1.435e-05	1.0355e-05	1.279e-05	5	.05
S	1.23	1.2	1.235	1.23		
Se	0.0001195	0.0001085	0.000111	9.66e-05		
Sr	0.133	0.128	0.1345	0.13		
V	0.0136	0.01355	0.0139	0.0144	.1	
W	9.26e-05	8.06e-05	8.805e-05	8.405e-05		
Zn	0.000742	0.001365	0.002145	0.000636	2	25
TSS (mg/L)	108.465	90.35	106.5445	103.972		
e.coli (CFU/100 mL)	258.3	1491.6	441.6	2491.6	1000	1000
totalcoliform (CFU/100 mL)	6575	10758.3	7283.3	14766.6		

Table 5: Average (median) water quality concentrations in acequia sites. These are compared to criteria from Ministry of Environment. Those that exceed recommended criteria are boxed.