water and landscape
AGUA y TERRITORIO

Mining, water, and socio-environmental transformations in the Condor mountain range: Case study of the Mirador Mining Project, Ecuador

Minería, agua y transformaciones socioambientales en la cordillera del Cóndor: estudio de caso Proyecto Minero Mirador, Ecuador

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ABSTRACT

This article analyzes the impact of large-scale mining on water resources in indigenous territories located in the southern Amazon of Ecuador, where the first open-pit mining project is being implemented. Territorial transformation processes are studied under the approach of water justice and dispossession due to contamination in the expansion of the mine's exploitation phase. Mixed methodologies were applied through semi-structured interviews and surveys. The results identify the existence of socio-environmental conflicts associated with the impact on water resources due to infrastructure construction activities, tailings, production and transport of copper concentrate from the project. In the mining context, not only is the social-ecological landscape restructured, but the indigenous communities are also culturally modified, as they inhabit sacrificial zones that reduce the availability and quality of water for subsistence and ancestral practices.

KEYWORDS: Mining, Socio-environmental impacts, Conflicts, Transformations.

RESUMEN

El artículo analiza el impacto de la minería a gran escala sobre los recursos hídricos en territorios indígenas, ubicados en la Amazonía sur del Ecuador, donde se ejecuta el primer proyecto minero a cielo abierto. Se estudian los procesos de transformación territorial bajo el enfoque de la justicia hídrica y el despojo por contaminación en la ampliación de la fase de explotación de la mina. Se aplicaron metodologías mixtas a través de entrevistas semiestructuradas y encuestas. Los resultados identifican la existencia de conflictos socioambientales asociados a las afectaciones de los recursos hídricos por actividades de construcción de infraestructura, relaveras, producción y transporte de concentrado de cobre del proyecto. En el contexto minero, no solo se reestructura el paisaje socioecológico, también se modifica culturalmente a las comunidades indígenas, al habitar zonas de sacrificio que disminuyen la disponibilidad y calidad del agua destinada a subsistencia y prácticas ancestrales.

PALABRAS CLAVE: Minería, Impactos socioambientales, Conflictos, Transformaciones.

Mineração, água e transformações socioambientais na cordilheira Cóndor: estudo de caso Projeto de Mineração Mirador, Equador

RESUMO

Este artigo analisa o impacto da mineração em grande escala sobre os recursos hídricos em territórios indígenas localizados no sul da região amazónica do Equador, onde está a ser implementado o primeiro projeto de mineração a céu aberto. Estuda os processos de transformação territorial sob o enfoque da justiça hídrica e a desapropriação por contaminação na expansão da fase de exploração da mina. Foram aplicadas metodologias mistas através de entrevistas semi-estruturadas e inquéritos. Os resultados identificam a existência de conflitos socioambientais associados aos impactos sobre os recursos hídricos decorrentes das atividades de construção de infraestrutura, rejeitos, produção e transporte do concentrado de cobre do projeto. No contexto da mineração, não apenas a paisagem socioecológica é reestruturada, mas também as comunidades indígenas são modificadas culturalmente, pois habitam zonas de sacrifício que reduzem a disponibilidade e a qualidade da água para subsistência e práticas ancestrais.

PALAVRAS-CHAVE: Mineração, Impactos socioambientais, Conflitos, Transformações.

Transformations minières, hydriques et socio-environnementales dans la chaîne de montagnes Cóndor : étude de cas Projet minier Mirador, Équateur

RÉSUMÉ

L'article analyse l'impact de l'exploitation minière à grande échelle sur les ressources en eau des territoires indigènes, situés dans le sud de l'Amazonie de l'Équateur, où est réalisé le premier projet d'exploitation minière à ciel ouvert. Les processus de transformation territoriale sont étudiés sous l'approche de la justice de l'eau et de la dépossession due à la pollution lors de l'expansion de la phase d'exploitation minière. Des méthodologies mixtes ont été appliquées à travers des entretiens et des enquêtes semi-structurés. Les résultats identifient l'existence de conflits socio-environnementaux associés aux effets des ressources en eau dus aux activités de construction d'infrastructures, de barrages à résidus, de production et de transport du concentré de cuivre du projet. Dans le contexte minier, non seulement le paysage socio-écologique est restructuré, mais les communautés autochtones sont également culturellement modifiées, en habitant des zones sacrificielles qui réduisent la disponibilité et la qualité de l'eau destinée à la subsistance et aux pratiques ancestrales.

MOTS-CLÉ: Exploitation minière, Impacts socio-environnementaux, Conflits, Transformations.

Estrazione mineraria, acqua e trasformazioni socio-ambientali nella catena montuosa del Cóndor: caso studio Mirador Mining Project, Ecuador

SOMMARIO

L'articolo analizza l'impatto dell'estrazione mineraria su larga scala sulle risorse idriche nei territori indigeni, situati nell'Amazzonia meridionale dell'Ecuador, dove è in corso il primo progetto minerario a cielo aperto. I processi di trasformazione territoriale sono studiati secondo l'approccio della giustizia idrica e dell'espropriazione dovuta all'inquinamento nella fase di espansione dello sfruttamento minerario. Sono state applicate metodologie miste attraverso interviste e sondaggi semi-strutturati. I risultati identificano l'esistenza di conflitti socio-ambientali associati agli effetti delle risorse idriche dovuti alle attività di costruzione di infrastrutture, dighe di smaltimento degli sterili, produzione e trasporto di concentrato di rame dal progetto. Nel contesto minerario, non solo viene ristrutturato il paesaggio socio-ecologico, ma anche le comunità indigene vengono modificate culturalmente, abitando zone sacrificali che riducono la disponibilità e la qualità dell'acqua destinata alla sussistenza e alle pratiche ancestrali.

PAROLE CHIAVE: Estrazione mineraria, Impatti socio-ambientali, Conflitti, Trasformazioni.

Introduction

The socio-environmental impact of mining activities on water resources constitutes a global problem that has acquired critical relevance in recent decades, given the increase in demand for minerals and the increase in mining operations in sensitive ecosystems. This has, in turn, resulted in a rise in competition for scarce water resources, disturbing the availability and quality of water in various regions of the world[1]. In Latin America, the expansion of extractive projects on indigenous and rural territories has drastically redefined the relationships between communities and their natural resources, especially water. These interventions not only alter water ecosystems, but also transform local power structures, placing communities in disadvantaged positions compared to large corporations [2]. Conflicts over water resources are often about environmental justice and the vindication of territorial rights, where water becomes a battlefield between economic development and ecological sustainability[3].

Large-scale mining constitutes one of the main challenges that Ecuador currently faces. By promoting the transformation in the productive structure guided by a discourse that introduces ecological transition and industrialization as development strategies[4]. Starting a new era of extractivism, mining is inserted as the main source of income in large-scale exploitation within the dynamics of countries in the global south. A situation that worsened in 2008, when the reform of the Constitution of Ecuador was proposed with a biocentric philosophy, granting rights to nature and encouraging Sumak Kawsay in the National Development Planning as a progressive model framed in equity, cultural and agrarian revolution, and knowledge[5]. Meanwhile, the Mining Law was approved in the Montecristi Assembly, which is totally contrary to the ideology of the Andean peoples who promote the legal legitimacy of nature.

The Mirador Mining Project is the first large-scale metal project in Ecuador developed within the southern Amazon of the country. Located in the Cóndor mountain range, this area is part of the most representative Amazon biome in the world due to its large forests, tropical areas, settlements of indigenous communities, biological diversity, and high rainfall. This project has emerged as a critical case in order to examine the tensions between mineral exploitation and ecosystem sustainability, reformulating not only the natural landscape, but also the ways of life of indigenous and settler communities, who depend on these habitats for their subsistence.

In terms of water justice, the construction of tailings dams in areas of the Amazon poses serious threats to the integrity of water resources. Studies such as those by Ojeda-Pereira, Pezoa-Quevedo, Campos-Medina and Cacciuttolo, Cano, Custodio[6] illustrate how the pollution generated by mining waste perpetuates socio-territorial inequalities, compromising not only environmental health but also equity in access to water. However, the discourse expressed by mining companies emphasize the adoption of improved technologies and circular economy strategies, which are emerging as a promising way to mitigate these impacts. They highlight these as being alternative options for sustainable management of mining tailings and protection of water resources to transform environmental risks into opportunities for the development of mining practices that are both economically viable and responsible with the environment and communities[7].

This article proposes to examine in depth the territorial transformations caused by large-scale mining operations in the Amazon region of Ecuador, focusing on the socio-environmental impacts derived from the construction of tailings dams and infrastructure works promoted as mining facilities and the reserves calculated in a newly identified sector north of the Wawayme River. At this location, they have obtained legal permits to increase their daily production from 60 kilotons per day (ktpd) to 140 ktpd, equivalent to 46.2 million tons per year (MTPA). This development would involve the integration of key infrastructures such as the Mirador Norte Tajo and the northern waste dump, in addition to the construction of a steel factory to melt steel balls. Moreover, two new mineral processing lines will be added, each with a capacity of 35 ktpd, which provides for an increase of 5 ktpd in the capacity of each of the existing lines, along with the necessary auxiliary works. This expansion could potentially reconfigure

[1] United Nations, 2023.
[2] Boelens; Seemann, 2014.
[3] Martínez-Alier, 2015.
[4] Maldonado; Massa; Arcos, 2018.
[5] Secretaría Nacional de Planificación y Desarrollo, 2013.
[6] Ojeda-Pereira; Pezoa-Quevedo; Campos-Medina, 2023. Cacciuttolo; Cano; Custodio, 2023.
[7] Mancini et al., 2024.

socio-ecological systems, directly affecting the distribution and quality of water[8].

Given the aforementioned, the article highlights its scientific contribution by addressing the socio-environmental transformations observed during the exploitation phase of the first large-scale copper project in the Ecuadorian Amazon. Unlike previous research focused on the exploration phase, this study documents tangible and specific impacts, such as the alteration of water resources, cultural practices, and the territorial dynamics of the Shuar indigenous and mestizo communities. Moreover, the interdisciplinary approach that intertwines political ecology and water justice provides critical perspectives on the cumulative effects of the exploitation phase, an area that has received less attention in the academic literature. By demonstrating how mining activities reconfigure ecosystems and affected communities, the research contributes new understandings of socio-environmental conflicts and the creation of sacrifice zones. Finally, the findings identified are of practical use in similar mining contexts, especially in the Global South, to guide the formulation of public policies that promote community governance respectful of indigenous worldviews and plurinationality.

Theoretical framework and previous studies

Extractivism in Latin America has been extensively analyzed through various theoretical lenses that highlight the complex interactions between development, inequality, and the environment, as well as the resistances that emerge in response to these processes, which help to understand the profound repercussions of extractivism. Accumulation by dispossession[9] sheds light on the process of global mercantilist expansion, which is often grounded in the systematic dispossession of communities through the intensive exploitation of natural assets. This framework is essential to understand projects such as the case of the Mirador mine in Ecuador, where mining exploitation not only transforms the physical landscape but also reconfigures local economic and social structures[10]. Meanwhile, the concept of "environmentalism of the poor"[11] is introduced, examining the ecological-distributive conflicts generated by extractivist practices. It highlights how the most affected communities tend to be those that benefit the least, signaling a criticism of the intrinsic inequalities in extractivism. The resistance against the dominant development model, especially from indigenous and peasant communities, use their ecological and cultural knowledge to formulate alternatives that challenge the impositions of neoliberal development, reaffirming their right to define their own paths and life practices[12].

Food sovereignty and resistance against multinational corporations go hand in hand with the decline of local surveillance of natural assets, which often leads to the erosion of the very foundations of community life[13]. From a broader perspective, the *Epistemology of the South* is proposed as a way to recognize and value indigenous and local knowledge in the formulation of alternatives to development[14]. while in parallel exploring *Buen vivir*, (the indigenous concept of the good way of living) and transitions towards post-extractivist economies that respect both human rights and ecosystems[15].

In this debate, the consensus on commodities and the impact of popular organizations on the transformation of extractivist policies are explored, showing how they have reshaped the productive and social structures of countries in the Global South[16]. Simultaneously, the potential of civil organizations to influence and change extractivist policies is analyzed, highlighting community agency in the face of corporate and state interests. This integrated approach provides a comprehensive view of how extractivism is contested and renegotiated on the ground, enabling a critical and constructive evaluation of the possibilities and challenges faced by communities in their struggles[17].

Thus, accumulation by dispossession provides a crucial framework for understanding how mining extractivism in Latin America[18], particularly in projects such as the Mirador mine in Ecuador, implies significant dispossession of local communities. This process drastically alters socio-environmental relationships, and consequently, leads communities to seek resistance strategies based on reconfiguring their relationships with the natural environment, especially water[19].

[8] Van Teijlingen, 2019.
[9] Harvey, 2003.
[10] Harvey, 2003.
[11] Martínez-Alier, 2002, 56.
[12] Escobar, 2010.
[13] Shiva, 2005.
[14] Santos, 2009.
[15] Gudynas, 2011.
[16] Svampa, 2013.
[17] Bebbington, 2011.
[18] Sacher, 2015.
[19] Ministerio del Ambiente, 2015.

In this context, the experiences of community resistance in Colombia offer valuable perspectives. The Western Environmental Belt (Cinturón Occidental Ambiental, COA) movement in Colombia demonstrates how communities can formulate alternative hydrosocial relationships that challenge the predominant extractivist model[20]. This movement, rooted in a political ecology of place, uses community practices of care for water and other common goods to counteract the impacts of extractivism.

At the legislative and political levels, both in Colombia and Ecuador, it is evident how environmental legislation can be used by communities to protect their territories. In the case of Mirador, although legislation has initially facilitated the development of the project, in Colombia the communities have sought to use legal frameworks to establish popular consultations and municipal agreements that reflect an autonomous commitment to the planning of the territory and natural assets, similar to the COA strategies. These community strategies face significant challenges due to the powerful dynamics of global capitalism and national economic interests that promote extractivism. However, they also present opportunities to redefine local power relations and develop sustainable practices that respect the cultural and ecological visions of indigenous and peasant communities. These initiatives highlight the ability of organizations to propose development and resistance options that contrast with extractivist models, promoting a rearticulation of socio-environmental and territorial relations that go beyond the simple opposition to extractivism.

Taken together, accumulation by dispossession and community responses in Latin America offer fertile ground for critical analysis and the development of resistance strategies that not only challenge current mining projects, but also propose alternative visions for the future of regional development[21] which explores how community movements in Ecuador renegotiate their participation in green development projects.

This theoretical framework addresses how indigenous and peasant communities apply and adapt theories on environmental justice and resource management in their struggles and resistance strategies. Bourguignon, Villamayor-Tomás and Boelens[22], discuss the creation of hydrosocial territories and the construction of subjects in contexts of water conflict, providing an outline as to understanding local responses to the challenges imposed by extractivism. These strategies reflect a political ecology approach, where local autonomy is prioritized, and indigenous and peasant knowledge is valued in the management of their natural assets[23]. The opposition of the organizations not only challenges the extractivist model, but also proposes alternatives based on the concept of *Buen vivir* good ways of living, which aspires to greater harmony in the relationship with nature. Highlighting the need to understand water disputes not only as controversies over scarce resources, but as fundamental confrontations over the vision of development and equitable equality in environmental benefits. Thus, water justice from this critical perspective reveals the profound implications of water governance in the perpetuation of inequalities and in community resistance against imposed development models.

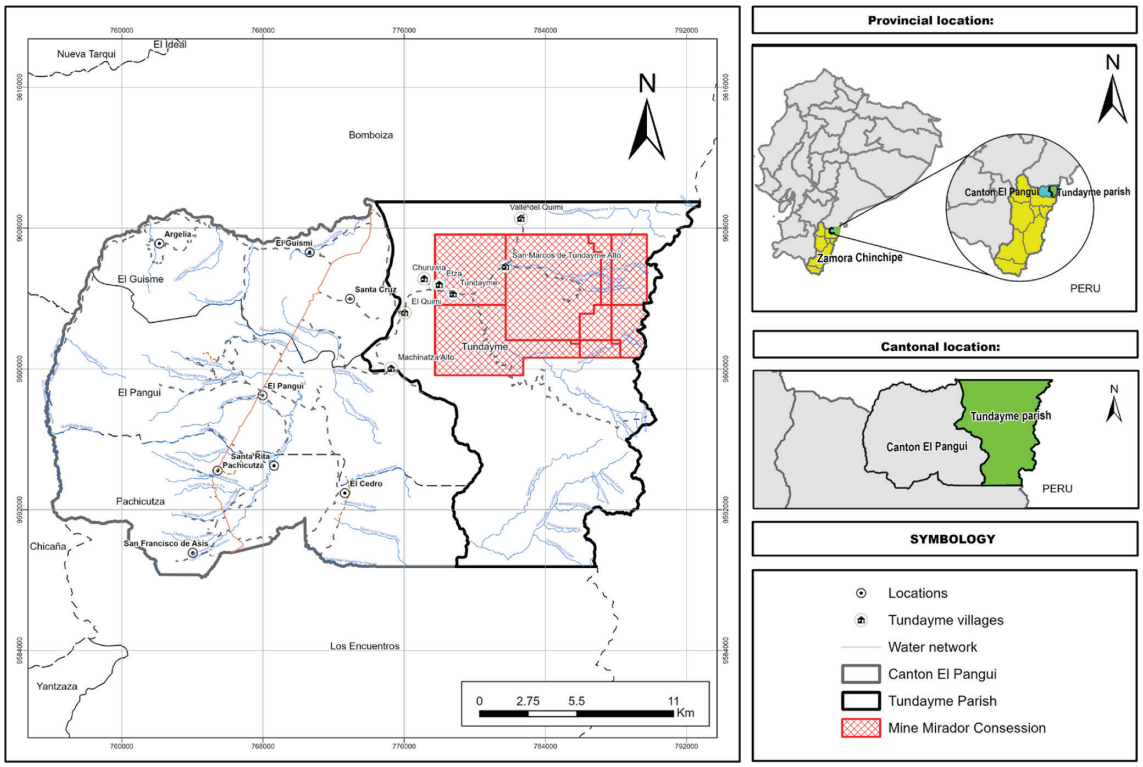
Socio-territorial context and study area

The research is carried out in the Tundayme parish, located in the province of Zamora Chinchipe, in the southeast of Ecuador. This region is part of the Ecuadorian Amazon, characterized by its diverse topography and biodiversity, since it is located in the Cordillera del Cóndor, an area of significant ecological and biological importance due to its high endemism and for being the territory of numerous indigenous communities[24].

As seen in Map 1, the parish of Tundayme has a population of 737 inhabitants, of which 163 people self-identify as indigenous, which represents approximately 22.12 % of the total population[25]. The Mirador Mining Project is in the parish managed by EcuaCorriente S.A. (ECSA). This represented a significant turning point as it was the first large-scale copper mining experience in the country, with approximately 6,690 hectares that occupies 26.08 % of the territory, considering that the surface of the Tundayme parish is 25,643 hectares[26]. The project was initially approved for an exploitation of 25 ktpd in 2006, has escalated to 60 ktpd in 2015 and, to 140 ktpd in 2022. This expansion has led to the construction

[20] Roca Servat; Palacio Ocando, 2019.
[21] Dupuits, 2021.
[22] Bourguignon; Villamayor-Tomás; Boelens, 2024.
[23] Hidalgo Bastidas, 2019.
[24] Gobierno Autónomo Descentralizado Parroquial Rural de Tundayme, 2019.
[25] Instituto Nacional de Estadística y Censos (INEC), 2010.
[26] Gobierno Autónomo Descentralizado Parroquial Rural de Tundayme, 2019.

Map 1. Location of the Tundayme parish, populated centers, and concession area of the Mirador mine



Source: Author, 2024.

of additional infrastructure such as the Tagus Mirador Norte, significantly increasing the impact on the natural landscape and local ecosystems[27].

Tundayme's economy, predominantly based on subsistence agriculture, faces challenges due to the lack of basic services, reflecting a high rate of poverty and limitations in educational and health infrastructures. The introduction of mining activities has promised economic transformations, although not without controversies related to environmental and social impacts[28]. The Quimi and Wawayme rivers, vital for the community´s agricultural practices and drinking water supply, have been especially impacted. Pollution and modification of natural channels, along with deforestation associated with the construction of mining infrastructure, have significantly altered the hydrology of the area[29].

Access to water sources is intrinsically linked to the environmental health of its watersheds, which are critically affected by mining activities. Large-scale mining operations have a profound impact on the micro-basins that supply water to the region, due to contamination and physical alteration of water courses[30]. The modification of water management, including the use of the Wawayme River and the obtaining of groundwater for human use, has directly impacted the distribution of essential water resources for indigenous and peasant communities[31]. Alterations in land use and water management have triggered significant resistance by affected communities, who see their traditional livelihoods and access to basic resources threatened[32].

Materials and Methodology

Description and justification

The Mirador Mining Project has implemented extensive water resource management, taking advantage

[27] Gesambconsult, 2023.
[28] Gobierno Autónomo Descentralizado Municipal del Cantón El Pangui, 2020.
[29] Gobierno Autónomo Descentralizado Municipal del Cantón El Pangui, 2020.
[30] Gobierno Autónomo Descentralizado Parroquial Rural de Tundayme, 2019.
[31] Gesambconsult, 2023.
[32] Gesambconsult, 2023.

of both the surface waters of the Wawayme River and groundwater to support its expanded operations to 140 ktpd. This water management, detailed in the environmental licenses, includes authorizations to increase the extraction of water concessions. The extraction of large volumes can alter the natural flows and biodiversity of the region, while the risk of contamination by heavy metals and toxic chemicals can compromise water quality, directly affecting aquatic biodiversity and the availability of clean water resources for the environment, human and agricultural consumption[33].

The challenges associated with water management in Mirador are not limited to environmental impacts, but also pose serious social and community challenges. The dependence of local communities on these resources for agriculture, fishing and domestic needs makes water security a central axis of their subsistence. The construction of tailings dams and dams has caused the modification of water courses, such as the Wawayme River, currently used for mining operations, which could significantly alter natural hydrological cycles and may cause socio-environmental conflicts.

Information collection techniques

In the study, a mixed methods approach was adopted to address the interdisciplinary complexities of the research. The quantitative design focused on obtaining and analyzing numerical data captured through semi-structured interviews applied to the Shuar and mestizo communities, using probabilistic sampling to guarantee the representativeness of the sample. Environmental interpretation was used in the design of the survey, preparing it in a simple language that was understood by both the indigenous communities and the settlers of the parish, which facilitated the identification of possible socio-environmental impacts on their territories. Table 1 details the variables used in the semi-structured interviews.

As seen in Table 1, the socio-environmental impacts were determined based on the variables of the project's Environmental Impact Study. Matrices of natural resources (soil, water, flora, fauna and noise) were established for the impacts that are considered within the three stages that exist in the exploitation phase: construction, operation and closure, and abandonment of the mine.

The data collection phase began in the parish of Tundayme where information was obtained from secondary academic sources, Territorial Planning Plan, Environmental Impact Study, and reports generated by local institutions. The sampling framework was integrated with information from the 2010 census of the National Institute of Statistics and Census (INEC). This registered the population of the canton at 737 inhabitants, composed of indigenous and mestizos, self-identified according to their culture and customs. Likewise, according to their nationality or indigenous people, the communities inhabit: Shuar and mestizos. Table 2 explains the sample units to which the surveys were applied.

The sampling units to which the surveys were applied used probability sampling by clusters or multistage sampling can be observed in Table 2. The map of the Tundayme parish was designed in the ARCGIS program. The total area was divided into geographic quadrants using UTM coordinates, which only listed the populated quadrants, to obtain the total sample to which the surveys were applied. The target population included the 146 inhabitants of the Shuar communities and the 591 mestizo inhabitants of the parish. For the quantitative approach, a sample size of 260 surveys was determined, based on the demographic

Table 1. Study Variables

Variable	Magnitude	Indicators
Perception of socioenvironmental impact	*Tipology*	*1. Sex* *2. Age* *3. Ethnic identification* *4. Post/Ocupation*
	Problems and impact	*1. Existence of problems and impact* *2. Principal socioenvironmental problem perceived* *3. Causes of the socioenvironmental impact* *4. Actions taken with relation to the impact* *5. Environmental and social impact (EIS)*

Source: Author, 2024.

Table 2. Fact Sheet

Location	Parish of Tundayme
Sample	Probabilistic sampling by clusters or multistage
Tecniques	Surveys and semi-structured interviews
Dates of Field Work	February-November 2023 November-February 2024

Source: Author, 2024.

[33] Gesambconsult, 2020.

distribution of the homes and socioeconomic characteristics of the parish[34].

In the qualitative method, non-probabilistic sampling was used, focused on members of the Shuar community and settlers, to delve into the cultural and social aspects through an ethnographic approach. It was based on the use of ethnography, semi-structured interviews, and participant observation techniques, focusing on obtaining a deep understanding of cultural and social dynamics[35]. The data collection process was structured in four phases: a) An initial contact was established with the Shuar indigenous communities and farmers, explaining the objectives and expected benefits of the study; b) Subsequently, surveys were carried out and socio-environmental mapping techniques were used to examine territoriality and socio-environmental impacts[36] c) In the third phase, ethnographic methodologies were applied, and in-depth interviews were conducted to analyze the protagonist´s perception on water justice. And d) Finally, proposals for community governance of water resources were prepared based on participant-action research.

Analysis

For data analysis, the quantitative responses were processed using the SPSS statistics software (28th. edition), where descriptive and correlation analyzes were carried out[37]. The qualitative data obtained through interviews and participant observation were analyzed using NVivo (12th. edition), which made it possible to manage and analyze the textual data to minimize research biases[38]. Data triangulation was carried out to integrate the findings and provide a holistic understanding of the impacts of the mining project on the population of the parish.

Results

In Ecuador, the mining project has been a significant actor in the development of this activity since 1990, when it began geochemical explorations in the cantons of San Juan Bosco and El Pangui. In 2001, the rights to the Curigem 18 and Curigem 19 concessions were transferred to Gatro Ecuador Minera, marking a series of key restructurings. Gatro carried out a division of these concessions in 2002 and 2003, resulting in the creation of several new areas[39]. Subsequently, Corriente Resources Inc, a Canadian company, initially focused on identifying and selling mineral properties. Since 2003, it directed its efforts towards the development of the Mirador project. Until early 2010, Corriente held 100 % of the shares of Ecuacorriente S.A. In 2008, the company sought partners with financial and technical resources, culminating in 2009 with a purchase offer from the Chinese consortium Tongguan/CRCC. In August 2010, Tongguan/CRCC acquired 100 % of Corriente, marking a strategic change from Canadian to Chinese management, focused on more intensive and extensive mining.

In 2006, ECSA obtained environmental license approval for the exploitation phase at 25 kilotonnes per day (ktpd) and achieved increases in production capacity authorized in 2012 to 30 ktpd and in 2015 to 60 ktpd. The operation began in 2019, consolidating the project as the first in large-scale copper metal production in the country. Currently, ECSA proposes a significant expansion to increase production from 60 ktpd to 140 ktpd (46.2 MTPA), which will include new infrastructure such as the Mirador Norte Tajo and the northern waste dump. This expansion and development process has been accompanied by several approved EIS to ensure environmental compliance.

In 2014 and 2016, environmental licenses for the beneficiation phase were approved, initially for 30,000 TPD and later expanded to 60,000 TPD. In 2019, a complementary Environmental Impact Study (EIA) was approved for this expansion. It has established intensive use of water resources, which poses significant environmental challenges. The project currently uses a total of 560 liters per second (l/s) of surface water for its mining operations, including 243 l/s from the Wawayme River and 317 l/s from runoff and percolation. Additionally, human consumption within the project is supplied with 3.7 l/s of surface water and 5.2 l/s of groundwater. The management of aquifer resources requires rigorous planning and supervision to minimize environmental impact and ensure the sustainability of the affected watersheds.

[34] Güereca Torres; Blásquez Martínez; López Moreno, 2016.
[35] Coles, 2010.
[36] Sandoval Forero, 2018.
[37] Güereca Torres; Blásquez Martínez; López Moreno, 2016.
[38] Allsop et al., 2022.
[39] EcuaCorriente S.A, 2018.

Perception of socio-environmental transformations in indigenous and peasant communities

To understand the perception of the population, semi-structured interviews were conducted to identify their position regarding the presence of the mine and, above all, their perception of the territorial transformations in their communities, as seen in Figure 1.

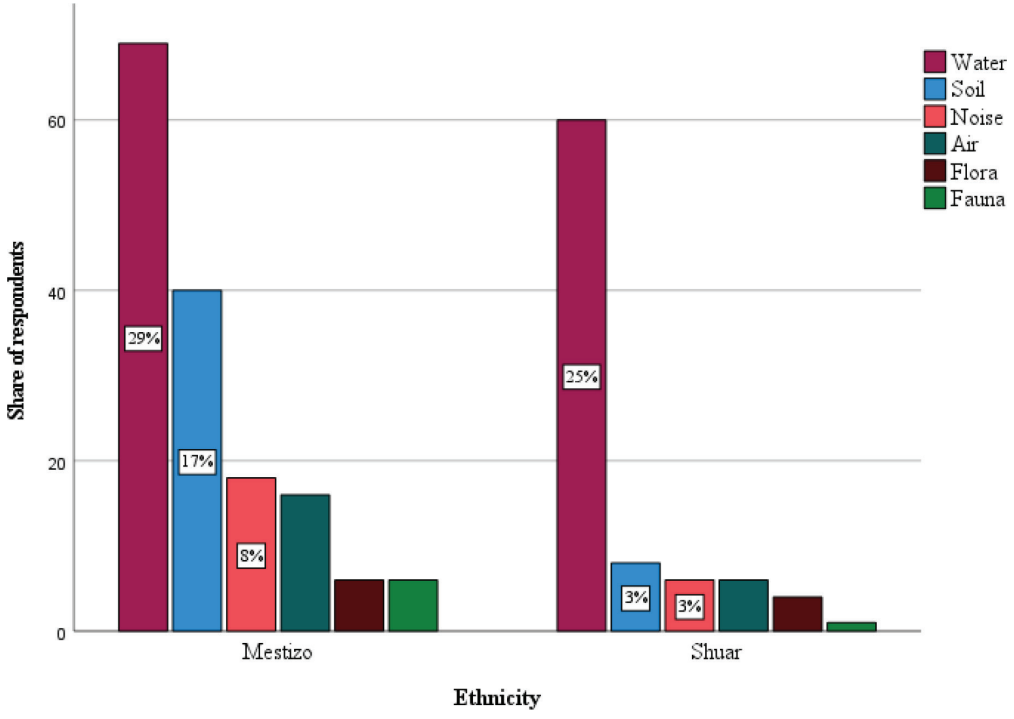
The responses manifest that both the Shuar communities with 33 % and the mestizo communities with 59 % perceive the existence of socio-environmental impact in their territory. In which, they consider that the main natural resource that is being affected is water with 29 % and 25 %, respectively. However, they also mention the tangible presence of modifications in resources such as soil and flora which have intensified throughout the extraction stage.

The Tundayme community's perception of water pollution is influenced by observations of visible changes in water resources, often associated with industrial activities. It has been reported that rivers, such as the Quimi, have experienced variations in their coloration, appearance of foam and unusual odors, which could indicate the presence of chemical contaminants. These changes are perceived by residents as direct signs of environmental deterioration, potentially linked to nearby mining operations. Furthermore, fish mortality observed in certain areas reinforces concerns about the cumulative impact of contaminants on aquatic ecosystems.

In rural communities, where access to water treatment infrastructure is limited, significant dependence on natural sources for water supply is observed. This increases the vulnerability of these groups to contamination, since supply alternatives are scarce and there are often no efficient systems to verify the quality of the water consumed. Although records of health conditions related to the use of contaminated water are sporadic, they have been enough to generate a sense of concern regarding water consumption and its long-term effects on community health. There is noticeable distrust among residents towards the measures implemented to mitigate water contamination, in part due to a lack of effective communication about the remediation and purification strategies used by the mining company.

Likewise, in conversations with the communities, they express a need for greater transparency and participation in decisions that directly affect their water resources. This situation highlights the relevance of community participation in environmental monitoring

Figure 1. Primary concerns of the community



Source: Author, 2024.

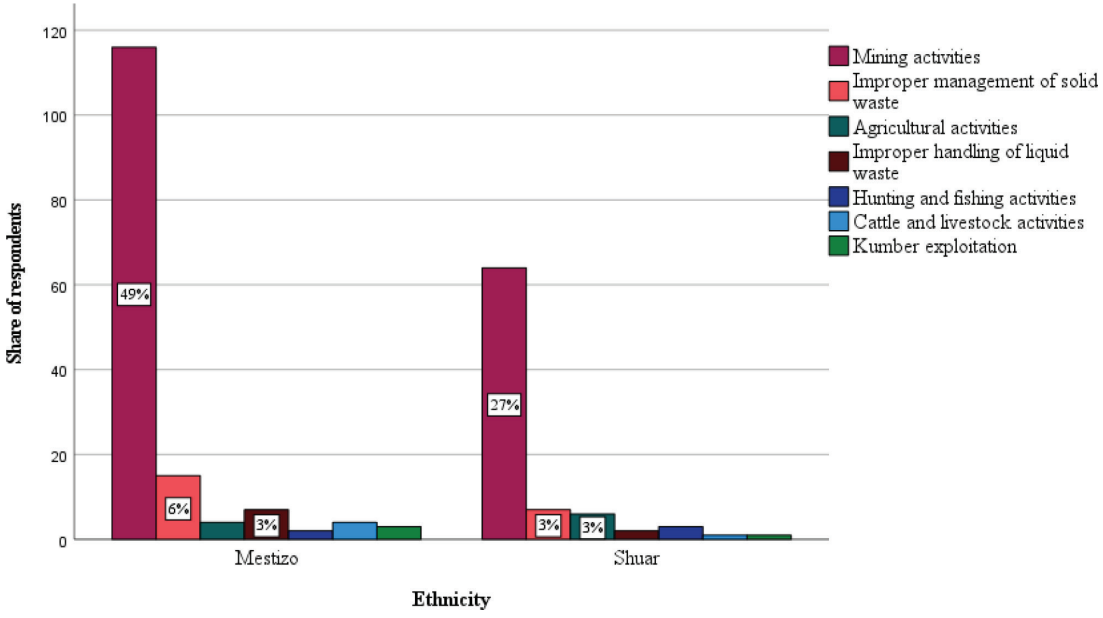
and in the design of real solutions for water management. Fear of future water scarcity dominates community discourse, reflecting not only immediate environmental concerns but also anxieties about long-term water resource sustainability. These feelings are framed in a broader context of territorial transformations that have altered both the physical geography and the socioeconomic dynamics of Tundayme, aggravating the difficulties in the management of environmental assets and ecological resilience.

As seen in Figure 2, the prevalent notion in the community that mining has a negative impact on water resources is strengthened due to the cultural and spiritual connection that the inhabitants have with water, especially the Shuar. Mining interventions, evident in the modification of water channels and in observable pollution, such as changes in the color of the water and the presence of industrial waste, are not only physical threats, but also assaults on sociocultural structures. Water, more than a resource for subsistence, is a sacred element that intertwines community life, ritual practices, and cultural identity. The degradation of water due to mining, therefore, is experienced by the community not only as an ecological loss but as an erosion of cultural integrity and a displacement of their traditional practices, which results in increasing community resistance and dissatisfaction towards mining.

In the context of the Mirador Mining Project, industrial water use, and associated facilities have raised significant concerns among local communities. The project's beneficiation plant uses water considerably, with a design that includes a consumption of 2.5 m^3 for each ton of ore processed, which amounts to a daily total of 150,000 m^3, of which 93.3 % comes from recycled water[40]. This high recycling rate, although efficient from an industrial perspective, does not necessarily mitigate community concerns about water resource extraction and management, especially in an area with sensitive ecosystems and communities that directly depend on water for their subsistence.

Community perceptions of water justice focus on access to and quality of water resources, influenced by the view that mining activities prioritize industrial needs over domestic and ecological needs. The project's hydraulic infrastructure, such as the acid water treatment plant and sedimentation pools, although technically adequate, is seen as an imposition that disrupts the natural water cycle and potentially introduces contamination risks. This is particularly critical during periods when water demand exceeds recirculation capacity

Figure 2. Activities that impact water resources



Source: Author, 2024.

[40] EcuaCorriente S.A, 2018.

and supplemental sources are required, such as during production trial periods. The fact that the mining project must complement its water supply with additional sources from the Wawayme River and collection points on the Quimi River during periods of drought, highlights the region's susceptibility to climate variability and water management focused on mining.

Local communities, particularly the indigenous Shuar and mestizos, interpret these actions as a threat to the sustainability of their own water resources, which are crucial for agriculture, fishing, and human consumption. The construction of infrastructure, such as interceptor canals and waste dumps, are perceived by communities as an intrusion on the landscape that brings with it significant alterations to local watercourses. This not only affects water availability, but also quality, raising concerns about sediment and other contaminants that could affect daily activities and the health of communities. The industrial use of water at the mine reveals an inherent conflict between the operational needs of mining and the ecological and cultural needs of local communities.

The construction of tailings dams, such as those at Quimi and Tundayme, designed for the storage of waste or tailings generated during the mineral beneficiation process, represents a fundamental and often problematic part of the mining infrastructure. Tailings dams are containment structures that allow the deposit and management of mining waste in the form of sludge, which contains a mixture of water and undesirable materials extracted along with the mineral[41]. These structures are critical to preventing the dispersion of toxic materials into the environment and managing the environmental impact of mining. The Quimi tailings dam, used in the first years of production of the project, and the Tundayme tailings dam, designed to operate for more than 25 years, show the magnitude and permanence of these infrastructures in the landscape. The construction of these tailings dams not only modifies extensive areas of land, but also requires the manipulation and redirection of natural bodies of water, as seen in the case of the Tundayme River, whose waters are diverted to avoid contamination and to facilitate the mine operation.

From the perspective of water justice, the construction of tailings dams directly affects territorial and socio-environmental transformations. It alters river ecosystems and affects the availability of water resources for local communities, influencing ancestral activities such as agriculture and fishing. In addition, there is a risk of water contamination due to contact with heavy metals and other chemical pollutants. For this reason, it is a constant concern of the community, since they are concerned that the changes not only reduce the flow of the rivers, but also pose an impact on aquatic biodiversity, which is essential for the livelihood of the population. The analysis of these technical infrastructure constructions, such as tailings dams, are not only physical implementations, but are actions that reflect political, economic, and cultural decisions that contribute to perpetuating long-term inequalities.

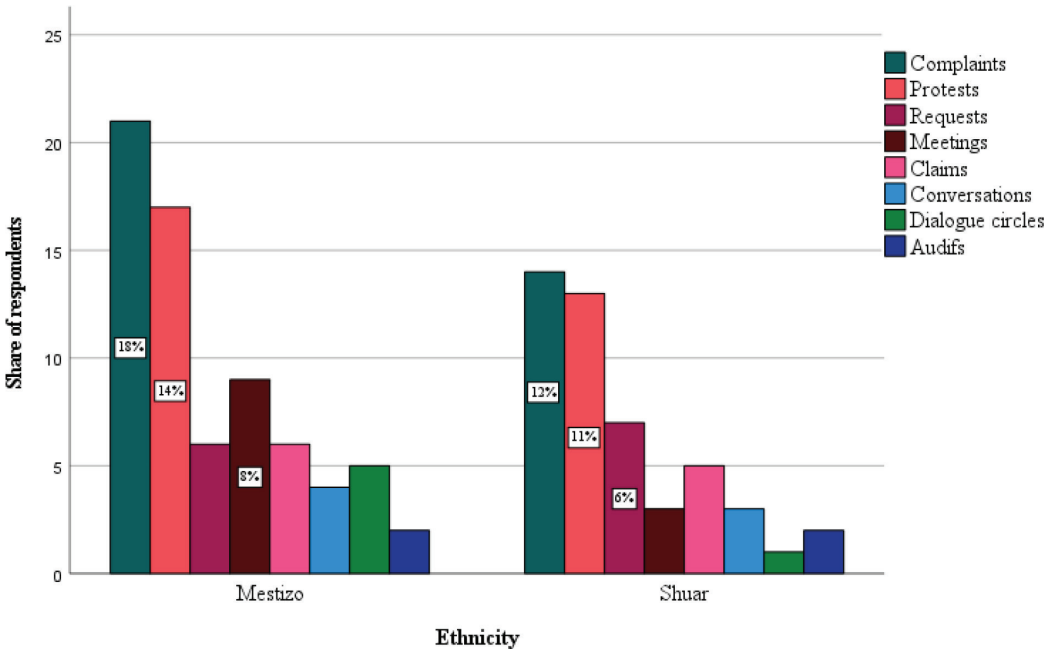
As seen in Figure 3, among the main resolution strategies that the communities have sought are complaints Shuar 12 % and mestizo 18 %, respectively. This reveals a series of transformations in the relationships between local communities, both indigenous and mestizo, and the companies that have operated the project over time. These changes reflect not only an evolution in business practices and management policies, but also in the way communities organize and respond to external interventions. The transition from Canadian to Chinese management in 2010, marked a significant variation in the interaction between the company and communities. Under the Canadian administration, practices were perceived as paternalistic by local communities, where their demands were met directly and without a structured negotiation process, reflecting a management style that prioritized social peace to facilitate the sale and transfer of the property mining concession.

In contrast, the arrival of the Chinese administration introduced a more regulated and structured approach, which, according to local accounts, resulted in a culture shock and a perception of rigidity and distance. This change in management is reflected in the defense tactics and territorial organization utilized by the communities. The creation of the Amazon Community of Social Action Cordillera del Cóndor Mirador (CASCOMI), a community organization, was in response to the state-police action on the displacements that occurred in the former neighborhood of San Marcos in 2015. This account is an example of how communities began to formulate more structured and collective responses to what they perceived as threats to their territories and ways of life.

This shift can be interpreted as a transformation in the community's collective memory and resistance

[41] EcuaCorriente S.A, 2019.

Figure 3. Community actions to protect their territories



Source: Author, 2024.

strategies. Communities, when confronted with a management model that they perceive as less receptive and more bureaucratic, have had to adapt, and modify their forms of interaction and negotiation. It has implied modifications in the way compensation, or improvements are requested and negotiated by communities, as well as how they are articulated and organized to protect their interests:

> "That, the inheritance of their ancestors is the wisdom transmitted at the time of tilling mother earth to produce their farm, but now their descendants are prevented from receiving said agricultural knowledge to their generations, because the National Government did not assume this cost and allowed the violation of Human Rights in their own territories, where they exercised their legitimate rights as peoples"[42].

The implementation of structures such as tailings dams and modifications to the use and access to water have had direct impacts on the landscape and the availability of critical resources for communities, which has reinforced the need for a more organized and founded defense of their territories. Water management has become a field of struggle and negotiation, given its direct impact on agricultural practices. The alteration in the management of the mine has brought with it technical and environmental challenges, as well as profound social changes that have reconfigured the confrontation between the company and the communities resulting in socio-environmental conflicts that have forced the communities to adapt their resistance strategies, thereby reflecting an evolution in their organizational capacities and in their approach towards the defense of their rights and territories.

Opposition to the mining project has moved towards sophisticated resistance strategies other than conventional protests. Participatory territorial planning and community monitoring are key tools for Cascomi, which has led initiatives to integrate local development concepts into land-use plans, using state mechanisms to demand the rights of communities. In addition, community monitoring, supported by the Observatory of Socio-environmental Conflicts (OBSA) at the Technical University of Loja (UTPL), has supported communities to generate scientific data on water quality with ancestral bio-indicators. These citizen-led science initiatives seek to provide alternative evidence for judicial processes and state decisions. Similarly, extraordinary protection actions have been filed for violation of the rights of nature and lack of prior consultation, resulting in criminalization processes. Despite these challenges, the actions continue

[42] Former president of the Decentralized Rural Parochial Autonomous Government of Tundayme, 50 years old, (Interviewed in Tundayme on February 10, 2024).

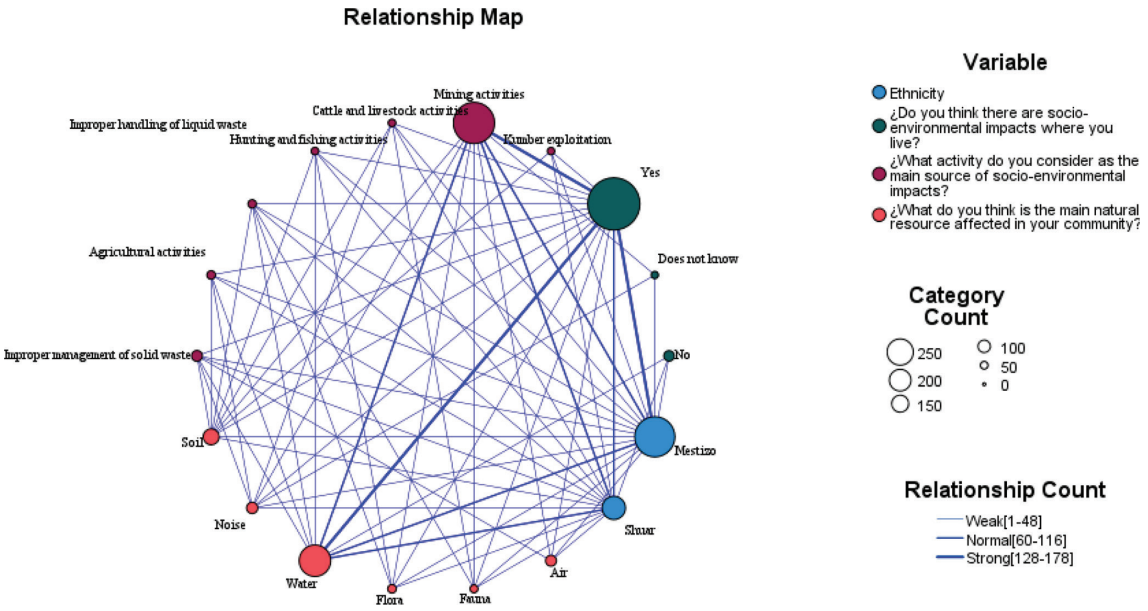
to be fundamental tools in the defense of their territories and the demand for justice.

Figure 4 shows the relationship that exists between the perception that indigenous and mestizos communities have about the socio-environmental impacts, in which both coincide in that water resources are mainly affected due to large-scale mining exploitation activities. This points to the fact that, indeed, the beginning of the project in an exploitation and benefit phase increased the concern of the residents about the current state of their territories. This could be attributed to the increase in production and extension that the mine currently has, both in infrastructure construction and the tailings dams. In addition, the second phase of the project increased the pressure on the use of water resources for exploitation as well as the new incursion into the mine facilities by the development of a steel plant.

The intensive use of water in the supply phase of the Mirador Project reveals the complex and often conflicting dynamics between industrial development and local communities. The daily consumption of 13,572 cubic meters of water (m^3), with 96 m^3 of new water and 13,476 m^3 recycled, not only underlines the magnitude of the project, but also raises critical questions about sustainability and access to water for local indigenous populations[43]. These communities, which have historically depended on the services of nature for their survival, are facing drastic changes in their environment and in the distribution of water.

Socio-cultural and economic transformations have been generated in the local communities. During the construction and exploitation phases, activities such as clearing, earthmoving and drilling have modified the landscape and reduced available natural resources, affecting agricultural practices and ancestral rituals. These intensive activities, evaluated as direct and cumulative impacts, have reconfigured both the physical environment and the social and cultural structure, driving conurbation and real estate speculation in rural towns. At the same time, the project has encouraged local economic development through the hiring of labor and the implementation of infrastructure such as an industrial plant for manufacturing steel balls, contributing to tax revenues and fostering a mining-centered economy. However, the sociocultural system of the Shuar communities has lost many of its ancestral components. The absence of river rituals, which are fundamental to the Shuar cosmovision, and the

Figure 4. Correlations between ethnicity, affected resources and activities that give rise to it



Source: Author, 2024.

[43] Gesambconsult, 2023.

abandonment of traditional festivals and games have been observed. In addition, the Shuar language is only spoken by the older generations, while its use is practically non-existent among the new generations.

Discussion

The research results clearly illustrate the phenomenon of neo-extractivism, characterized by the expansion of the limits of capital towards previously peripheral regions and the excessive exploitation of non-renewable natural resources[44]. They highlight how the perception of indigenous and mestizo peoples about the impacts of mining reflects a conflict between two antagonistic worldviews. On the one hand, the neoliberal vision of the mining company, which considers the territory as a sacrificial space for its megaprojects; and on the other, the vision of the Shuar peoples, who see the territory as a community of life[45]. Under this vision, extractivist policies are considered models of dispossession and inequality, often to the detriment of cultural practices and the sustainability of local communities and spaces of violence[46].

The findings of this research reveal a pattern of concern about the environmental and sociocultural impacts associated with the mine, particularly in terms of management, quantity, and quality of water resources. Dynamics that occur in open pit mining megaprojects that have drastically transformed environmental and social conditions, which has been researched in the state of Zacatecas, Mexico, through the exploitation of watersheds and pollution[47]. As well as other examples developed in northern Peru[48].

In Tundayme, the communities have perceived significant changes in water quality. The construction of mine infrastructure and production has implied an increase in the use of water concessions, both for mine production and for waste management, resulting in the contamination of water sources that could alter the hydrological systems that communities use. This situation has led to intense competition for scarce water resources, affecting both the natural environment and the agricultural practices of the communities.

Furthermore, the opinion of the communities in Tundayme about inadequate management and negative impacts on their territory highlights a broader struggle against a development model that prioritizes economic gains over ecological and social well-being, a criticism that they also recognize as central in modern eco-territorial conflicts[49]. These authors argue that it is essential to reevaluate how natural resources are managed and valued within the neoliberal development schemes that dominate the region.

The concept of pollution dispossession reflects this dynamic, where the introduction of large-scale mining infrastructure has transformed previously virgin and biodiverse areas into sacrificial areas. This process not only affects the natural landscape, but also implies a reconfiguration of social structures (economic, political, and cultural), where the traditional and ancestral activities of indigenous and mestizo communities are being threatened by pollution and alterations in bodies of water. In Tundayme, water, which for the Shuar indigenous communities is much more than a resource for subsistence, it is a sacred element that sustains community life and cultural practices, is at risk of being irreversibly degraded[50].

This situation has generated water conflicts that reflect disputes over quality and its future deterioration[51], where divergent interpretations of the causes of contamination reveal a clash between the technical discourses of the project and the empirical perceptions of the affected population. Furthermore, local resistance to mining expansion is based on a defense of the territory that goes beyond simple environmental activism, transforming into a dispute for autonomy, dignity, and cultural preservation within the framework of political ecology[52].

The creation of sacrifice zones in Tundayme, in which the economic value of minerals prevails, such as how tailings deposits, located predominantly in economically disadvantaged municipalities, intensify socio-territorial inequalities. This highlights a global pattern of dispossession and pollution linked to extractive

[44] Svampa, 2015.
[45] Casanova Casañas, 2021.
[46] Silva Santisteban, 2017.
[47] Guzmán López, 2016.
[48] Jiménez Bautista, 2016.
[49] Svampa, 2015.
[50] Leifsen, 2017.
[51] Leifsen; Sánchez-Vázquez; Reyes, 2017.
[52] Hogan Benham, 2015.

practices[53]. Mining infrastructure physically alters the landscape, and also reconfigures the socio-ecological fabric, increasing the vulnerability of local communities and displacing their cultural and spiritual practices.

In this context, the conflicts between the indigenous worldview and the neoliberal extractivist vision reveal a profound clash in the conceptualization of natural resources, especially in water management[54]. The privatization of control has reconfigured power dynamics, overlooking the cosmological values of the affected communities and deepening structural inequality[55]. This reality is also reflected in Chile, where an institutional gap between centralized management and local initiatives persists. Although efforts to decentralize water management have been implemented, the current model's inability to harmonize both levels perpetuates conflicts, demonstrating that legal and structural reforms remain insufficient to meet social demands and ensure sustainable water management[56].

The resistance of the Shuar and mestizo communities, is a clear example of how resistance practices go beyond simple opposition to a specific project. These communities are fighting to preserve their land relations, which have sustained their lives and those of previous generations[57]. The imposition of infrastructures such as tailings dams and water treatment systems, seen in this light, are not only environmental threats, but also violations of the ontological rights of people, who see their connection with water and territory altered.

Finally, the bibliographic discussion illustrates how communities in the Southwest of Antioquia resist extractivism through hydrosocial relations and the demand for prior consultations[58]. This pattern of resistance is similarly observed in La Araucanía, Chile, where the patrimonialization of water and social capital are essential elements for local cooperation against privatization. This underscores the need to strengthen community governance[59]. In a similar vein, the case of the Shuar communities is intertwined with these struggles, as they too oppose mining and seek a new economy that fully respects water, territory, and life. In all these scenarios, the communities demonstrate a resistance that transcends mere protection of their resources, emerging as advocates for alternative models of local development.

Conclusions

The research at Tundayme profoundly highlights how extractive practices in large-scale mining not only transform the physical landscape, but also restructure the socio-ecological and cultural landscape of indigenous communities. This phenomenon, evidenced through the alteration of water resources and the imposition of structures such as tailings dams and treatment plants, not only leads to environmental degradation, but also represents cultural and spiritual dispossession. Affected communities, especially the Shuar, face not only the loss of a vital resource but also of their intrinsic cultural and spiritual practices, triggering significant resistance against the extractivist model. This analysis highlights the critical need to implement policies that respect plurinationality and indigenous worldviews, integrating measures that promote water justice and cultural sustainability in development and extraction projects.

The creation of sacrifice zones, where economic value prevails over life and cultural integrity, underscores the need for governance that respects plurinationality and indigenous cosmogonic visions. It is crucial to promote an environmental governance model that integrates the practices, knowledge, and values of affected communities, ensuring that the governance of their environmental assets is not only fair and transparent, but also consistent with the principles of cultural sustainability and water justice. Considering human and cultural dimensions when addressing environmental conflicts, emphasizes that true sustainability can only be achieved by strengthening the integration of cultural diversity in the country's development and conservation policies.

This study stresses the urgent need to reevaluate the current development paradigm, which has historically subordinated the interests and rights of indigenous peoples in countries of the Global South. The research highlights that the effective inclusion of these communities in the consultation and decision-making for the legitimacy of extractive projects is essential to guarantee that development is congruent with their needs and aspirations. Furthermore, the analysis delves into the importance of respecting indigenous ontologies and integrating community governance practices

[53] Ojeda-Pereira; Pezoa-Quevedo; Campos-Medina, 2023.
[54] Sempértegui; Báez, 2023.
[55] Strang, 2019.
[56] Guerrero-Valdebenito et al., 2018.
[57] Sempértegui; Báez, 2023.
[58] Roca-Servat; Palacio Ocando, 2019.
[59] Boso Gaspar; Millán; Sánchez Galvis, 2023.

of nature, particularly water. In summary, this article calls for a critical review and the adoption of a more inclusive and equitable development model, urging both the scientific community and key actors to deepen the study of theses dynamics to forge a more just and sustainable future.

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