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TESI DI LAUREA

ECOLOGICAL ASSESSMENT OF THE MINE LA COLOSA LOCATED IN THE FOREST RESERVE ZONE IN CAJAMARCA, COLOMBIA

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INTRODUCTION

Colombia entered the mining market in the administration of (1998-2002) at the explicit suggestion of the International Monetary Fund (IMF), which invited the reactivation of the Colombian economy and the stimulation of the exploitation of natural resources with foreign investment; this proposal carried another requirement of the IMF: reforming the Mining Code, years later for the same line during the National Development Plan [PND] 2011-2014, then-President Santos established the mining sector as an economic development engine with the responsible use of the wealth and natural resources to motivate sustainable growth in the country.

The gradual decrease in production in current mining deposits, in metals such as gold, silver, and others, have forced mining companies to develop new projects in countries that a few years ago were not considered potentially attractive and that today the economies allow the exploitation of mines with smaller amounts of ore, as is the case of Colombia a country also lacking in mining regulations.

The need to start up new mining projects has promoted changes in cut-off laws, which define the minimum concentration of material existing in a deposit so that it can be economically exploited. These have dropped to about 0.3 parts per million in the case of gold, which implies that to extract one gram of mineral, it is necessary to blast, remove and dispose of about three tons of potentially contaminant rock, which affects ecosystems. (Fierro, 2012).

In the Municipality of Cajamarca, in the Department of Tolima-Colombia, areas of artisanal mining exploitation by AngloGold Ashanti (AGA) were identified, which allowed the company to locate promising geological gold formations. Similarly, between 2006 and 2009, the company acquired 4 concession contracts through INGEOMINAS to explore and exploit gold and minerals, such as platinum, silver, copper, and their concentrates. Consequently, AGA requested IN 2008 to the Ministry of the Environment the remotion of 515.75 Ha located in the forest reserve zone (FRZ) for exploration work, but only 6.39 Ha were granted.

The project region has a strategic hydrological reserve serving about 70% of the inhabitants of the department who live and benefit from the greater basin of the Coello River. Its economic activity par excellence is agriculture, with large areas of fertile land and abundant possession of water sources. However, the daily life of the mentioned municipality has been altered by the arrival of the multinational to its territory. The mining exploration stage is on hold, but if the necessary licenses are obtained, the multinational will continue its exploration and exploitation process, worsening the outlook. «The ambitious open-pit mining project aims to have a total gold production estimated at 28,33 million ounces ». (AngloGold Ashanti [AGA] Operational profile 2019, p. 2).

Despite showing an agricultural and livestock aptitude in Cajamarca, the mining phenomenon has aroused particular interest during the past years. Mining has been present since colonization times, a practice of particular relevance carried out in the rivers as in sinkholes as artisanal or illegal mining. However, the discussion on exploiting mines, specifically gold mining, has taken on more significance in the country. (Gobernación del Tolima, 2011).

In the development of the exploration stage of La Colosa mining project, a series of conflicts originated due to misinformation and the execution of harmful activities for the ecosystems in the zone. It is added that the exploitation of an open-pit mine generates environmental problems and irreversible social impacts, such as the increase in the migrant population, damage and contamination of water resources, transformation in land use, a deficit in the municipality's agricultural capacity, which generates food security at risk and, the alteration in the biophysical system.

Special attention has been given, as the discussed mining activity is located inside the Central Forest Reserve. «The forest reserve areas established through the issuance of Law 2 of 1959 are oriented towards the development of the forest economy and the protection of soils, waters, and wildlife». (Congress of Colombia, 1959). By law, mining exploration activities cannot be carried out in forest reserve areas without applying for an area subtraction license. In February 2008, Cortolima, the regional environmental authority, discovered that AGAC did not comply with this norm after carrying out exploratory activities within the forest reserve without the respective subtraction license and, consequently, ordered the immediate suspension of operations in those areas. «The multinational had to stop its operations for two years, and the Ministry of the Environment imposed a financial sanction of 139,256,000 Colombian pesos (approximately USD 40,000) for violating environmental regulations. Ultimately, AGAC ended up canceling the fine, but later the company decided to appeal this ruling». (PAX 2016, p.8)

Specifically, there is a lack in information that contextualizes the reality of the project and its environmental, social, and economic effects. Therefore this research is justified by the importance of characterizing the area on effect and identify possible changes in the territory influenced by mining activity, as well as generating qualitative and quantitative information for future decision-making.

Among the objectives that frame this investigation are: i) to know the characteristics of the exploitation area of the La Colosa mining project geographically, ii) to identify the environmental, social, and economic impacts of the project followed by iii) to carry out an ecological planning method by Ian McHarg diagnosis of its biophysical factors that make up the region to finally iv) generate an overlapping of maps to interpret the possible transformations of the territory as a result of mining activity.

METODOLOGY

Mining is the set of activities related to discovering and extracting minerals found on the earth's surface. Among the minerals that can be obtained among the most sought-after are gold, copper, iron, and coal. These minerals are mixed with many other elements, but occasionally small amounts are found in a large exploited area. To develop extractive activity, it is necessary to create mines of different sizes, from small operations to mines that promote hundreds of thousands of tons. The exploitation methods used to extract the mineral depend on the technology used, the type of mineral, the size and depth of the deposit, and the economic and financial aspects of the project.

For the development of the first part of this document, the outcome of the characterization of the zone and identification of impacts was mostly descriptive-informative; its structure makes the primary section a theoretical investigation whose information is provided from secondary sources (It required a comprehensive documentary base, research documents, reports, and university texts.) Indeed, this work used techniques for collecting and analyzing qualitative and quantitative information, so the methodology formalized a triangulation approach.

With the contextualization of the project's situation within Cajamarca, the Ecological Planning method is applied to define the current conditions of the territory with its attributes and to picture imminent transformations of the territory, which was eminently a descriptive-expositive method.

Following, a more detail methodology description:

- The first unit is based on the ***collection and analysis of documents*** obtained from the company reports, academic authors, government and non-governmental organizations, accompanied by two interviews: Jorge Mario Vera, professor at the University of Tolima, doctoral student and teacher, a researcher on environmental issues and social activist in defense of the territory. And another interview with Renzo García, an environmentalist and biologist with a master's degree in territory, conflict, and culture, Co-founder of the Environmental Committee in Defense of Life and the Environmental Observatory of the University of Tolima. The interviews led to the collection of information, which helped with the basis of this report. An active research approach was employed: many of the themes investigated were issues of concern raised by the interviewers and local documents. In this way, the context of the region is located within the country's economic, social and environmental system.

- Following, ***impacts of the mining activity are identified***, such as effects on water resources, air and soil quality, consequences on wildlife, landscape, and Social values due to the project within a crucial area. Impacts are mentioned and listed, accompanied by data supported by documentation from the company, organizations, and academic groups.

- Next, by the ***ecological planning*** Method by Ian McHarg, the region's main characteristics are analyzed first by making the layer cake model adapted by Steiner that allows seeing the baseline of natural resource data necessary for ecological planning as a matrix. McHarg's layer cake is a suitable beginning to order an understanding of place providing the theoretical foundation for most geographic information systems».

- Following, these last characteristics described above are designed in ***Autocad*** at a scale of 1:50,000. Eleven (11) maps are elaborated showing the biophysical characteristics. The purpose of landscape planners and ecosystem managers to inventory biophysical processes is a meaningful tool to evaluate human ecosystems as people interact with each other and their environment. Understanding territory settings can be fundamental for sociocultural inventory and analysis. «If the process is successful, the constituencies will select the fittest environments, adapting these and themselves to achieve a creative fitting.» (McHarg, 1978, p. 89)

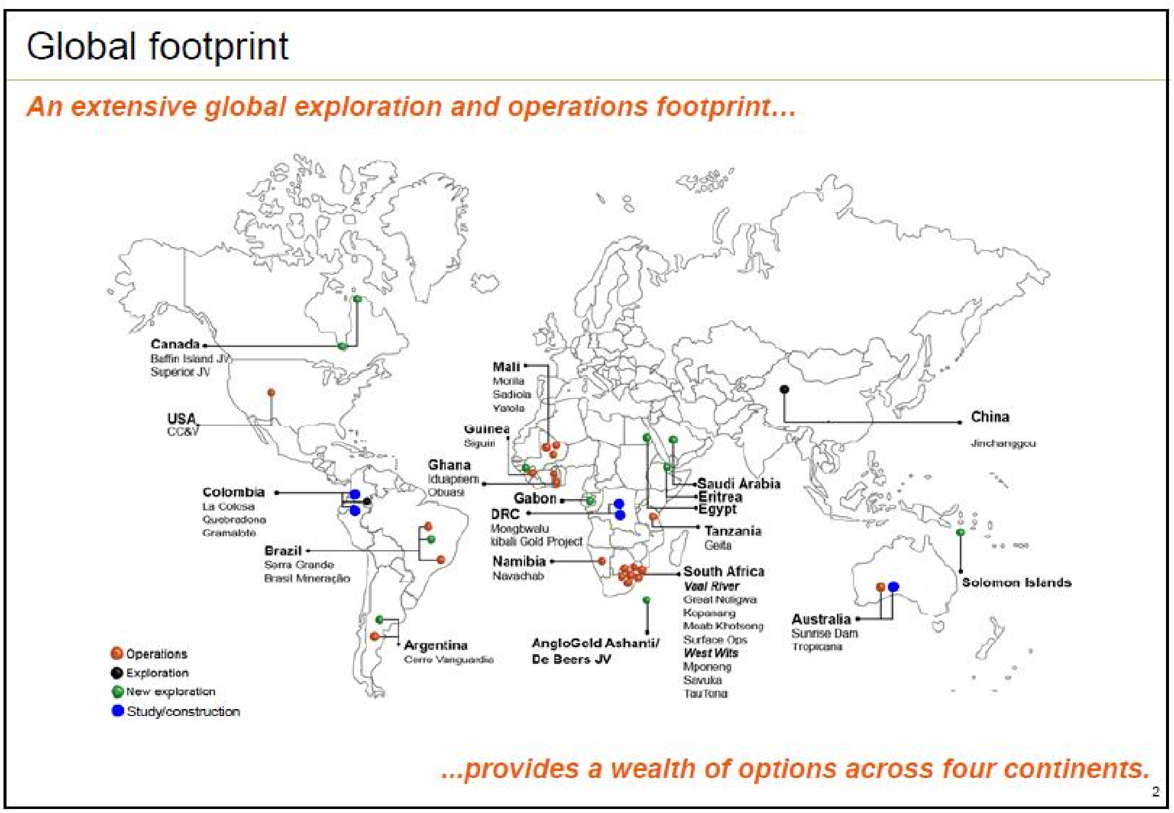
- As the last step, ***maps are superimposed*** on each other to allow advising a possible future modification of the territory due to mining motivation. The priority is to recognize the region's intrinsic attributes and assess a paper that gathers the impacts of mining activity in one way but also warns about the possible changes in the territory, warning about the correct use of the lands.

A REVIEW OF GOLD EXTRACTION

Anglogold Ashanti global profile

The company is the third-largest gold extractor globally and the largest on the African continent, with an extended portfolio of projects and exploration activities (21 operations and five projects) across 12 countries on four continents, Argentina, Brazil, Colombia, Guinea, Ghana, Tanzania, Congo, and Australia. Employing an average of 36,952 people (including contractors) in 2020. It has its primary financial institutions on the Johannesburg (South Africa) stock exchange and shareholders in the United States, United Kingdom, New York, Paris, Australia, and Ghana stock exchanges, creating a market capitalization of $9.4bn as of 31 December 2020. As of 31 December 2012, AngloGold Ashanti had a total inclusive attributable Mineral Resource of 241.5Moz.

Figure 1.Anglogold Ashanti global footprint



Source: AGA- The AngloGold Ashanti Story, 2012, p.5

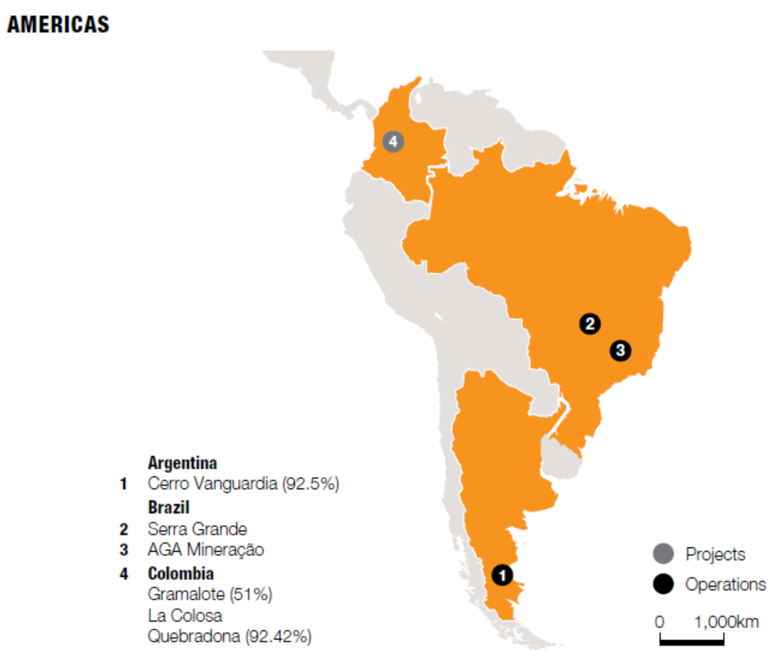
As another indicator, the South African company AngloGold Ashanti, the second gold mining company in the World, outstands because:

> « (…) it was awarded the Greenpeace "Public Eye Award" for being the Most Irresponsible Company in the World due to its deplorable actions in terms of human rights and aggression against the environment in Ghana, a country where the company has been operating for many years». (Colombia Solidarity Campaign, 2011, p. 3).

AngloGold interest in Latin America

AngloGold Ashanti has three operations in Latin America, called by them the Americas, the Cerro Vanguardia mine in Argentina, AngloGold Ashanti Córrego do Sítio Mineração operations and Serra Grande, both in Brazil, and three exploration projects in Colombia.

Figure 2. The Americas projects and Operations



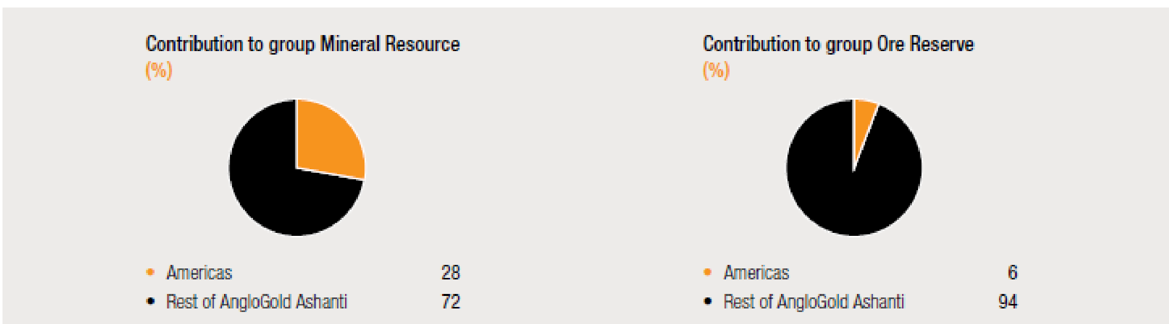
Source: AGA, 2015, P. 18.

«The projects in Colombia form a significant contribution to AngloGold Ashanti's Mineral Resource with the three projects, La Colosa (AngloGold Ashanti 100%)

Quebradona (AngloGold Ashanti 92.42% and B2Gold 7.58%) and Gramalote (AngloGold Ashanti 51% and B2Gold 49%) contributing to 37.60Moz». (AGA, 2015 p. 18)

As of 31 December 2015, the total attributable Mineral Resource (inclusive of the Ore Reserve) for the Americas region was 57.63Moz (2014: 72.48Moz), and the attributable Ore Reserve 3.21Moz (2014: 7.56Moz). This is equivalent to around 28% and 6% of the group's Mineral Resource and Ore Reserve. As seen, The Americas projects and operations have a significant impact on the company's gold reserves.

Figure 3. AGA's Mineral Resource and Ore Reserve.

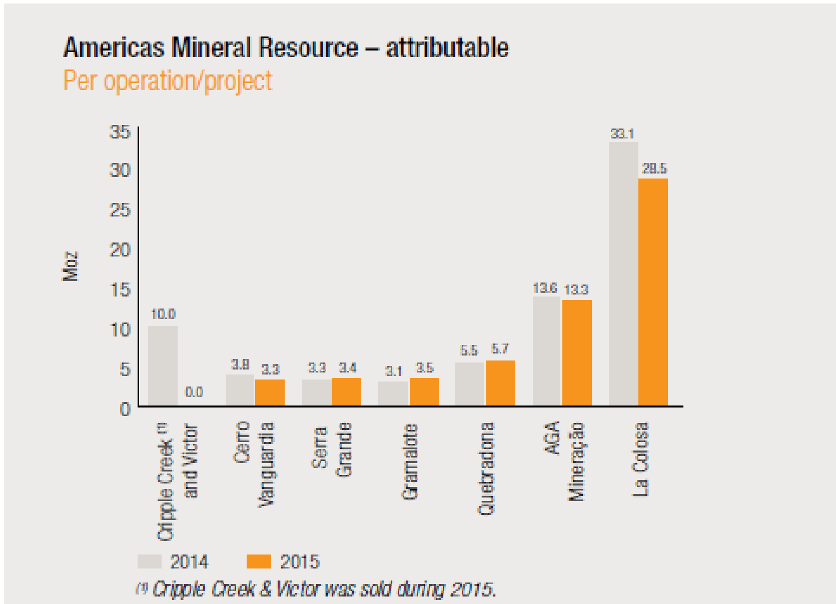


Source: AGA, 2015, P. 18.

Systematic regional greenfields exploration has been undertaken by AngloGold Ashanti and its joint-venture partners (B2Gold, Glencore International, and Mineros S.A.) in Colombia since 2004.

At the Gramalote joint-venture (AngloGold Ashanti 51% and B2Gold 49%), AngloGold Ashanti is currently responsible for managing the project. At the wholly-owned La Colosa project, infrastructure drilling continued after an area adjustment permitting for new platforms was completed. Pre-feasibility study [PFS] development has focused on infrastructure site facility scenarios. AngloGold Ashanti secured regional district scale opportunities surrounding La Colosa and continues with regional targeting of similar gold-rich porphyry mineralization.

Figure 4. The Americas Mineral Resource - attributable



Source: AGA 2015, P. 22.

Due to the significant discovery of the company, it has turned all its attention and considerable budget to developing this project that knows will bring remarkable economic benefits in the long term. «Considering a total budget for Pre-feasibility and feasibility around 500 US$ M and a total capital cost (including contingency 25%) of 3,000 to 3,500 US$ M.» (*Tapia, 2011, p. 13)*

Figure 5. Budget for feasibility studies

Item	Study Cost 2008 - 2010	Budget 100% US$m					
Year		2011	2012	2013	2014	2015	Total
PFS	55.4	69.6	88.3	108.6	-	-	321.9
FS	-	-	-		112.9	62.0	174.9
Total	55.4	69.6	88.3	108.6	112.9	62.0	496.8

Source: *Tapia 2011, p. 9*

Activity in Colombia

In the municipality of Cajamarca, specifically in the Tolima department, artisanal mining areas were identified by the AngloGold Ashanti company based on information provided by the Colombian Institute of Geology and Mining (Ingeominas) as a result of explorations between 1976 and 1978 in the area of Cajamarca. The institute identified mineralization anomalies; a provided report by the unit concludes that the area around Cajamarca has a high potential for disseminated gold deposits, which allowed the multinational to locate the favorable geological formations of the project.

According to an AGA report, its business in Colombia began in 1999 under Sociedad Kedhada. Initially, its operations were not very notable, allowing the company to operate discreetly for years. The multinational relates that its first explorations started between 2000 and 2002 when the company began its active greenfield explorations in Colombia; this exploration resulted in two significant discoveries, Gramalote in the Antioquia province and La Colosa in the Tolima province. The company was legally constituted in 2003; from that moment and due to the feasible regulatory situation towards the mining sector, it allowed the company to acquire many concessions to start with exploration activities in various parts of the country.

According to AGA-Colombia Country Report, 2008, p.5:

> «AngloGold Ashanti's presence in Colombia dates back to 2003, when it was the first company to establish a systematic grassroots exploration program in Colombia. Since these early days, the company has staked 13.1 million hectares of exploration claims countrywide. Of these, 11.2 million hectares have been explored with systematic stream sediment sampling, prospecting, and in some areas, airborne geophysics. As a result of this work, 423 mineral contracts covering 825,025 hectares are active. Follow-up work ranges from drill target definition through pre-feasibility studies. These prospects are operated either 100% by AngloGold Ashanti or in joint ventures with partners B2Gold, Mineros S.A, Mega Uranium, and Glencore. AngloGold Ashanti has thus far relinquished 10.4 million hectares and plans to complete the first

> exploration stage on the remaining 2.7 million hectares in 2009. To date, the program has generated 42 drill targets, of which 24 have been drilled, with two resulting in significant discoveries, Gramalote (a JV with Vancouver-based B2B Gold Corp) and La Colosa».

Seven years after the gold multinational arrived to study the region, the company started operating under the AngloGold Ashanti label. La Colosa project was formalized when In December 2007, then-President Álvaro made public the finding of one of the ten most substantial gold mines in the world in Cajamarca-Tolima. (PAX, 2016).

The data on mining titles, cut to October 2010, confirms that of the 51,528 approximate hectares that comprise the total area of the Municipality of Cajamarca, 44,276 hectares, that is, 85.93% of the area of the municipality, are under 31 mining titles granted to nine holders. «The Mining Titles include zinc, gold, platinum, molybdenum, copper, silver, iron, chromium, cobalt, titanium, lead, nickel, and other concessional minerals». (Tierra minada, 2011, p. 1). AngloGold Ashanti has 30,400 hectares granted in 21 mining titles only for the municipality of Cajamarca-Tolima, which shows that this company has 68.75% of the total area of the municipality under its extractive interest.

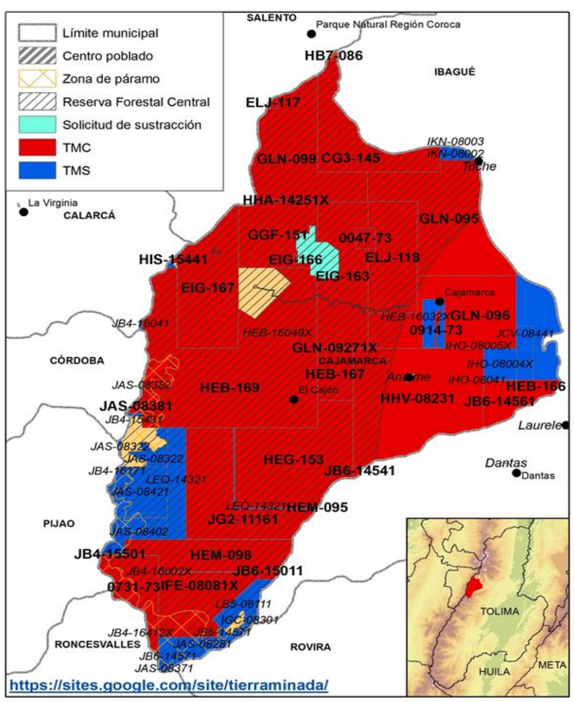
Currently, the company has other subsidiaries in Colombia, which are mentioned in its publicly available reports. The creation of subsidiaries is common practice for multinationals, especially in the case of 'joint ventures with other companies, as with Quebradona and Gramalote (Other mining projects in the country by AGA). This practice can offer administrative advantages and the possibility of maintaining a low profile concerning the breadth and reach of their operations. Another possible reason for creating subsidiaries is to avoid potential environmental and labor liabilities that often result from open-pit gold mining.

It is noticed how all the territory is designated for mining titles as the area with diagonal lines represents 79% of the municipality within the forest reserve zone. (Figure 6)The red area highlights the zones with granted mining titles, in blue the area of requested mining titles, and light blue the 515,75 Ha of the initial La Colosa project. The project is located 14km from the town of Cajamarca.

Gutiérrez (2013):

> «La Colosa would produce about 24 million ounces of gold; the environmental cost of this exploitation can be calculated if it is taken into consideration that more than 100 tons of rock must be removed to produce just one ounce of gold […] La Colosa, according to various estimates, would also produce 100,000 tons of mining waste per day, plus 8 tons of cyanide, 500 tons of carbon dioxide. It would use 70,000,000 liters of water […] all that to produce just 50 kilos of gold. Personally, I don't know if the market price justifies, even in strictly economic terms, the tremendous environmental and social damage that this would produce. AngloGold today has the municipality fully occupied: it has 21 mining titles that cover practically 60% of the municipality of Cajamarca (30,440 hectares), with which the damage that is expected in the area if this exploitation begins would be irreversible.».

Figure 6. Titles and mining applications of the Municipality of Cajamarca



Source: Tierra Minada 2011, p. 1.

According to Martínez Rivillas, (2009), in the territory of Cajamarca there are:

- Precious minerals: Gold and Silver
- Metallic minerals: Antimony, Mercury, Zinc, Molybdenum and Filoniano
- Non-metallic minerals: Graphite and Talc, rocks
- Construction materials: Pozzolans, Grabas and Sands.

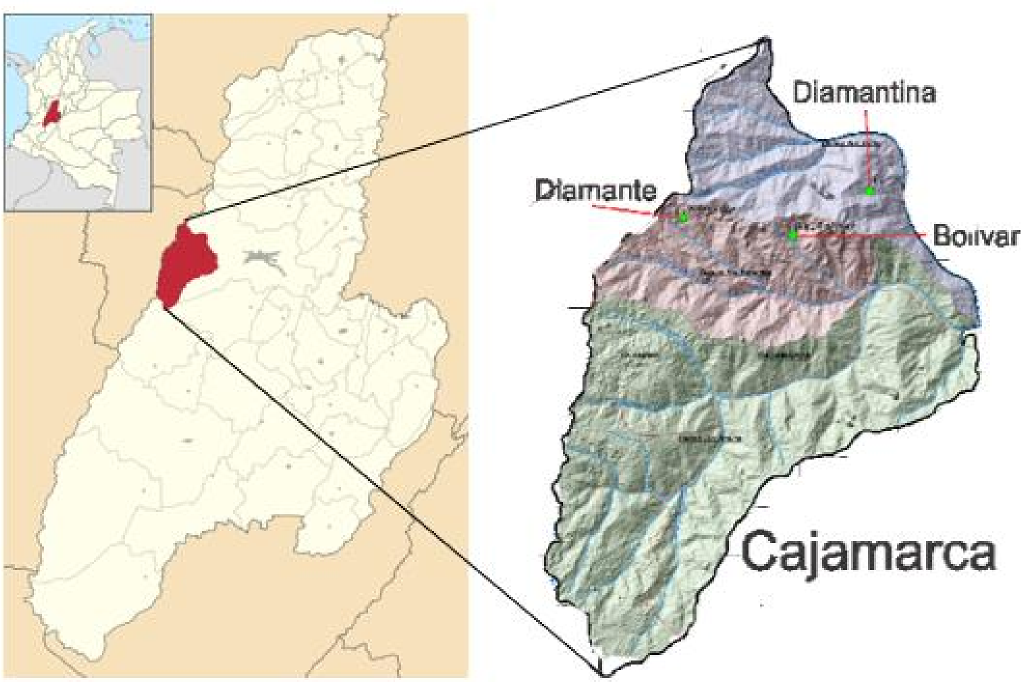
In the country's mining panorama, the mobilization of communities has been decisive for the resistance to extraction projects in the country. Different mobilizations have been held in Ibague, which have gathered up to 30,000 people against La Colosa project and in defense of water. Furthermore, a community action group brought together Coello River's users against the mining project since around 800,000 people depend on this river; even the region governor has positioned himself against the project. In 2015, more than 500 community and social leaders from Ibague, academics, and environmentalists met at the Cooperative University of Ibague and voted unanimously against the project plan.

GEOGRAPHIC CONTEXT

Tolima Department is one of the thirty-two departments that, together with the Capital District, make up the Republic of Colombia. Its capital is Ibagué, located in the country's center-west, in the Andean region. The project is located west of the Tolima department (see Figure. 7). In the municipality of Cajamarca, with an area of 51621 hectares in the middle of the central mountain range. It is located in La Luisa, La Paloma, La Bolívar, and El Diamante communities, 37 km from Ibagué. La Colosa project lies in steep terrain in Colombia's region and is the most extensive greenfield discovery made by AngloGold Ashanti.

> « Of the 516.21 square kilometers of the municipality. 0.2% corresponds to the urban area (1.2 km) and 99.8% to the rural sector (515.20 km2). Regarding land use, 23.32% of the territory is dedicated to agricultural exploitation, 29.85% is pastures for livestock production, 36.81% to forests, and 9.53% to other uses». (Gobernación del Tolima, 2015, p. 18).

Figure 7. Geographic context of Cajamarca



Characterization of the area of influence of the mining project

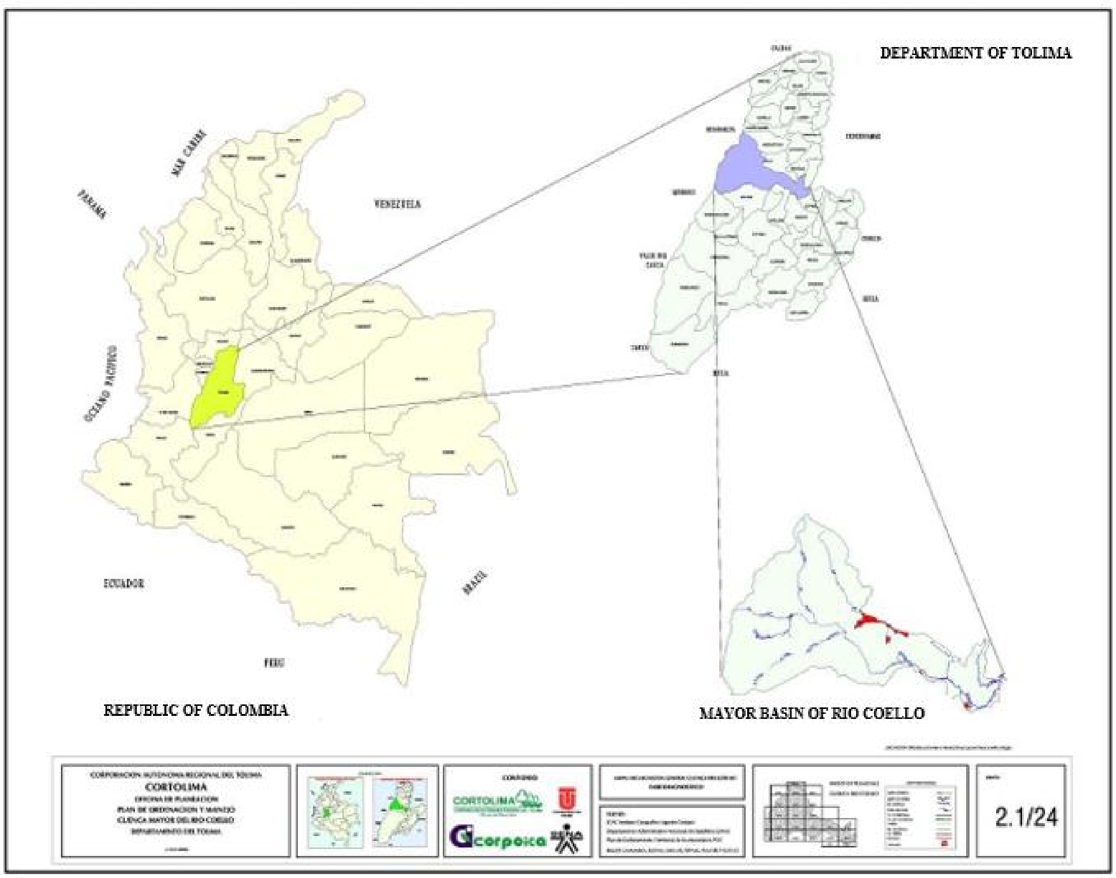
The project is located in the upper part of the Greater Coello River Basin in the Central Forest Reserve of Colombia. However, the location and impact of the project will establish broader rings of influence, which will affect departmental, interdepartmental, and national levels due to the contamination of surface waters by cyanide and other heavy metals, a degree of transformation of cultural patterns in addition to others impacts. Findings of gold mineral values have been identified in sediment samples from stream sands and rock samples taken from outcrops located in the La Colosa and La Arenosa stream micro-basins. These micro-basins contribute their waters to the main tributaries of the Coello River basin.

From its source to its outlet, the Greater Coello River Basin has a length of 124,760 km. (see Figure 2) «Its waters run from a West-East direction, draining an area of 184,257.1 ha, corresponding to approximately 7.8% of the total area of the Tolima Department». (CORTOLIMA 2018, p. 37)

The Coello River Basin is one of the most influential in this territory, which supplies 87% of the urban and rural area of the city of Ibagué. The Greater Coello River Basin is a portion of the hydrographic network that originates in the territory of the Los Nevados National Natural Park, and its Buffer Zone is within the Regional System of Protected Areas, becoming a biological corridor that houses not only local species of the area but also native species at a regional level. Therefore, the Coello river basin is considered of crucial importance for the department of Tolima due to the development it promotes, mainly due to water resources for human consumption, electricity generation, and agriculture.
«Water requirements are estimated at 0.5m3 -1m3/ton of processed ore, depending on water recycling. About 1.5% to 2% of water is estimated to be drawn from the Coello River» (AGA-La Colosa site visit, 2011, p. 13). Additionally, power lines must run near the site; then, a new electrical substation may be required to supply 100MW –140MW feed to the plant; the power supply study is awarded to HMV engineering South Africa company.

The regional environmental authority, *Cortolima*, has issued AGA a permit to use four liters of water per minute from rivers and streams in *La Colosa. A* relatively low amount due to the priorities established for water use in the Coello River basin, mainly drinking water and water for agricultural use, is associated with Cortolima's resolution announcing that the water resource is currently exhausted. The former president of AGA admitted that the amount of water currently permitted is insufficient for its needs, and AGA will need more water in the short term, and therefore additional water permits.

Figure 8. General location of the Greater Coello River Basin



Source: CORTOLIMA, 2021

Hundreds of families and medium urban sectors subsist thanks to its climate, vegetation, and livestock variety. Cajamarca, in its highest part, is a Páramo. The Ministry of Environment and Sustainable Development designated more than 175,000 hectares of the Tolima Department, including the Páramo´s**,** forest reserve areas.

> «Páramo**´s** are considered strategic ecosystems, especially for their role in regulating the hydrological cycle that supports the supply of water resources for human consumption and the development of economic activities for more than 70% of the Colombian population. These territories are also characterized by their high biotic and sociocultural wealth ». (Ministerio de Ambiente y Desarrollo, n.d)

Figure 9. Ridge containing La Colosa Project

Source: AGA 2008, Las Americas report p.5

According to Fierro and Cabrera 2013, Colombia has the most elevated level of biodiversity in the world per square kilometer. To this is added that historically it has presented an indefinite potential for producing natural resources. However, the reality is that in Colombia and Latin America, the industry dynamics defined for the exploitation and use of these resources have had a social impact, generating social conflicts in the areas designated for extraction.

Subtraction of area from the central forest reserve zone

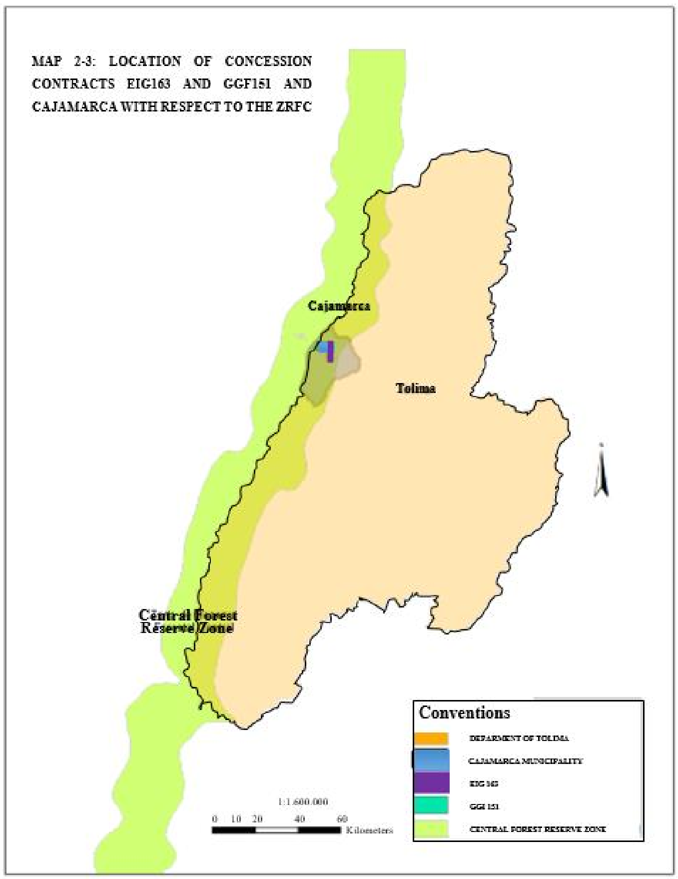
As mentioned above, one of the central arguments within the framework of the mining project is related to the intentional subtraction of the area of the Central Forest Reserve Zone, CFRZ, which, as previously shown, is part of the areas of interest of the multinational (see Figure 5). The exploration area falls within the Central Forest Reserve, A zone of 15km to the west and 15km to the east of the Central Andes Mountain Range. The exploration area was previously used for grazing and pasture. Law 685 of 2001 «Establishes the FRZ as excludable from mining; however, it also specifies in its article 33 that to carry out mining activity in any FRZ, the interested party would have to previously request the license to remove the area corresponding to FRZ». Information that was ignored by the multinational before the start of its operations.

Contemplating that a large area of the La Colosa project area is located within the FRZ, on February 20, 2008, Cortolima realized that no extraction request was processed; consequently, through resolution 205 of February 21, 2008, Cortolima ordered the AGA to immediately stop the mining exploration activity carried out until it obtains the subtraction of the corresponding area of the central forest reserve. This was the determination made by Cortolima as a preventive action.

> « On February 27 and 28 of 2008, the monitoring group of the Directive of Licenses, Permits and Environmental Procedures of the Ministry of Environment, Housing and Territorial Development carried out a technical visit to the exploration area and decided to open an investigation into the AGA for alleged violation of current environmental regulations; in the sense that the company carried out exploration activities consisting of the construction of exploration platforms, exploration wells, expansion and maintenance of roads and construction of camps and other infrastructure». (MAVDT 2008, p. 3).

As a result of the investigation opened by the Ministry to AGA, it was imposed a fine of approximately 40,000 dollars for violating environmental regulations. Lastly, through resolution No. 814 of May 4, 2009, the Minister authorizes exclusively the partial and temporary removal of 6.39 ha from the CFRZ, a minimum extension concerning the 515.75 ha requested. For the Minister, the given area is sufficient for carrying out the exploration phase activities. Once the exploration is completed, it will regain its character as FRZ; consequently, a new request process must be presented to proceed to the exploitation stage.

Figure 10. Location of the project zone respect to the Central Forest Reserve Zone

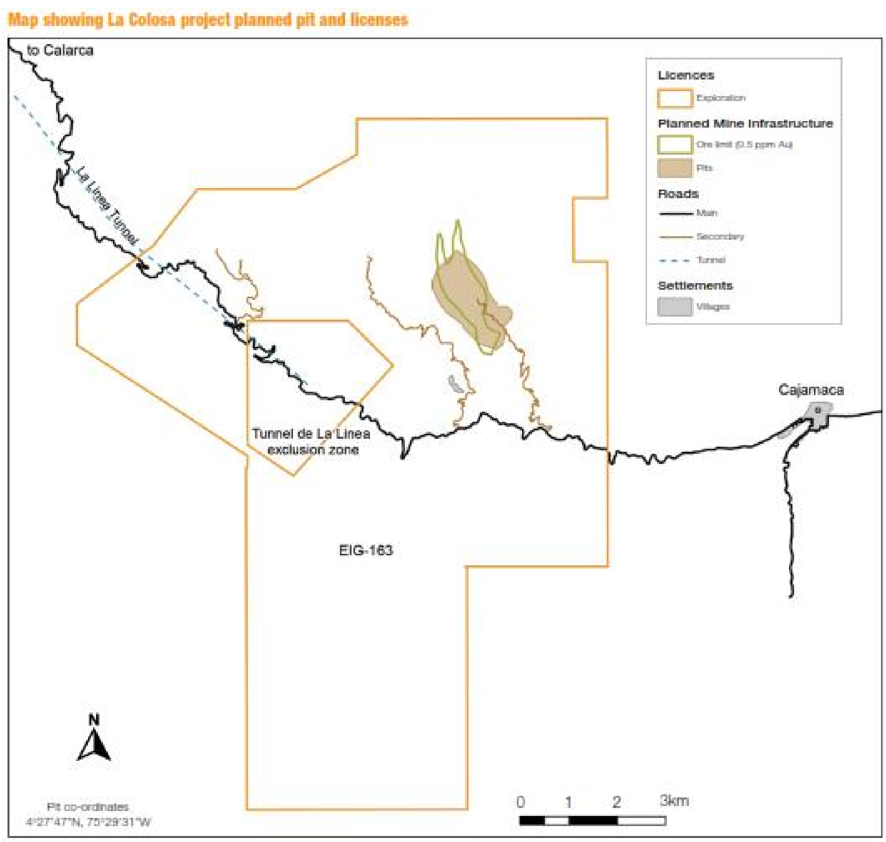


Source: Sanchez,2013

Note: The green light area correspond the Central Forest Reserve Zone, blue and purple zones correspond to mining concession contracts

«The exploration permits (originally consisting of permits EIG-163, EIG-166, EIG-167, GLN-09261X, HEB169, and GGF-151) have been consolidated so that the property now comprises only one exploration permit, namely EIG-163, which totals 9210ha (Figure 11). However, it is unclear how many areas they have renounced and how many have been transferred to partner companies. The combined lease is in its fourth year of exploration and expires on 28 February 2037. The total period for the concession contract (exploration, installation, construction, and exploitation) is 30 years, which may be renewed for an additional 20-year period». (AGA 2020, p.7).

Figure 11.EIG-163 exploration permit, which totals 9210ha.



AGA, Mineral Resource and Ore Reserve Report, 2020, p.8

In the table, there is the status of licenses already mentioned for the year 2015; it should be clarified that the situation of these licenses changed after a few years, and now are interrupted.

Figure 12. Status of Mining permits by 2015

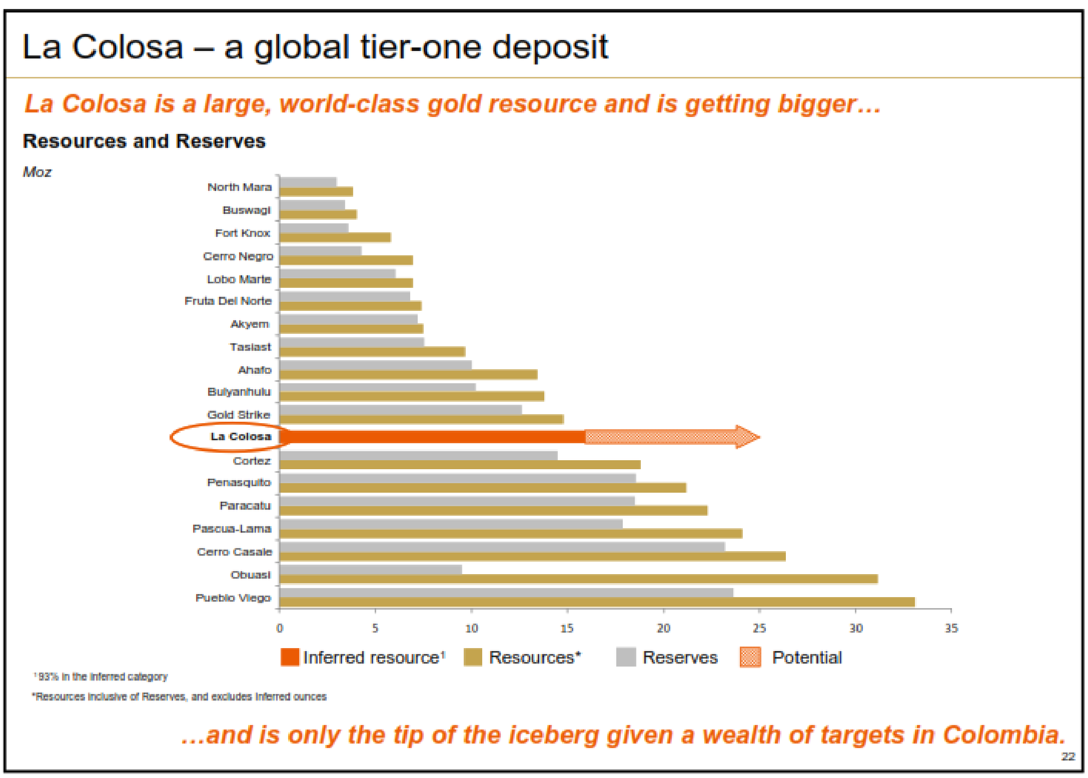
Mining permit	**Size**	**Status by 2015**
EIG-163	2,58 ha	Finished seventh year of exploration (Second extension of exploration)
EIG-166	22 ha	Supposed to be in second year of construction
EIG-167	3,208 ha	Supposed to be in first year of exploration
GLN-09261X	4 ha	Running seventh year of exploration
HEB-169	7,578 ha	Supposed to be in third year of construction
GGF-151	1,832 ha	Starting eight year of exploration (third extension of exploration)

Source: AGA, 2015, P. 26.

LA COLOSA PROJECT

La Colosa mining project is considered one of the largest estimated gold reserves in the world: the resource initially inferred by the AGA was 12.3 million ounces of mineral. However, this estimation had doubled since the moment the exploration process was resumed in 2010 with the addition of new drilling information when it reached a magnitude of 16 million ounces in September 2011, and today it is estimated that the quantity could be 28.33 million ounces (see Figure 13). « Furthermore, according to AGA still, the estimated resource potential of 25Moz to 35Moz (equivalent to almost 60 billion dollars». (AGA, 2011, p.20). Based on this finding, the AGA considers La Colosa the essential gold project in Colombia. (AGA Operational profile, 2019).

Figure 13. La Colosa- a global tier-one deposit



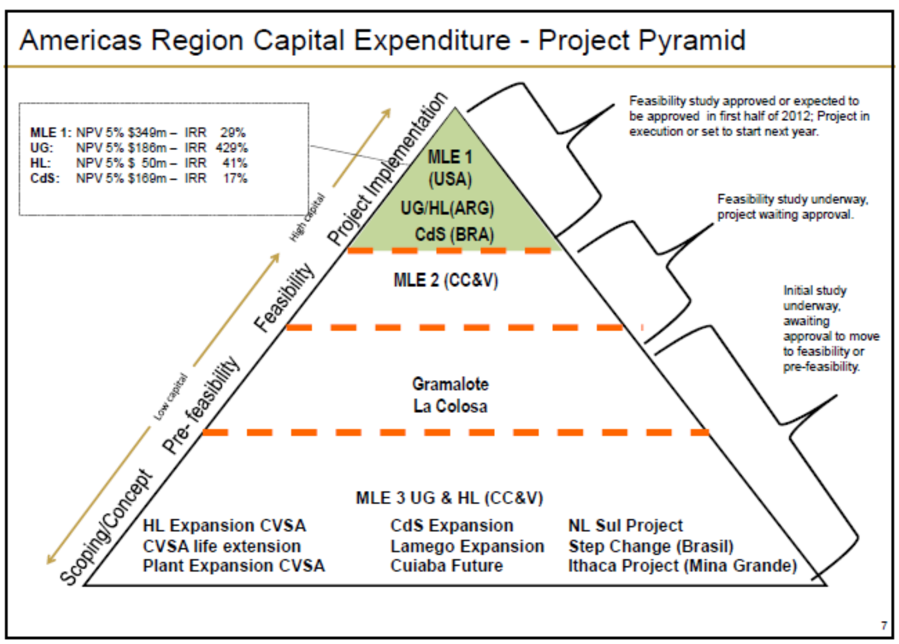
Source: AGA- The AngloGold Ashanti Story, 2012, p.5

Exploration, actual state

« A mining project should only be started with the knowledge of the extent and value of the mineral deposit. Information on the location and value of the mineral deposit is obtained during the exploration phase. This phase includes inspections, field studies, test drilling, and other exploratory analyzes». (ELAW, 2010, p. 15). Within the exploratory phase, geological surveys, geophysics, and rock drilling activities have been carried out for metallurgical and geotechnical purposes. In this stage, the infrastructure designs and the entire process are defined following technical, environmental, social, and economic parameters.

The company follows a methodological pyramid with steps from the beginning of the project and as it progresses. The first step is discovering and scoping the mine with its initial studies, awaiting approval to advance to the pre-feasibility and feasibility step. Once all the permits are approved, the project's implementation phase begins, which requires high capital investment. The company estimated times were PFS, and FS, and Construction period 6.5 years.

Figure 14. Americas Region Capital Expenditure



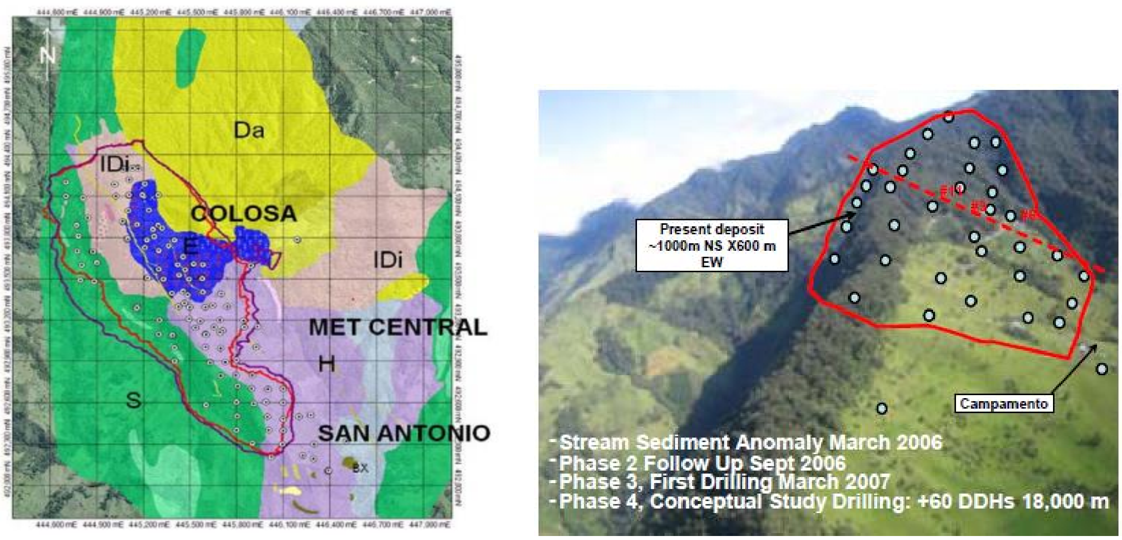
AGA, Investor Site Visit November –Las Americas, 2011, p. 4

Although the project has been interrupted, it is essential to state the company's progress in La Colosa in the past years. It can be specified that AngloGold Ashanti advanced almost entirely in its exploration and pre-feasibility phases; the company reports a total drilling of 148,062m with an average size of 100m x 100m and others of 75mX75m plus 50 X 50 in a high-grade zone. Were completed in 2017 before activities were suspended in early 2017 when force majeure was recognized by the national mining authority relating to the environmental permits required to continue the project's mining exploration activities (AGA, 2020, p. 8). The drilling consists of introducing a diamond-tipped drill to obtain continuous rock fragments (Cores). (see Figure 15)

Another document by AngloGold by 2015 stated:

> « A total of 138,969m (397 holes) has been drilled to date, with the year-on-year increase related to mineralization found in the northwest extension of high-grade mineralization. Geometallurgical studies related to comminution modeling focused on obtaining hardness parameters are advancing. Additional metallurgical comminution tests have been carried out for poorly represented areas. This metallurgical data has been correlated with multi-element assay and spectral mineralogical data to obtain proxies for metallurgical parameters. 43,529.05m (153 holes) have been scanned using a sisuMobi system equipped with an RGB camera and a shortwave infrared (SWIR) camera». (AGA, 2015)

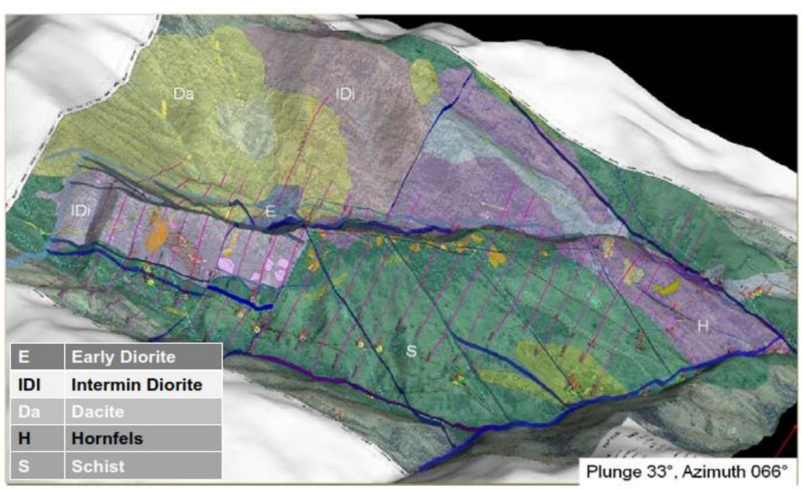
Figure 15. La Colosa- Resource and Geotechnical Drilling



Source: AGA- La Colosa Site Visit, Report Colombia, 2011, p.5

Note: This geological map shows the points where drilling has been carried out. Each square on the map grid is 300 × 300 metres (9 hectares).

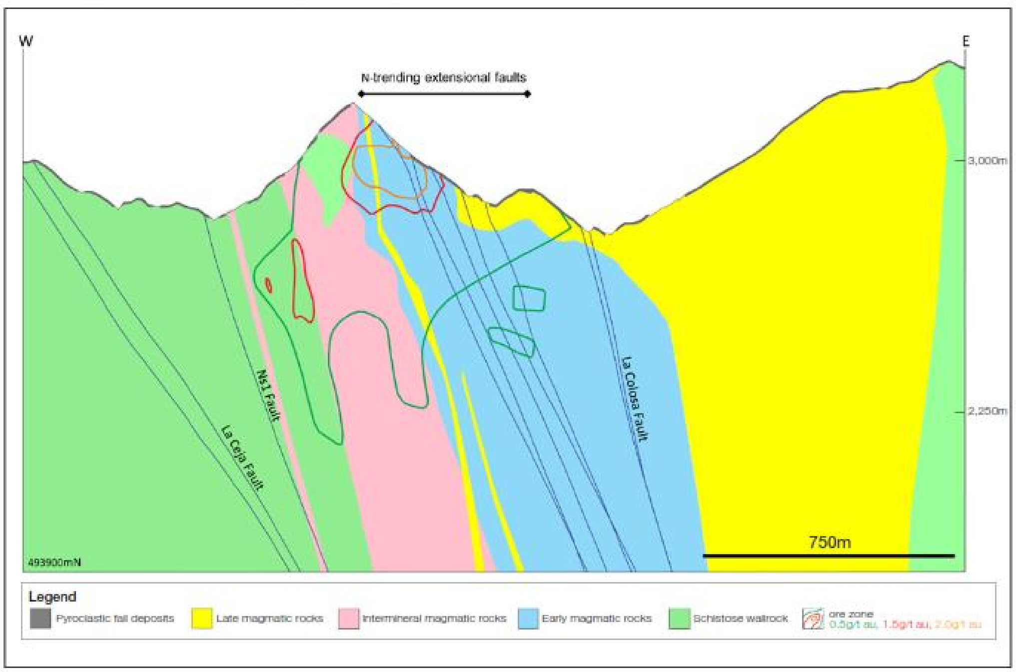
Figure 16. La Colosa Structural Model



Source: AGA- La Colosa Site Visit, Report Colombia, 2011, p.5

At La Colosa, approximately 200,000 m of drilling support an Indicated Mineral Resource estimation. Gold grades were estimated using the ordinary kriging method. The following is the La Colosa Mineral Resource reported at a cut-off grade from 0.5g/t to 2.0 g/t. (see Figure 17) La Colosa is a high-tonnage removal project with a low-grade mineral. The disposition of the reservoir and the coating to be extracted are determined by the mineral/waste ratio from which it must be extracted. This parameter, commonly called the ratio, can be highly variable from one deposit to another. However, in all of them, it conditions the economic viability of the exploitations and, consequently, the depth that can be reached by surface mining. (Bustillo & Lopez, 1996).

Figure 17. W-E Geological cross-section through La Colosa, elevation in meters AMSL



Source: AGA Mineral Resource and Ore Reserve Report 2020, p.8.

Note: the estimated ore zones are delimited indicating the quantity of mineral projected as g/t as green: 0.5g/t Au, red: 1.5 g/t Au, orange: 2.00 g/t Au.

At this stage, the company presents the entire design of the completed project to the minister of the environment. According to preliminary calculations, the EIA and environmental compensation plan resulted in a 1:8 ratio. Eight must be delivered in better condition for each hectare used, in addition to carrying out revegetating and recovery of hectares used. If these plans are approved, the ministry issues an environmental license to develop the project; This includes construction, operation, compensation, and closure topics.

Gold estimation

At La Colosa, some 138,969m of drilling supported the Indicated Mineral Resource estimation. Gold grades were estimated using ordinary kriging, which was performed into a block size of 50m x 50m x 10m using lithological domains in a grade-based mineralization envelope and the waste surrounding the mineralization. All available geological drill holes, surface sampling, and mapping data were validated for the modeling procedure.

The La Colosa Mineral Resource is reported at a cut-off grade of 0.3g/t. The mineralization has been classified based on kriging variance related to drilling spacing.

Figure 18. Mineral estimation at La Colosa

La Colosa		Tonnes	Grade	Contained gold	
as at 31 December 2015	Category	million	g/t	Tonnes	Moz
Open pit	Measured	–	–	–	–
	Indicated	821.67	0.85	695.68	22.37
	Inferred	242.51	0.78	189.65	6.10
	Total	**1,064.18**	**0.83**	**885.33**	**28.46**

Source: AGA, Mineral Resource and Ore Reserve Report, 2015

Exploitation: Phase to be carried out in the future

Construction and assembly:

The construction of all the necessary infrastructure will take about three years; this phase includes the opening or rehabilitation of roads and the construction and equipping of workshops, camps, laboratories, and administrative facilities. The objective is to assemble all the infrastructure necessary for the exploitation works and fuel tanks for the operation of the machinery, among others.

Currently, the project has a field infrastructure that supports access to the Mineral Resource with roads, accommodation, heliport, office, and surface infrastructure for pre-logging and organization of the drilling core (see Figure 19). Four camps have been built to house 190 people, each equipped with office areas, bedrooms, and sanitary units. A total of 6,840 m2 has been intervened in addition to the accesses. Complementary to that is a core shed facility in the city of Ibague, where geological and geo-metallurgical logging is performed. (AGA-Mineral Resource and Ore Reserve Report, 2015, p.26).

Figure 19. Project infrastructure

AGA – Operational profile. Colombia, 2019, p.3

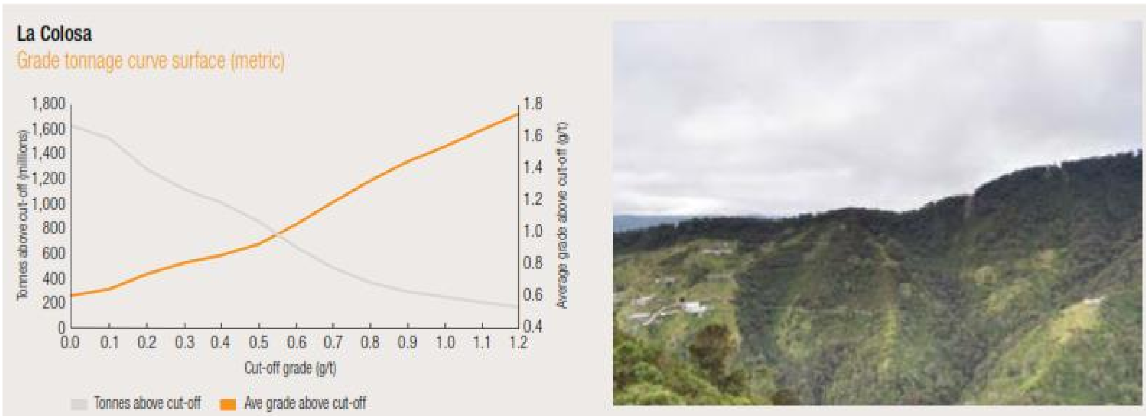
Source: Tapia, 2011. P.2

Extraction

Open-pit mining is a type of strip mining in which the ore deposit extends very deep in the ground, demanding the removal of layer upon layer of overburden and ore. In many cases, logging of trees and clear-cutting or burning vegetation above the ore deposit may precede the overburden removal. The use of heavy machinery, usually bulldozers and dump trucks, is the most typical means of removing overburden. «Open-pit mining often involves the removal of natively vegetated areas and is, therefore, among the most environmentally destructive types of mining, especially within tropical forests». (ELAW, 2010, p. 16).

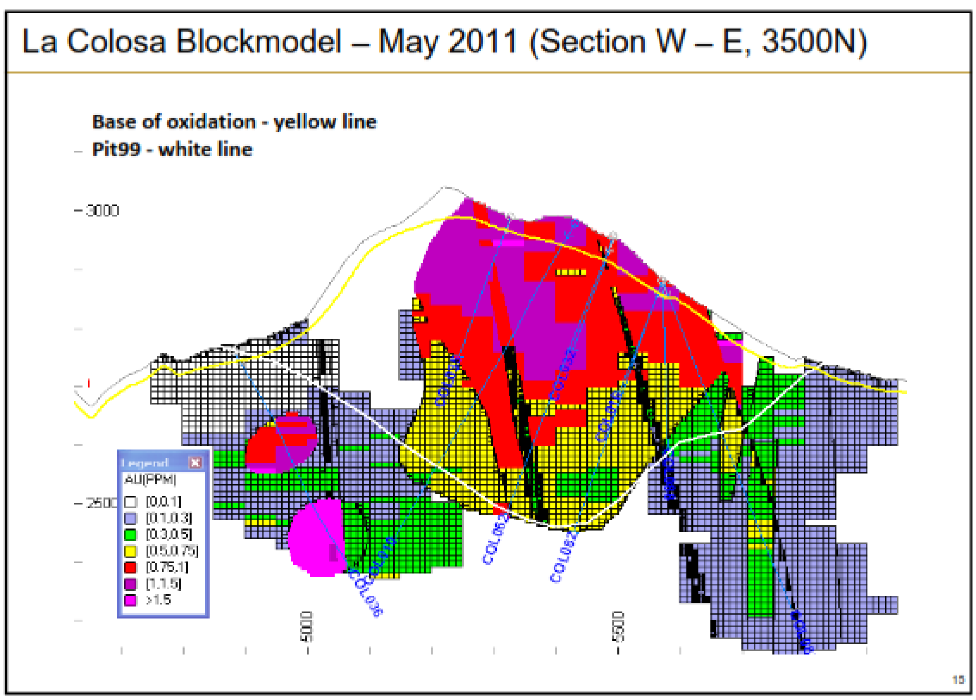
The rock debris generated in this project means those materials with lower gold content, a value that varies from project to project. This measure corresponds to the minimum concentration of gold that makes the project technically and economically viable. In the case of La Colosa, the cut-off grade is variable. To do so, it would be required to remove and expose large masses of rock (see Figure 20) that could reach millions of tons and use substantial amounts of toxins that presumably include more than 500 million tons of ANFO and thousands of tons of tons of cyanide to be used in the beneficiation process.

Figure 20. Cut-off grade tonnage surface



Source: AGA, Mineral Resource and Ore Reserve Report, 2015, p.26

Figure 21. La Colosa Blockmodel



Source: AGA- La Colosa Site Visit, Report Colombia, 2011, p. 8

Figure 21 shows the current topographic profile (grey line) and the topographic profile with the projected mining pit (white line) and rock oxidation level represented by the yellow line. The grey and white colors show rocks with less than 0.3 ppm gold, making them non-mineralized rocks, commonly referred to as "sterile." The colors green, yellow, red, and purple represent rocks with a gold concentration greater than the cut-off grade and are known as mineralized rocks ("ore").

These rocks are chemically treated to extract their gold through beneficiation. The excess material, not gold, called "tailings" (of liquid or semi-solid consistency), is discarded and accumulated in the same area. In the case of La Colosa, it is proposed to dispose of the tailings directly over the valley of the La Guala stream (AGA, 2014c), forming a dam structure with the rock waste ("sterile"). In other words, the "sterile" waste is disposed of in the dump, which at the same time acts as a tailings dam. (Geoenvironmental research group, TERRAE, 2016). Regarding the pit, complemented with what is stated in the technical documentation of (Tapia, 2011), it can be concluded that it will have a maximum depth around 650 m concerning to the current topographic line close to 3,425 meters above sea level. This height, anywhere in Colombia, corresponds to the Páramo ecosystem.

Mineral processing

The project is currently at an early stage, and the floatation of the sulfide ore is being considered. The strategy has identified several possible technical options, but all are highly capital-demanding, which is currently a significant risk for the project. (AGA, 2015)

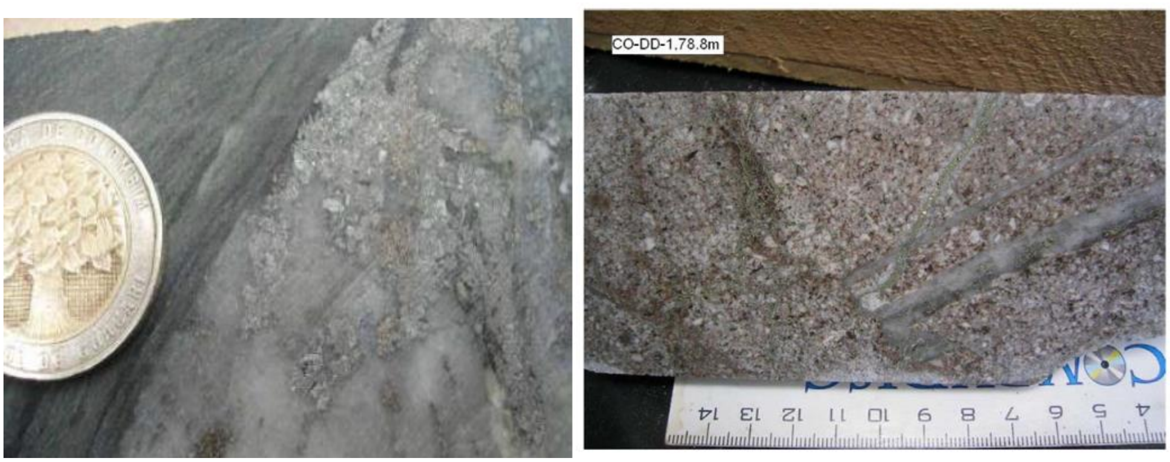
Mineral beneficiation

Although metallic ores contain elevated levels of metals, they generate large quantities of waste. For example, the copper content of a good-grade copper ore may be only one-quarter of one percent. The gold content of a good-grade gold ore may be only a few one-hundredths of a percent. Therefore, the next step in mining is grinding (or milling) the ore and separating the relatively small quantities of metal from the non-metallic material of the ore in a process called ‘beneficiation.’

The main impact of this process is located in the grinding since it releases contaminants when they take the form of tailings, which are remnants that result from grinding the mineral to fine particles and after extracting the valuable metals (ELAW, 2010).

Since gold is contained in very fine particles in the rock (see Fig. 13), AngloGold describes the process of mineral beneficiation in two steps: crushing and grinding and then concentration and flotation. Technical work has been undertaken to collect and analyze the information required for pit optimization and geotechnical and hydrogeological studies. The results are used for pit design, slope stability, risk analysis, and capital and operational expenditure estimates. «Results for recovery test work included tests for gravity separation, whole ore leaching, and flotation/ concentrate leaching. Flotation may have slightly lower recovery but markedly lower processing costs, with a gold recovery of 75,6% to 82%». (Tapia 2011, p. 13).

Figure 22. Particles of Gold contained in rock



Source: *Tapia 2011, p. 15*

> «Gold grains vary from almost pure gold to a lesser amount of gold-silver telluride. The chemical composition of Au-Ag-Te grains is variable. The gold grains are generally fine-grained, around 15 microns. Coarse-grained gold (116 microns) was found in samples from metamorphic rocks. Gold grains occur both liberated and 'locked' in sulfides and silicates. The percentage is not established, but a significant

> amount of gold is associated with silicates such as K-feldspar and plagioclase. Sulfide minerals associated with gold are dominantly pyrite and, in a much lesser amount, pyrrhotite and arsenopyrite». (AGA- Mineral resource and ore reserve, 2008)

The crushing seeks to break the rock into 2 cm in diameter fragments and then pulverize them to sizes of 0.1 mm (the typical thickness of human hair). A combination of multistage crushing and milling circuits undertakes the process. Afterward, gold recovery can then initiate, depending on the nature of the gold contained in the ore.

> «Free milling and oxidized refractory ores are processed for gold recovery by leaching the ore in an alkaline cyanide leach solution are agitated (stirred) tanks. In this process, the ore is crushed and heaped into a tank. Low-strength alkaline cyanide solution is irrigated over the heaped pad for up to three months. The dissolved gold-bearing solution is collected from the heap's base and transferred to carbon-in-solution (CIS) to separate the gold columns. The gold cyanide complex is adsorbed onto activated carbon. Gold that has loaded (adsorbed) onto activated carbon is recovered by re-dissolving the gold from the activated carbon (elution), followed by precipitation in electro-winning cells and subsequent smelting of the precipitate into doré bars. At some operations, by-products are generated, such as silver, sulphuric acid, and uranium». (AGA, 2008, p. 9)

Waste from the mining benefit: Tailings disposal

High-grade mineral deposits consist almost entirely of non-metallic materials and often contain toxic metals (such as cadmium, lead, and arsenic). If a mining project involves extracting a few million metric tons of metallic ore, then the mining project will generate an even larger quantity of tailings. «One of the central questions determining whether a mining project is environmentally acceptable is how a mining company makes the final disposal of this high volume and toxic material. In the long term, tailings disposal and management aim to prevent the mobilization and release of the toxic compounds found in these waste products into the environment». (ELAW, 2010, p.19).

As information given by the company in La Colosa, there are around 0,81g of gold for every ton of rock, which would generate millions of tons of discarded rock. In addition to bathing in large amounts of chemicals, this rock will generate large quantities of sulfuric acid by oxidation of the sulfides they contain since it has been under the surface of the earth for hundreds of years, and its exposure to oxygen generates this oxidation reaction.

Tailings dam:

As previously seen, beneficiation involves adding a large amount of water and toxic/non-toxic chemicals. Given the low concentration of gold in this deposit, the entire volume of mineralized rocks will be discarded after beneficiation, generating significant volumes of a mixture of water, chemicals, and pulverized rock.

As mentioned above, the material not subjected to the beneficiation process, either because it does not contain gold or has low gold content that its extraction is not economically profitable, will be disposed of in the dump, which in the particular case of La Colosa will act at the same time as a containment structure or tailings dam. (TERRAE, 2016).

The company planned to transport the mineralized rock present in the subsoil of the Cajamarca mountains through a mining pipeline or conveyor belt to allocate the benefits plant and the dam of tailings in the municipality Piedras-Tolima. On 5 December 2012, in the municipality of Piedras, representatives of AGA performed an informative meeting with the community. In the session, they began clarifying that they were not looking for gold in the area but for a place to process the ore from La Colosa and that they were carrying out tests to assess soil stability. However, due to the popular consultation held in Piedras municipality on 28 July 2013, the community rejected 99,2% of the proposal, which forced the company to change the initial designs of the project.

Consequently, AngloGold proposes to allocate the benefits plant in the city of Ibague and maintain the dam of tailings in the municipality of Piedras. As a product of the population's rejection, the project is repeatedly downvoted, and the multinational is forced to study the third option. AngloGold Ashanti presented the last proposal to install the entire exploitation process of the La Colosa project in the municipality of Cajamarca: open pit, shredders, tailings disposal, metallurgy plant, tailings dam, and water treatment plant (See Figure 23).

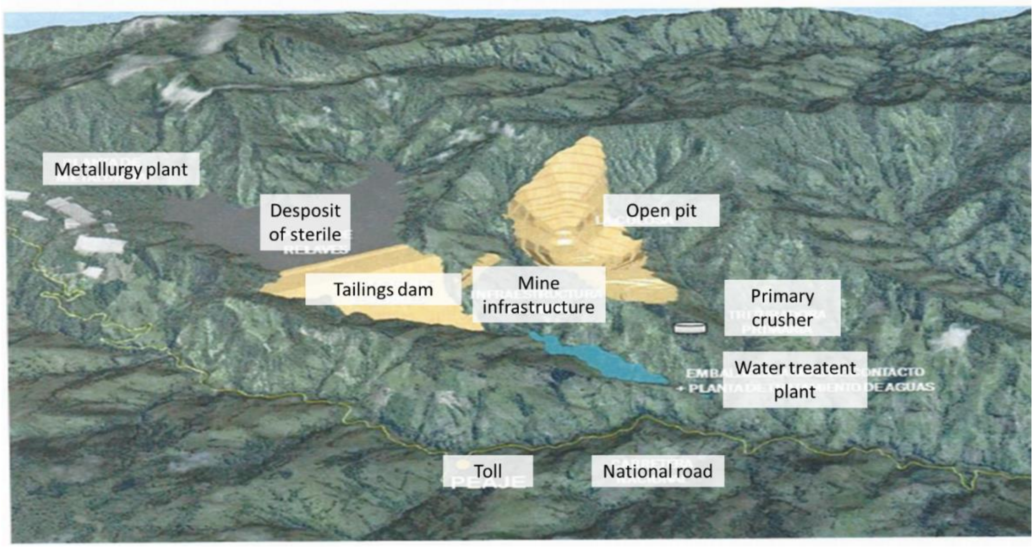
AGA claim has a large International Geotechnical & Tailings Review Panel with world-class experts established to ensure design, construction, operation, and closing use best-practice and technology. The TSF search uses a high-level selection of potential options. Initial filtering process to be followed by further refinement using Multiple Accounts Matrix (MAM), with Fifty-five potential TSF sites identified and placed in 23 groups; five groups selected for MAM assessment. One option points to placing the TSF outside Forest Reserve; The preferred sites must have a minimum total storage capacity of 1,420 Mt and a maximum embankment height of 250m.

Even in 2008, Robert Moran, a renowned hydrogeological expert in open-pit gold mining, expressed his concern about the location of a possible tailings dam in Cajamarca; due to its highly unstable seismology and topography, a breach could mean the risk of a toxic waste spill into the River Coello basin.

Water treatment plant

The contact water reservoir is located downstream of the sterile deposit; its function is to collect and store the waters that come into contact with the mined material in such a way as to avoid its release to the surface and underground currents. It is planned to have a water treatment plant to reuse some of this water in the industrial process and the rest to return pure to the environment. In the water treatment plant, the water is separated from the rock that no longer contains gold and is treated to the point that it remains in perfect environmental conditions. Then 60% is injected into the system, and 40% is released into the environment. This plant seeks to reduce the pressure on natural sources *(See annex 1 - Water use)*

Figure 23. Colosa Infrastructure Projection for year 2045



Source: AGA

- Metallurgy plant: Place where chemical processes are carried out to separate gold from mineralized rocks
- Deposit of sterile: Place where non-mineralized rocks (which do not contain enough gold but can be rich in sulfides, heavy metals, and other potentially harmful substances) are disposed of; they remain after the chemical process of separation of gold and rock
- Tailings dam: Structure composed of an artificial wall to retain tailings
- Mine infrastructure: Camps, offices, and other structures necessary for the development of the project
- Open-pit: Rock extraction site
- Water treatment plant: For the treatment of water that come into the process of chemical separation of gold and rock

The rock-crushing machines are typically located as close to the pit as possible. However, the tailing dam, the grinding machinery, the treatment plant, and the sterile Deposit can be located in different places. They may be a considerable distance from the pit, although transporting material for longer distances increases operational costs. All the operational steps require large areas of land. In addition, the methods of transport to move the material from one step to the next (be they roads, railway lines, conveyor belts, or slurry pipelines) also require significant areas.

The project at the pre-feasibility stage evaluated alternative mining methods, plant locations, and related infrastructure. Critical decisions related to ore transportation and the relocation of infrastructure facilities out of the forest reserve area have dramatically changed the definition of the project's direct and indirect area of influence and the scope of the environmental and social studies.

La Colosa planning clousure

According to AGA, closure planning is an activity that starts with the exploration and mine design stage and continues throughout the mine life; the plan is reviewed and updated every three years (annually in the final three years of a mine's life) or whenever significant changes are made. Consider operational conditions, planning, legislative requirements, international protocols, technological developments, and advances in practice.

Planning for closure is integral to the development and life of mine projects and AngloGold Ashanti's activities, as are estimations of associated liability costs and the assurance of adequate financial provisions to cover these costs. AngloGold Ashanti's total rehabilitation liability in Colombia for 2011 was $0.8m ($63.6m) for restoration purposes.

According to AGA, the mine closure consists of rehabilitating the areas where mining activities were carried out. Its objective is to return the operated areas to similar or better conditions than before starting the operations. The landscape, the water courses, and vegetation, are reinstated with the original territory.

Reclamation of mining zones historically has involved growing a few grass and herb species. Palmer et al, 2006 p.1 states:

> «Compared with unmined sites, reclaimed soils have higher bulk density, lower organic content, low water-infiltration rates, and low nutrient content. Decreased forest productivity may be related to surface material (e.g., brown versus gray

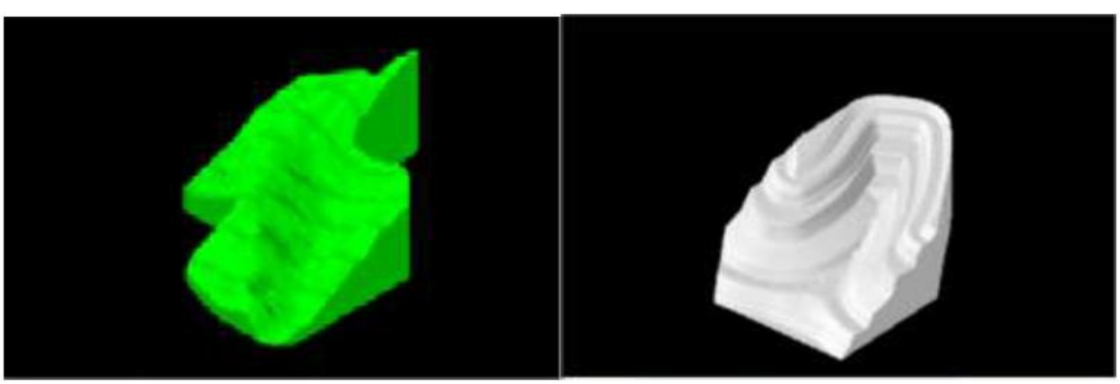
sandstone) used in the reclamation. In reclaimed forests, projected C sequestration after 60 years is only about 77% of that in undisturbed vegetation in the same region».

Because in mine recovery, the enclosing topography, vegetation, water composition, hydrology, and soils are radically altered from the initial state; significant potential Carbon storage is lost mainly because mined sites plant grassland, which sequesters much less; also mentioning that many reclaimed sites show little or no regrowth of endemic vegetation even after 15 years.

Impact projection

Due to the actual state of the project, the accurate magnitude of the project is unknown in terms of the amount of material to be excavated. Authors have carried out damage estimation works, elaborating a multi-temporal graphic representation referring to the time of the mine, generating projections like the destruction of the vegetal layer, emissions, and affectation of the aquifers, from which it is observed that:

- For the period from 0 to 5 years: At the end, the vegetal layer will not exist, and the emissions related to 3.2.2 will be presented. Furthermore, all the aquifers will be affected indistinctly, both the streams and the Vermellón River.
- In 5 to 10 years, aquifers' emissions and affectation will increase because it is the time of significant exploitation.
- Between the period of 10 to 15 years: The emissions given by the effect of exploitation and the destruction of the subsoil are constant and difficult to recover.



Source: Campos, 2014 p. 53.

La Colosa best practices

AngloGold Ashanti stated to be sensitive to the needs of local communities – specifically as these pertain to the security of the water supply and minimizing the environmental impact. Even in the project's early stages, part of the water required for the exploration phase has been drawn from rainfall and recycled by a system developed by the AngloGold Ashanti team on the ground.

Drill platforms are built from, rather than dug into, the mountain to further minimize the impact. The construction of eco trails and elevated drilling platforms were built to prevent and mitigate soil compaction.

Figure 24. Buadua bamboo elevated platforms

Source: *Tapia 2011, p. 15*

Aga environmental and social compensations

Based on the claim that the project will use a significant amount of water contaminating river systems, impacting the large-scale agriculture capability of the zone, an ***indigenous nursery*** has been set up, and certain species which were considered to be at risk have either been transplanted or are being propagated. A watershed reforestation program has been developed with communities around the project developed by students from some schools in Cajamarca. (see Fig 25)

In adition, AGA mentions that studies demonstrate that there would be no material impact on the project's agricultural or domestic use of water. The in-country team continues to work on broad awareness and education campaign to show the benefits of responsible mining while explaining how impacts are mitigated and compensated for to achieve a net positive impact.

Community: Total community investment by AngloGold Ashanti in Colombia was $1.2m in 2012 (2011: $1.2m).

Figure 25. AGA Social compensations

Certain species have been transplanted at the La Colosa nursery in Colombia to protect indigenous plant life

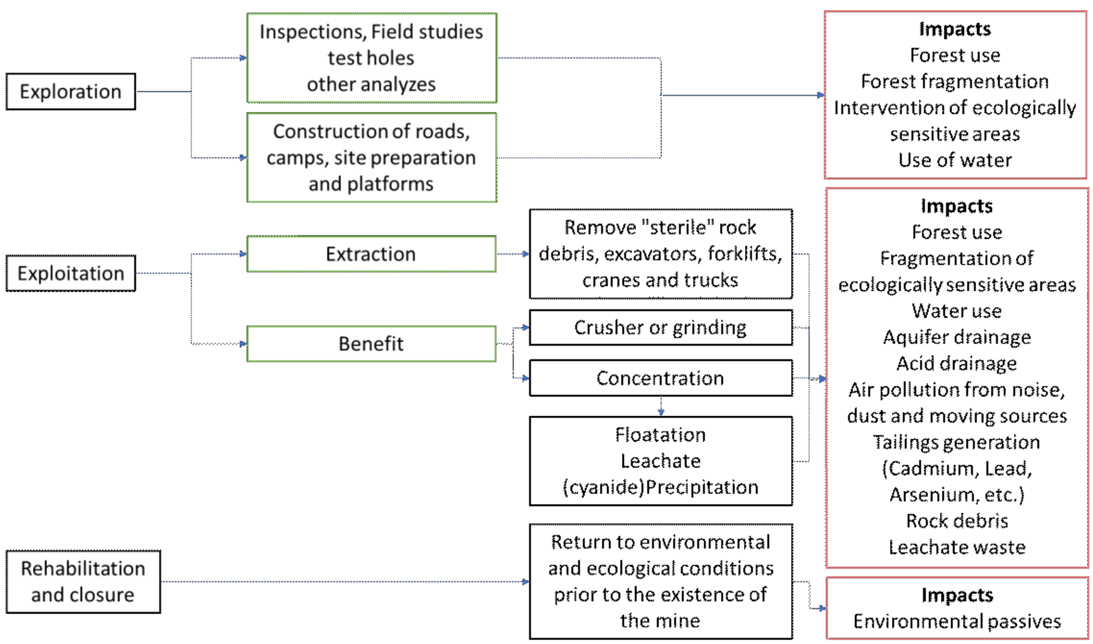
Source: *Tapia 2011, p. 9*

ENVIRONMENTAL IMPACTS

In this section, some threats to the La Colosa project will be presented due to the mining activity, such as contamination and water shortages, air and soil quality reduction, removal of tons of mountainous soils, and the generation of toxic mining waste (rock material and tailings), among others. Activities such as the volumes of pollutants used in the beneficiation process, the use of explosives (ANFO), and the generation of tailings waste are some factors that threaten human health and the ecosystems near the La Colosa mining project.

Additionally, the area's geological, hydrological, and physiographic characteristics are specific elements that must be considered when assessing the magnitude of impacts or damages.

Figure 26. Flowchart of Environmental impacts by phases of the project



Source: Arango 2014, edited from ELAW, 2010

Impacts on water resources

The water used by the La Colosa mine has been estimated by AGA at one cubic meter (1m3/s) for each ton of rock processed. This implies that 31.5 million cubic meters of water will be needed annually; if 60% of the water taken were recirculated, as AGA declares, the water footprint per gram of gold would be 464 liters. The company has claimed that the footprint would be more diminutive, but supporting technical analyses have yet to be presented; therefore there is great potential to provoke disputes with other downstream water users. The main rivers of the area, the Bermellón and the Coello, supply water to the populations of Cajamarca, Ibagué, Coello, Espinal, San Luís, and Chicoral, and to the rice growers of Tolima, from which 2,400 families directly benefit. (Colombia Solidarity campaign, 2011).

The most significant impact of a mining project is its effects on water quality and the availability of water resources within the project area. Key questions are whether surface and groundwater supplies will remain fit for human consumption and whether the quality of surface waters in the project area will remain adequate to support native aquatic life and terrestrial wildlife. (ELAW 2010, p. 21). “Many studies show that when more than 5 to 10% of a watershed’s area is affected by anthropogenic activities, stream biodiversity and water quality suffer”. (Palmer, 2010, p.1)

Acid mine drainage and contaminant leaching

When mined materials, such as the walls of open pits, tailings, and waste rock, are excavated and exposed to oxygen and water, acid can form if iron sulfide minerals are abundant and there is an insufficient amount of neutralizing material to balance the acid formation. The acid will dissolve metals and other contaminants from mined materials and form an acidic solution high in sulfate and metal-rich, including elevated concentrations of cadmium, copper, lead, zinc, and arsenic.

Table 1. Reference values of heavy metals and metalloids typical of Acid Mine Drainage

Element	Reference value	Health affectation
Copper	2 mg/l	Acute gastrointestinal effects
Chrome	0,05 mg/l	Carcinogenicity and genotoxicity
Arsenic	0,01 mg/l	Carcinogenic
Cadmium	0,03 mg/l	Kidney damage
Lead	0,01 mg/l	Central and peripheral nervous system. Cumulative in bones.

Nickel	0,07 mg/l	Carcinogenic
Zinc	0,03 mg/l	Phytotoxic

Acid drainage and contaminant leaching are the most relevant threats to water contamination related to ore mining. A mine presenting acid mine drainage can have devastating long-term impacts on rivers, streams, and aquatic life-affecting fishes, animals, and plants. If uncontrolled, the acid mine drainage may run into streams or rivers or leach groundwater. Streams affected by acid mine drainage present a pH value of 4 or lower, similar to battery acid, when plants, animals, and fish are unlikely to survive in these conditions; likewise declines in stream biodiversity have been linked to the level of mining disturbance in watersheds.

> "We found that significant linear increases in the concentrations of metals, as well as decreases in multiple measures of biological health, were associated with increases in stream water as sulfates in streams below mined sites...sulfates pollution is known to persist long after mining ceases. Conductivity, and concentrations of SO4 and other pollutants associated with mine runoff, can directly cause environmental degradation, including disruption of water". (palmer, 2010. p.1)

Cyanide and other toxins used in the mining process

Handling chemicals in mining is one of the principal causes of water pollution. Among them, cyanide stands out due to the high volume required for the beneficiation processes and high toxicity.

The amount of chemical reagents used makes large-scale mining a risk for human and ecosystem health. Due to its toxicity, cyanide has been controversial for its use in large-scale mining projects worldwide (Moran, 1998). In humans, the lethal dose is 1-2 mg/kg; it should be noted that it is highly reactive to many chemical elements. Mining companies justify using cyanide, arguing that they are subscribers to the International Cyanide Management Code, including the AGA. However, companies attached to it have generated contamination problems due to cyanide spills and their release into water and soil. Nevertheless, as La Colosa is an exploration area, Colombia is not a signatory to the Cyanide Code.

Accidents in the past led to the Berlin Declaration in 2000, which calls for banning cyanide-based gold mining, indicating that even the use of technologies is not guaranteed the safe exploitation of gold mines. Likewise, mining companies tend to reduce safety expenses by shifting their activities to developing countries with weaker legislation and fewer environmental controls. The statement also indicates that benefits such as job creation are always short-term and have no long-term positive effects.

In conclusion, cyanide is the substance most used in benefitting large-scale gold mines, and given its high toxicity, some companies have signed a management code for it. However, this is not a guarantee of the non-occurrence of incidents, as spills negatively impact the environment (surface and groundwater) and human health.

Groundwater quality and availability

After analyzing the eventual impacts that the project may have on surface waters, it is essential to highlight the potential threats to groundwater. The water flow and the recharge of aquifers depend on the structure of soils and rocks since they are the materials where groundwater is stored; in the case of mining activity, they are removed and manipulated.

Even after mine-site reclamation (attempts to return a site to pre-mined conditions), groundwater samples from domestic supply wells have higher levels of mine-derived chemical constituents than well water from unmined areas. (Palmer et al. 2006)

Along with the effects mentioned above, the following indirect responses to the water resource can be additionally listed:

Table 2. Impact summary of Water Resources

Impact	**Impacts Summary**
Water Resources	Lost access to clean water
	Mine drainage and contaminant leaching
	Mine dewatering

	The need of 1m3/s to process each ton: High quantity of water to develop the project
	Mining affects surface and underground water resources in terms of quality and availability

Impacts of mining projects on air quality

One of the principal environmental impacts due to open-pit mining activity is air quality, mainly due to particulate material emissions. Although the project is still in the exploration stage, and there are no specific values from AGA to contrast the air quality of the area, the degree of pollution, and its permanence in the atmosphere, it is known that in any mining process, the exercise to obtain the mineral or metal involve the generation of contaminant elements.

The contaminant's main characteristics are structure and shape, concentration, chemical composition, and size; these particles are critical for causing health problems for the population and conditioning climate change.

Furthermore, the estimation of carbon in soils of the Anaime and Chilí páramo reaffirms that the páramo ecosystem and the high Andean forests are strategic reservoirs of organic carbon in soils at a depth of one meter. Forest ecosystems contain more carbon per unit area than any other type of land use, and their soils are of primary importance when considering forest management. (FAO, 2022, quoted by EOT, PG 319).

Hydrogen cyanide

The use of cyanide for gold recovery not only has implications for water but there is also for the relationship with air quality. Hydrogen cyanide (HCN) is a highly volatile liquid, considered a weak acid, with a pKa value of 9.22 at 25 °C, soluble in water and alcohol (Simeonova, 2004, p. 6). Volatilization is one of the most significant cyanide attenuation mechanisms produced within tailings storage facilities (Smith & Mudder, 1991).

During the cyanide leaching stage, it is commonly used in the form of sodium cyanide (NaCN), which is a precursor to HCN in contact with acids or acid salts. To counteract this situation, Lötter (2005) describes that the first step in effectively controlling cyanide should be minimizing its consumption during leaching operations. To avoid risks, complete control of the tailings is required, mainly in the regulation of the pH, in order to avoid the release of hydrogen cyanide.

It is estimated that the extraction of gold from low-grade minerals by cyanidation processes has resulted in the global emission of 20,000 tons of cyanide from hydrogen in the atmosphere (WHO, 2004, p. 10).

Table 3. Impact summary on Air quality

Impact	Impacts Summary
Air quality	Mobile sources
	Stationary sources
	Fugitive emissions
	CO2 emitted by machines
	Hydrogen cyanide

Impacts of mining projects on soil quality

Contamination of soils can be experienced in two ways: contaminated soil derived from windblown particles and soils contaminated from chemical discharges and sewage. Both forms of direct contamination can be harmful and reach rapid and long distances.

According to a study commissioned by the European Union:

> «Mining operations routinely modify the surrounding landscape by exposing previously undisturbed earthen materials. Erosion of exposed soils, extracted mineral ores, tailings, and fine material in waste rock piles can result in substantial sediment loading to surface waters and drainage ways. In addition, spills and leaks of hazardous materials and the deposition of contaminated windblown dust can lead to soil contamination».

Release of mercury

Mercury is commonly present in gold ore. Although concentrations vary substantially, mercury is found in gold ore and associated waste materials, even within a specific ore deposit. Suppose the mercury content in gold ore is 10 mg/, and one million tons of ore is processed at a particular mine (not unusual concentrations). In that case, 10 tons of mercury are potentially released into the environment. This is a significant source of mercury and should be controlled. In the process of gold recovery, mercury must also be reclaimed and collected. If not collected by air pollution control devices, this mercury could be released into the atmosphere and impact the environment and public health. (ELAW 2010, p. 27)

Table 4. Impact summary of Soil quality

Impact	Impacts Summary
Soil quality	Mine accidents (mercury spills)
	The blasting of a gram of gold would be 910 Kg of Anfo

Impacts of mining projects on wildlife

Wildlife is a large term that refers to all plants and animals or living organisms that are not domesticated. Mining affects the environment and associated biota by removing vegetation and topsoil, displacing fauna, releasing pollutants, and generating noise. A threatening case is the release of contaminants into freshwater food networks, as in the case of Selenium [Se] bioaccumulation to four times the toxic level; this can cause teratogenic deformations in larval fish, leaving fishes with Selenium concentrations beyond the threshold for reproductive failure (4 ppm), and bare birds to reproductive failure when they consume fishes with Se >7 ppm. Land animals may be exposed to concentrations higher than in the water since considerable animals feed on riverbed algae that can bioconcentrate [Se] as much as 800 to 2000 times that in water concentrations.

In some freshwater food webs, Selenium [Se] has bioaccumulated to four times the toxic level; this can cause teratogenic deformities in larval fish, leaving fishes with Selenium concentrations above the threshold for reproductive failure (4 ppm), and expose birds to reproductive failure when they eat fishes with Se >7 ppm (19, 20). Biota may be exposed to concentrations higher than in the water since many feeds on streambed algae that can bioconcentrate Se as much as 800 to 2000 times that in water concentrations

Noise and Vibration

Noise pollution associated with mining may include noise from vehicle engines, loading and unloading rock into steel dumpers, chutes, power generation, and other sources. Cumulative impacts of shoveling, ripping, drilling, blasting, transport, crushing, grinding, and stock-piling can significantly affect wildlife and nearby residents. Vibrations are associated with many types of equipment used in mining operations, but blasting is considered the primary source (ELAW 2010, p. 27).

Vibration has affected the stability of infrastructures, buildings, and homes of people living near large-scale open-pit mining operations, according to a study commissioned by the European Union in 2000

Habitat loss

The impacts on habitat arise primarily from modifying, removing, and reorganizing the land surface. Some effects are short-term and bonded to the mine site; others may be long-term effects with vast distances. Wildlife species coexist in communities that interact with each other, and the durability can depend on habitat structure, climate, altitude, and soil conditions.

The most direct effect on wildlife is the destruction or movement of land in the exploring phase, excavating, and piling of mine wastes, causing the expulsion of species in the zone. Predators, migratory species, and birds can conveniently leave these areas, but more settled animals like small mammals, insects, reptiles, and burrowing animals might be the most affected species. Many species can be rigorous on vegetation growing in specific areas; vegetation provides the essential food, home places, and cover to escape predators and nesting sites. So once removed, the species can experience the threat.

The habitat requirements of many animal species do not permit them to adjust to changes created by land disturbance. These changes reduce living space. The degree to which animals tolerate human competition for space varies. Some species tolerate very little disturbance. A species could be eliminated when critical habitat is restricted, such as a lake, pond, or primary breeding area. (ELAW 2010, p. 28)

Table 5. Impact summary of Wildlife effect

Impact	Impacts Summary
Wildlife	Habitat loss
	Habitat fragmentation
	Noise and vibration

Impacts of mining projects on social values

The social impacts of mining projects can be questionable and complex. The arrival of a mining project can create revenues, but it can also cause considerable social disruption. Mining projects, socially speaking, generate jobs, increase goods and services, and create roads, schools, and infrastructure, but the benefits and compensation may be unevenly shared. Mining projects can point to social pressure and violent conflict if communities feel affected or inadequately compensated. By 2011 the company projected a generation of 550 jobs, including contractors, so it is still being determined how many people from the area will be employed from these 550.

Other possible impacts are related to the potential increase in social issues such as crime, prostitution, drug, and arms trafficking, robberies, and AIDS; these possible effects are considered characteristic problems around mining activities worldwide, Constituting a concern not only for social and political organizations but also for institutional subjects on the local scale. The increase in the cost of living in urban and rural areas has been another of the problems that mining has brought with it. In addition, the decrease in skilled peasant labor.

In the wake of peace negotiations between the Government and insurgent (guerrilla) groups, security incidents in the area have increased. This has resulted in some incidents that have affected the company's and its suppliers' assets (storage facilities, vehicles). However, the armed forces have established a joint plan and procedures to prevent such incidents and mitigate any impact. (AGA Project profile La Colosa, Colombia, 2012)

When mining activities are not appropriately managed, the result is the degradation of forests, biodiversity, water, soils, and for instance, critical to people's subsistence. Defenders of mining projects must ensure that the fundamental rights of individuals and communities affected directly or indirectly are maintained and not infringed upon. These rights include the right to clean water, air, and soil, control and use of land, and the right to livelihood. Communities can feel notably vulnerable when mining impacts people's sustenance and livelihood, and multinationals and governments can underestimate or even ignore these impacts on social values, as in the case of the actual project La Colosa.

Human displacement and resettlement

During the year 2012, resettlements took place at La Colosa. AGA began negotiations with families in 2009 and is resettling families from the Diamante zone; by 2012, 30 of 35 families were resettled, Modifying the territorial ordering since the municipality has gone from having 42 villages to having 41. (Cardona, 2015) One of the biggest challenges lies in extending the project into new areas, as new infrastructure sites are being analyzed. (AGA Country fact sheet, 2012, P.2)

As pointed out by the International Institute for the Environment and Development (IIED):

> «The displacement of settled communities is a significant cause of resentment and conflict associated with large-scale mineral development. Entire communities may be uprooted and forced to shift elsewhere, often into purpose-built settlements not necessarily of their choosing. Besides losing their homes, communities may also lose their land and thus their livelihoods. Community institutions and power relations may also be disrupted. Displaced communities are often settled in areas without adequate resources or are left near the mine, where they may bear the brunt of pollution and

contamination. Forced resettlement can be particularly disastrous for indigenous communities who have strong cultural and spiritual ties to the lands of their ancestors and who may find it difficult to survive when these are broken». (ELAW, 2010)

Public health

Hendrix et al. 2009 examined specific forms of mortality in coal mining areas and found that chronic forms of heart, respiratory, and kidney disease, as well as lung cancer, remained elevated as the highest mortality rates are correlated to areas with the highest levels of mining activity. Elevated adjusted mortality occurred in males and females, suggesting that the effects were not due to occupational exposure, as almost all coal miners are men. The results of Hendrix regression analyses and other research suggest that poverty, low education level, smoking behavior, and environmental pollutants are among the factors that lead to higher mortality rates in coal mining areas. Higher mortality may also be due in part to conditions of elevated stress caused by economic disadvantage and environmental degradation.

Another case of direct and indirect contamination from mining was in the central Appalachian ecoregion of the United States when human health effects occurred from contact with streams and exposure to airborne toxins and dust. The state was informed and alarmed by excessive human consumption of selenium in fish from Mountaintop Mining impacted waters. Raised levels of airborne, hazardous dust have been documented around surface mining operations (Palmer et al., 2010, p. 1).

Table 6. Impact summary of Social values

Impact	**Impacts Summary**
Social values	Human displacement and resettlement
	Migration
	Public health
	Culture
	Aesthetic resources

Changes on the landscape

The destruction of the soil and the felling of forests causes the loss of the vegetal layer. It causes soil erosion, generating desertification processes with low possibilities of natural recovery and considerable changes in the landscape.

When the exploitation process begins, the first thing carried out by the mining companies is a cleaning of the vegetal cover of the area to intervene; this implies the loss of the biodiversity of fauna and flora present, as well as erosion, loss of fertile soil, and alteration of the processes of the orogeny, an increase of the geological risks due to the destabilizing effect of overloading, excavations or actions that affect the water table, the loss of physical properties, either in texture or in the edaphic structure. The project is supposed to dig huge craters with a diameter of up to 1 km and a depth of 600 meters, so it will be necessary to destroy the existing forest and remove the fertile soil to reach the rock that will later be dynamited, causing irreparable damage to the landscape.

AGA Mineral Resource and Ore Reserve Report, 2008

Tapia, 2011

Table 7. Impact summary of Landscape

Impact	Impacts Summary
Landscape	Excavation: huge craters with a diameter of up to 1 km and a depth of 600 meters
	Mining waste: tailings deposit
	Tailings dam

Biodiversity loss

The condition of biodiversity importance is related to a series of geo-climatic states, including three mountain ranges and extensive plains with a significant differential in humidity. This variety in physical conditions configured about 2 million years ago has allowed local adaptations of the diverse ecosystems that make up a large number of endemisms, as well as a complicated web of bio- and geochemical interactions that also lead to the high susceptibility of ecosystems, where a fragment of forest or Paramo can mean the disappearance of a unique ecosystem.

Furthermore, it is estimated that the existing forest can capture 5,470,000 tons of CO_2 per year, contributing to mitigating climate change and ensuring a national and global policy to control greenhouse gas emissions both nationally and globally.

Loses in Co2 capture

In the 515.75 Ha of possible mining exploration, a study commissioned by AGA has found 34 species of trees, more than ten species of mammals, 31 species of birds, 27 amphibians, and 24 reptiles. Many of these species are protected, including oak, wax palm, loggerhead palm, lichens, lamas, and orchids. Furthermore, it is estimated that the current forest can capture 5,470,000 tons of CO_2 annually, which benefits mitigating climate change and ensures a policy to control greenhouse gas emissions nationally and globally. *(La Colosa: En busqueda del dorado 2011, p. 25).* Mine-related contaminants persist in streams well below valley fills, forests are devastated, headwater streams are absent, and biodiversity is reduced.

Table 8. Impact summary of Biodiversity loss

Impact	Impacts Summary
Biodiversity	Biota
	Loses in Co2 capture

ECOLOGICAL PLANNING

When facing a large-scale project like La Colosa, it is essential to study the project from an approach that could help the planners and community analyze the problems and advantages of the region, landscape, and economic and social structure; this practice might be called *ecological planning*. This approach identifies how communities are affected by sequence reactions and presents options for the future base on impacts.

Ecological planning method

It is defined as the complete examination of biophysical and sociocultural information about the locality to suggest opportunities and constraints for decision-making about the correct landscape use. As Ian McHarg has repeatedly summarized in his writings and many public presentations, «The method defines the best areas for potential land use at the convergence of all or most of the factors deemed propitious for the use in the absence of all or most dangerous conditions. Areas meeting this standard are deemed intrinsically suitable for the land use under consideration». This concept can be reinterpreted as having clear opportunities and constraints for any particular land use as a survey will reveal the fittest locations and processes.

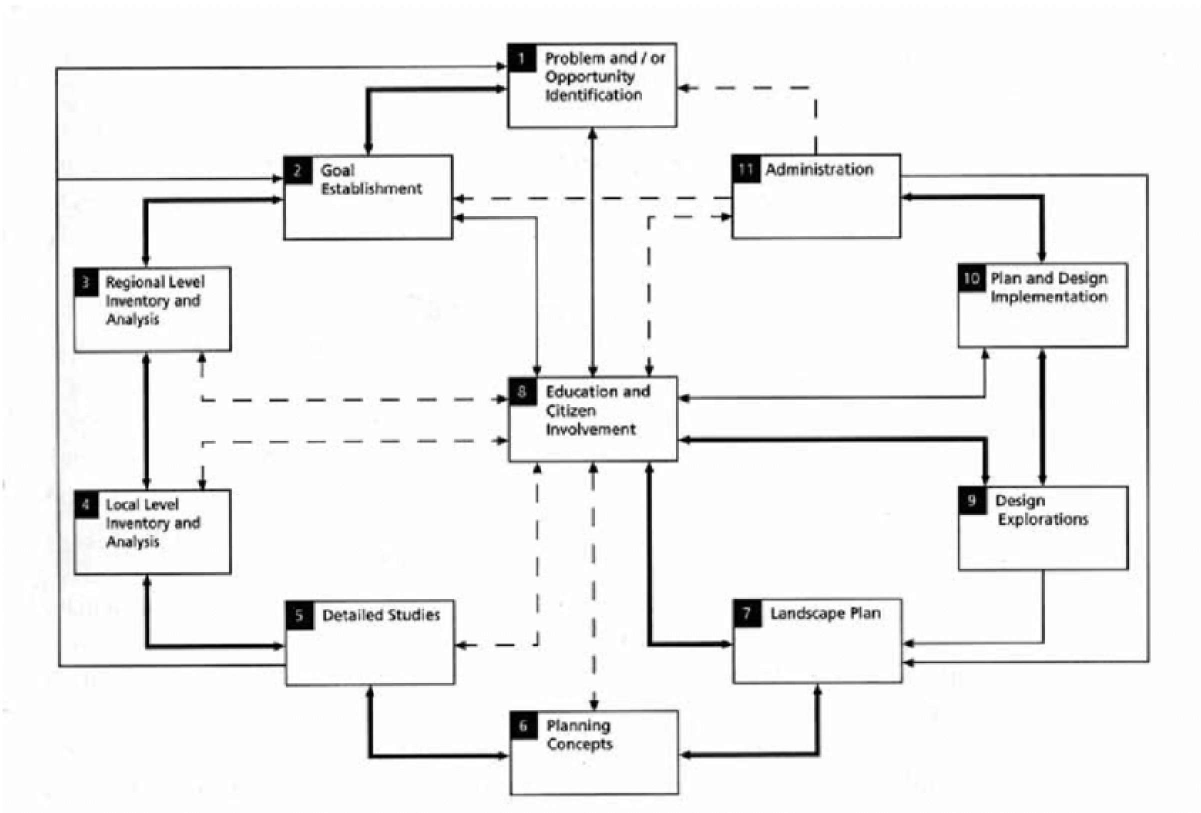
Ecological planning is fundamental for sustainable development. The World Commission promulgated the best-known definition of sustainable development on Environment and Development (WCED), known as the Bruntland Commission, as that which «meets the needs of the present without compromising the ability of future generations to meet their own needs». (WCED, 1987).

Many authors have made conventional prototypes and variations of Ecological Planning models. Each step in the model contributes to a final plan, which may result from a whole chain interacting process; in any case, material and information may be collected from each stage. Image 27 presents the model of ecological planning by Frederick Steiner, which was designed and adapted by different authors.

> «The approach to ecological planning developed by Ian McHarg at the University of Pennsylvania differs slightly from the one presented here. The Pennsylvania, or

McHarg, the model places a greater emphasis on inventory, analysis, and synthesis. This one places more emphasis on the establishment of goals, implementation, administration, and public participation yet does attempt to do so in an ecologically sound manner». (Steiner, 2000, p. 11)

Figure 27. Ecological planning model by Frederick Steiner



Source: Steiner, 2000, p.11.

Passages from 1 to 4 will be done for the actual study case. In Step 1, issues and opportunities for individuals or the area's conditions are identified. Consequently, step 2 established a Goal, and Steps 3 and 4, biophysical and sociocultural processes are managed by their inventories and analyses first at a more significant level, such as regional unit government, and second at a more specific level.

STEP 1: Identification of Planning Problems and Opportunities in La Colosa

Landscape planning handles the issues that affect the interrelationship between people and ecological processes where problems and opportunities in society drive specific cases. Human civilizations confront many environmental, social, political, and economic difficulties and possibilities as several issues involving land-use conflicts have arisen in recent years. The biggest challenge is accommodating the new growth while protecting the natural resources that attract people to this place.

In the development of the exploration stage of La Colosa mining project, environmental protection groups were conformed to develop a figure that demanded transparency in the project details and to evaluate potential impacts after opening the region to mining activities. Future environmental problems and irreversible social impacts were identified, such as the increase in the migrant population, damage and contamination of water resources, transformation in land use, the deficit of the municipality's agricultural capacity, which sets food security at risk, and alteration in the biophysical system is the exploitation of the open-pit mine starts its activities. These are the same problems that are being debated today and generate a conflict of interest, placing the integrity of communities at risk affecting the fauna, flora, and a massive ecosystem, on the other hand, rejecting a proposal that promises the reactivation of the Colombian economy due to the stimulation of resources due to foreign investment.

STEP 2: Goal Stablishment

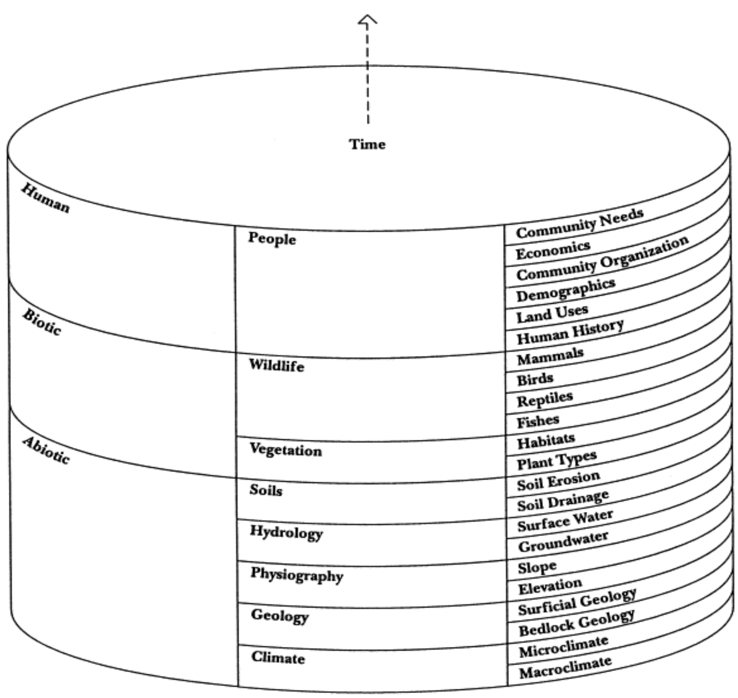
Make a description of the ecosystem's current situation through indicators to compare the current state of the territory versus once the mine operates to report the possible transformation of the territory.

STEP 3 and 4: Landscape Analysis, Local Level

The method deals with three scale levels: Region, locality, and specific site. One level involves interconnected scale levels. The use of different scales is compatible with the notion of levels of organization used by ecologists. According to this vision, each level of organization has distinctive features. The local level examines the processes that occur in a particular planning area. The main objective of this analysis is to gain knowledge about natural processes and human actions; such processes can be viewed as elements that compound a whole system. One of McHarg's fundamental idea is: Nature is a process consisting of physiography, hydrology, drainage, climate, soil, vegetation, wildlife habitat, and land use (Steiner, 2006, p.xiv). This system is valuable for analysis because it aggregates specific information into general groupings.

Ian McHarg and his collaborators have developed a layer-cake model (see Figure 28) that provides a central group of biophysical elements for the inventory of a place. Categories include the earth, the surface terrain, groundwater, surface water, soils, climate, vegetation, wildlife, and people (see table 9). These sciences provide a "layer cake" of data about a region, leading to a mapping overlay exercise to determine opportunities and constraints for development.

Figure 28. Layer cake model



Source: Steiner, 2000 Adapted from Ian McHarg 1997

Table 9. Baseline of natural resource data necessary for ecological planning

Baseline Natural Resource *Data necessary for ecological planning*	
**The region under study determined the relevant factors for La Colosa region*	
Climate	Temperature, Humidity, Precipitation, Wind,
Geology	Rock, ages, formations, properties, seismic activity, rock slides, mud slides
Groundwater hydrology	Water quantity and quality, water table, aquifer
Physiography	Slopes, aspect, digital terrain models
Surficial hydrology	Rivers, streams, stream orders, density, discharges, floodplains
Soils	Soils series, properties, depth to bedrock
Vegetation	Communities, species, distribution, age and conditions, visual quality, species number, rare and endangered species
Wildlife	Habitats, animal population, rare and endangered species
Human	Ethnographic history, settlement patterns, existing land use, existing infrastructure, economic activities, population characteristics

Source: Adapted from McHarg, 1997

Biophysical diagnosis of the territory of the municipality of cajamarca, tolima.

The territory's biophysical structure comprises the geomorphology, ecosystems, hydrology, soils, biodiversity, protected areas, socio-natural threats, and climate variability of an area. The characteristics of these elements should promote, condition, or restrict municipal land use.

Abiotic factors

They are the set of climatic variables, such as precipitation, temperature, and evapotranspiration, concerning other physical factors such as physiography, geology, soil types, and water resources; they constitute the support for the development and maintenance of the biodiversity and the provision of ecosystem services in the municipality.

Climate

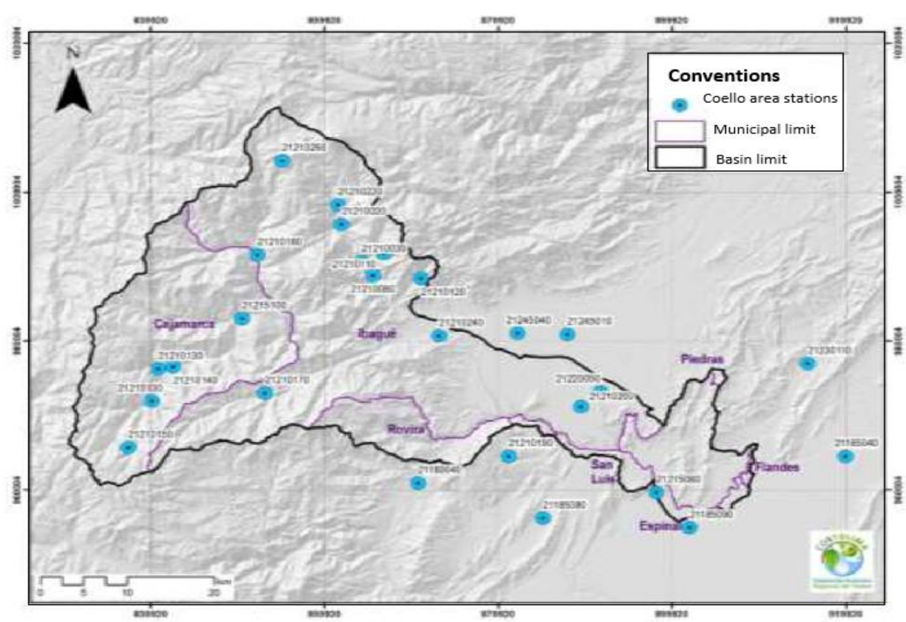
The figure below shows the Pluviometer's location and weather stations with influence in the study area, all operated by the Institute of Hydrology, Meteorology and Environmental Studies (IDEAM). The stations within the basin region are 26, of which five are located within the Cajamarca region, (See table 10) allowing accurate rainfall behavior values for proposed studies (CORTOLIMA, 2019, p.21).

Table 10. Inventory, characterization and geographic location of the climatic stations present in the municipality of Cajamarca - Tolima.

CODE	NAME	ELEVATION	CATEGORY	COORDINATES	
				LATITUDE	LONGITUDE
21210130	Las delicias	2070	Rainfall -pm	4.38033	-75.51175
21210140	El plan	2050	Rainfall -pm	4.383	-75.496
21210150	La cascada	3080	Rainfall -pm	4.28429	-75.54233
21215130	Cucuana	2120	Ordinary climatological - co	4.341	-75.518
21215100	Cajamarca	1920	Ordinary climatological - co	4.4415	-75.42458

Source: EOT, 2022, p.73

Figure 22. Geographic location of stations in the Coello basin



Source: Gestión Integral de Recurso Hídrico, GIRH – CORTOLIMA, 2019.

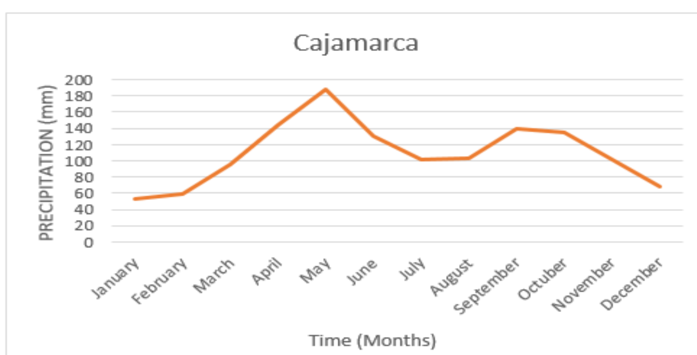
Pr***ecipitation***

The knowledge of the spatial allocation of precipitation in an area is fundamental for understanding precipitation regimes and categorizing areas based on the similarity between adjacent pluviometer stations. This can provide a first approximation to dividing geographic space into zones with similar agroecological patterns. For the characterization of precipitation, the analysis unit is constituted by the previous 26 mentioned stations to obtain rainfall values within the area to be analyzed; a selection of stations is made based on the Thiesen polygons criterion. The Thiessen polygons define the geometric affinity zones to the pluviometer stations, where a series of points delimit the influence areas.

> « The stations register periods of rain that begin to increase in February until reaching the maximum values in May; from May, it begins to descend again until July, where the lowest values of annual precipitation are presented, coinciding with the period of less rain in the area. As of August, the precipitation begins its ascent until it reaches its maximum value in October. The highest rainfall values are observed in the entire Hydrographic Subzone and throughout the year, showing a well-marked bimodal behavior». (CORTOLIMA, 2019). (See Figure 25)

Figure 25. Annual precipitation registered in Cajamarca weather station

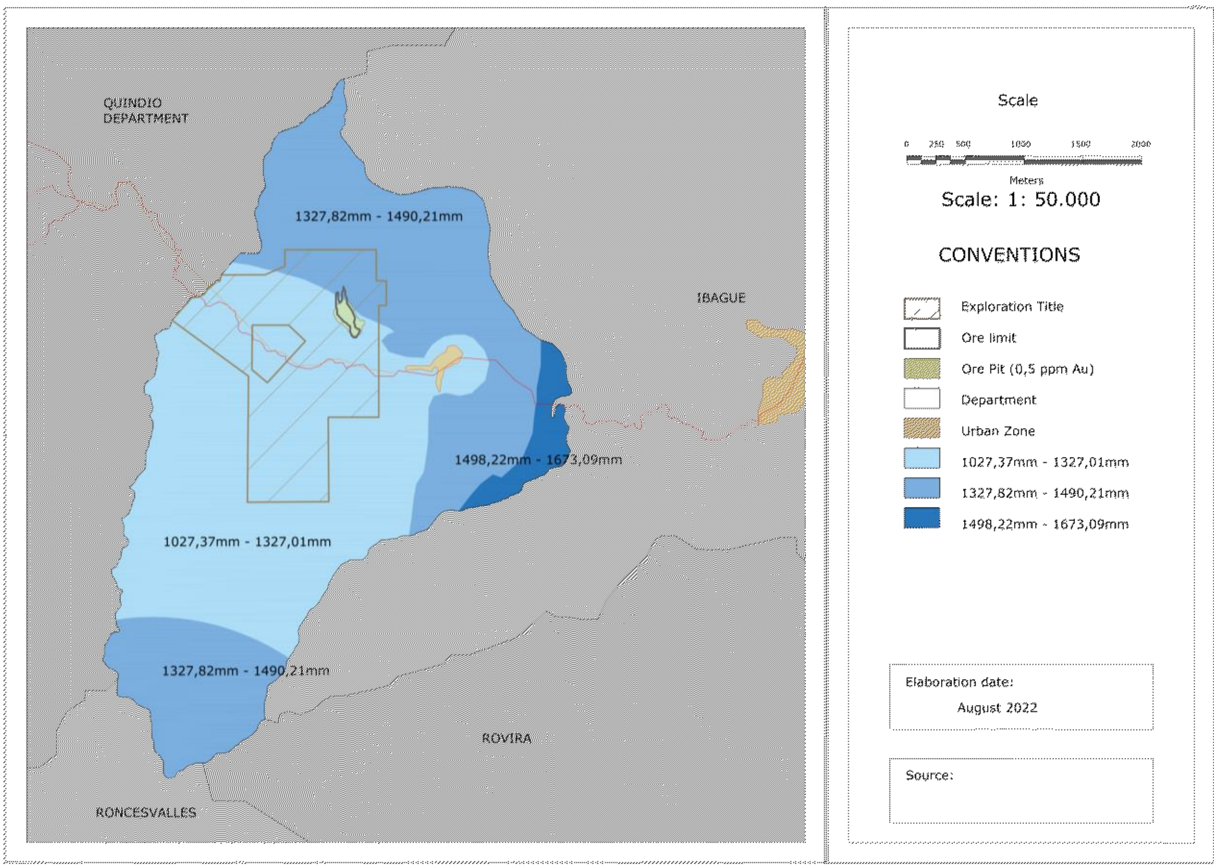
Month	Cajamarca
January	52.86
February	58.49
March	95
April	144.15
May	187.93
June	130.57
July	101.36
August	103.1
September	139.02
Octuber	135.21
November	101.44
December	68.56
Annual	1317.71
Media	109.81



Source: EOT 2000, p. 30, CORTOLIMA, 2019

The figure presents the spatial distribution of the average total annual precipitation (Isohyets) for the period 1987-2016 (29 years) in the Coello River Hydrographic Subzone, highlighting significant variability in the behavior of rain, with precipitation values that range between 2170.85 mm to 1027.37 mm. The previous image highlights that the project is located in an area with rainfall ranging from 1300-1400 mm per year.

Figure 26. Spatial distribution of the average total annual precipitation (Isohyets), for the period 1987-2016, in the Hydrographic Subzone of the Coello River



Temperature

For the five (5) weather stations in the Municipality of Cajamarca during the period in question (1985 - 2016), the temperature behavior in the municipal territory was analyzed.

According to the analysis, the municipality of Cajamarca reaches a multiannual annual average temperature of 15.85 °C

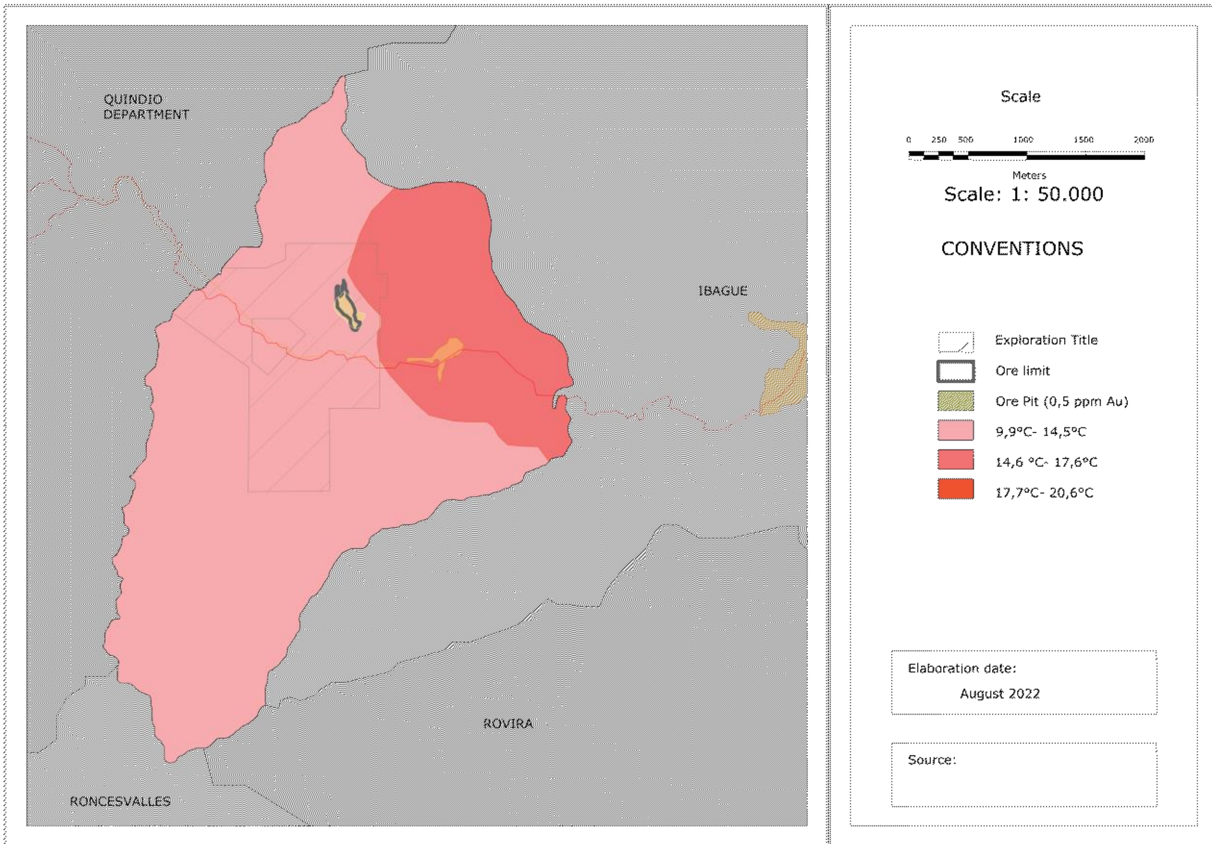
> «In Colombia, the surface temperature of the air is strongly conditioned by the height above sea level. "The temperature for the municipality of Cajamarca is variable. In the lower altitude sites, around 1500 m.s.n.m, approximate values are marked at 21 °C; in the medium height sites, that is 3600 m.s.n.m up to 6 °C, and in the highest peaks of the municipal topography that reach 3800 m.s.n.m. values less than six °C. The average temperature for the municipality is 13.2 °C». (Arango, 2014; EOT 2000)

Figure 23. Mean annual temperature by meters above the sea level in C°

M.A.S.L	1500	1800	1920	2100	2400	2700	3000	3300	3600
January.	21.5	19.2	18.3	17.0	14.8	12.5	10.3	8.1	5.8
February.	21.6	19.4	18.5	17.1	14.9	12.7	10.4	8.2	6.0
March.	21.8	19.5	18.6	17.3	15.1	12.8	10.6	8.4	6.1
April.	21.6	19.4	18.5	17.2	14.9	12.7	10.5	8.2	6.0
May.	21.6	19.3	18.4	17.1	14.9	12.6	10.4	8.2	5.9
June.	21.5	19.2	18.3	17.0	14.8	12.5	10.3	8.1	5.8
July.	21.4	19.2	18.3	16.9	14.7	12.5	10.2	8.0	5.8
August.	21.6	19.3	18.5	17.1	14.9	12.7	10.4	8.2	6.0
September.	21.6	19.4	18.5	17.2	14.9	12.7	10.5	8.2	6.0
October.	21.2	18.9	18.0	16.7	14.5	12.2	10.0	7.8	5.5
Noviembre.	21.2	19.0	18.1	16.8	14.5	12.3	10.1	7.8	5.6
December.	21.2	19.0	18.1	16.8	14.5	12.3	10.1	7.8	5.6
Annual.	**21.5**	**19.2**	**18.3**	**17.0**	**14.8**	**12.5**	**10.3**	**8.1**	**5.9**

Source: EOT, 2000, p. 28

Figure 24. Spatial distribution of the mean annual temperature (Isotherms), for the period 1985- 2016 in the Coello River Hydrographic Subzone.



The previous figure represents the general behavior of annual temperature since the maximum and minimum temperature values do not present significant differences throughout the year concerning the annual average, with variations of less than two centigrades (2°C).

It is observed that in the period of analysis (30 years), the most considerable Temperatures are mainly distributed in two periods (bimodal), the first summer season from January to April and the second from July to September. While those with lower temperatures correspond to November and December, linking the temperature variation to the occurrence of the two wet periods and the two dry periods.

Weather classification

A climate classification system mainly identifies areas with similar climates depending on the value of specific indicators that represent the magnitude of the climate to be characterized, using parameters such as precipitation and temperature. The Caldas-Lang unified system defines 25 climatic units; the methodology complements the Caldas relationship, which establishes the temperature values concerning altitudinal variation (height above sea level), with the Lang index, which establishes the classification ranges of the relationship between precipitation and temperature. In other words, the Caldas-Lang Climate Classification system relates height (m.s.n.m.), temperature (°C), and Lang's coefficient (P/T ratio). Table 11 shows the ranges and climatic types of the Caldas-Lang classification evidenced in the basin area.

Figure 29. Spatial distribution of the mean annual temperature (Isotherms), for the period 1985-2016, in the Coello River Hydrographic Subzone.

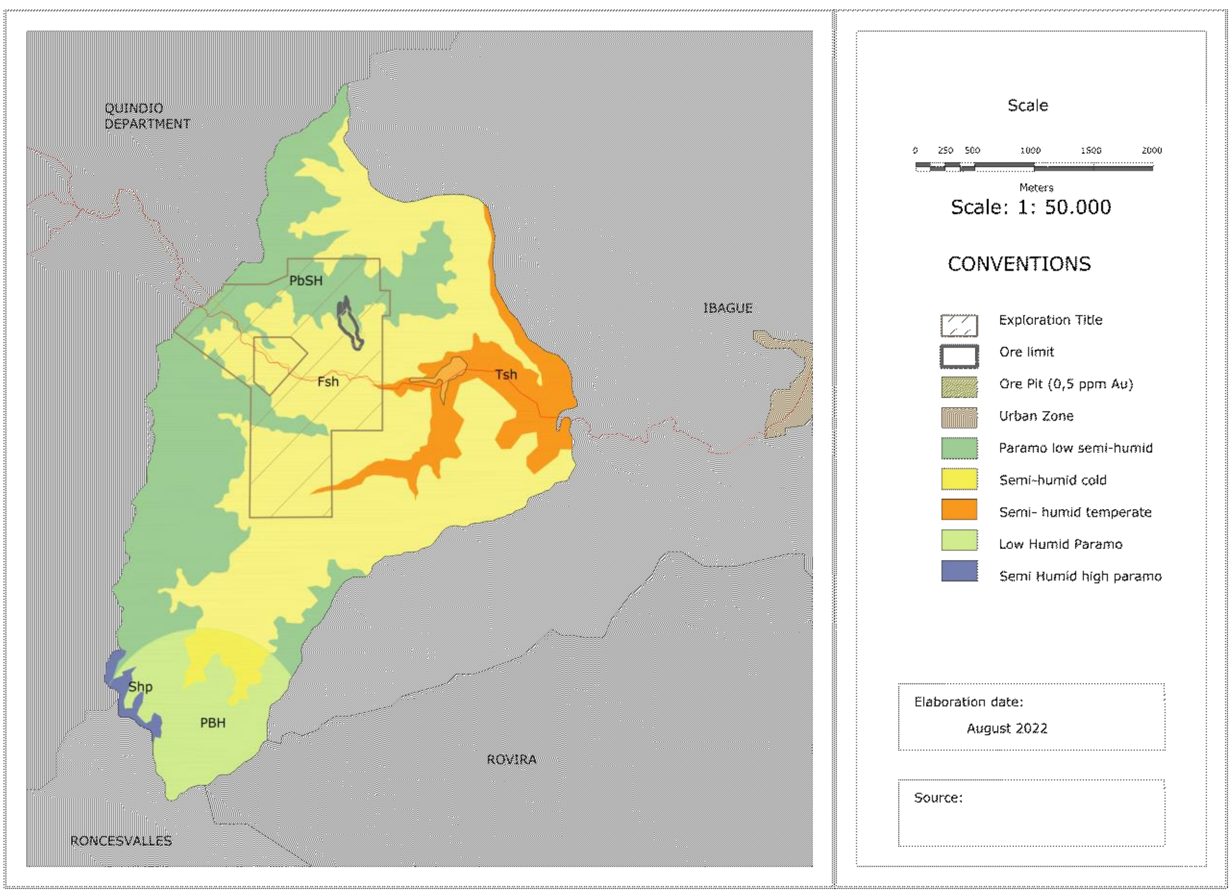


Table 11. Weather Caldas-Land classification in the Coello River Subzone

Weather classification		**Characteristics**
Semi-humid cold	Fsh	It includes heights between 2,000 and 3,000 meters above sea level, temperatures between 12 and 17.5 °C, and a P/T ratio between 60 and 100; it corresponds to the largest climatic province (37,608,032 hectares). The most predominant crops are corn, vegetables, beans, peas, and pastures dedicated to Norman, Holstein, and Native livestock. Representing 48,7 % of the total area.
Low semi-humid Páramo	PbSH	Includes a height between 3,200 and 3,700 m.a.s.l., temperature between 7 and 12°C, and a P/T ratio greater than 160. Its plant cover is made up of Páramo vegetation, including rocky outcrops and land wasteland, natural forest, and natural pasture, which is dedicated partly to grazing Norman and Holstein cattle. Representing 31,8% of the total area.
Semi-humid Temperate	Tsh	With heights between 1,000 and 2,000 meters above sea level, temperatures between 17.5 and 24 °C, and a P/T ratio between 60 and 100, coffee, corn, banana, plantain, and fruit crops are observed. Such as guava, mango, sapote, orange, lemon, and guamo. Representing 7,9% of the total area.
Low Humid Páramo	PBH	Corresponds to heights between 3,200 and 3,700 m.a.s.l., temperature between 7 and 12°C, and a P/T ratio between 100 and 160. The characteristics are very similar to those of High Páramo, with the difference there is already an economic activity of potato crops and livestock. In this area, there are tree species, such as the wax palm, and exotics, such as pines and eucalyptus.

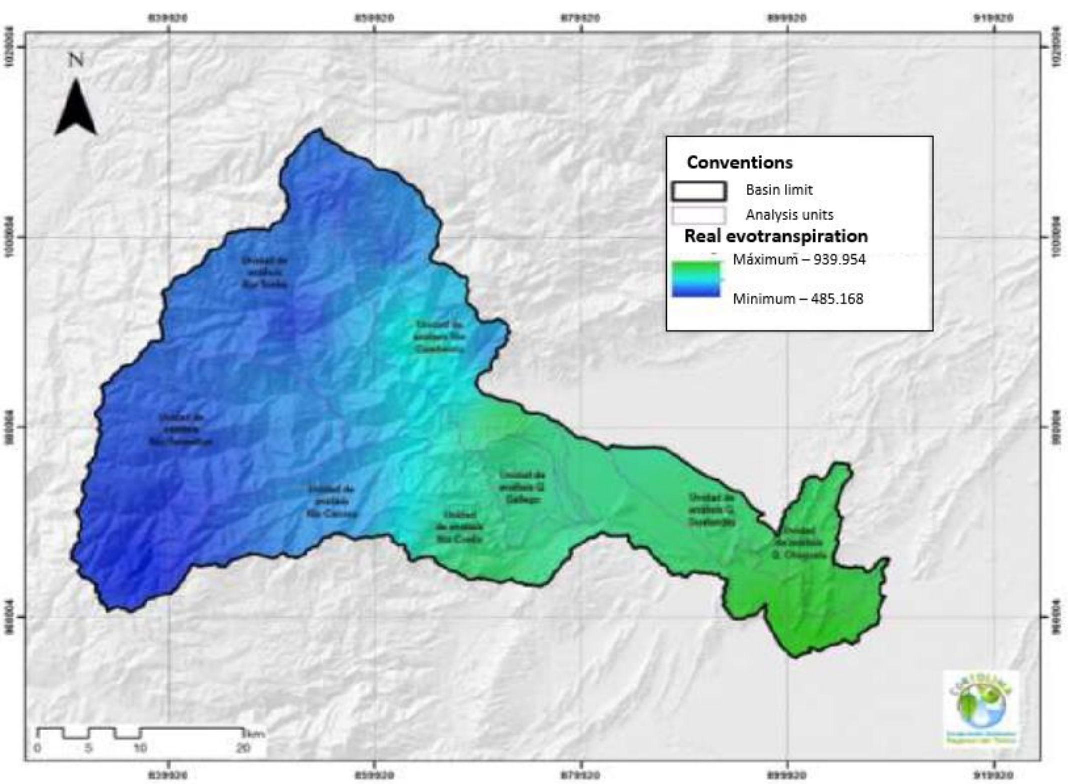
Source: CORTOLIMA, 2019, p.109

Evapotranspiration

Evapotranspiration is one of the essential components of the water balance. It represents the amount of water the system releases to the atmosphere in the form of water vapor through a combination of physical evaporation and vegetation transpiration. Evapotranspiration depends mainly on climatic conditions, which at the same time are a function of the physical properties of the ground-level atmosphere and vegetation, as well as the water quality and the water table's area.

> «In general, it can be deduced that evapotranspiration increases as going down in height and vice versa. ETP values of 598.7 mm per year are estimated in the Río Bermellón and Río Toche Analysis Units, situated at 1,379 m.a.s.l. to 4,970 m.a.s.l. In the lower part of the Subzone, Hydrographic values of 1897.3 mm per year are estimated in the analysis unit of Chaguala, which ranges from 1066 meters above sea level to 255 meters above sea level». (CORTOLIMA, 2019)

Figure 30. Spatial distribution of real evapotranspiration (ETR), period 1985-2016, in the Coello River Hydrographic Subzone



Source: Gestión Integral de Recurso Hídrico [GIRH], (CORTOLIMA, 2019, p.82)

Geology

According to studies of the geological units that constitute the territory of the area of influence of the Colosa exploitation polygons, the geological sequence stands starting from the oldest units to the most recent, grouping them by geological periods.

Table 11. Stratigraphic Units in La Colosa Zone

Stratigraphic units	**Characteristics**
Paleozoic (Cajamarca-Pzen Group)	The Paleozoic geological unit is made up of metamorphic rocks. This group represents 84.80% of the subsoil of the Colosa area of influence, partially covered by Quaternary units such as Pyroclasts and glacial and fluvial volcanic deposits. These rocks do not contribute significantly to soil formation since they are covered by thick layers of pyroclasts or have shallow weathering levels.
Cenozoic	Geological units formed by sedimentary rocks of continental origin.
Neogene	These bodies are in the form of Stocks and small volcanic necks outcrop in 3.15% of the area of influence of La Colosa. They are characterized by presenting aphanitic and porphyritic textures with variable compositions of Andesites and Dacites. Some of these bodies observe intense fracturing and faulting due to recent tectonic activity.
Quaternary	It is the last of the significant geological periods. It develops in the Cenozoic after the Neogene.
Quaternary (Morrhenic Deposits-Qm)	It is present in 10.56% of the area of influence of La Colosa, in some sectors of Los Alpes, La Luisa, La Paloma, Cristales, El Diamante, La Bolívar and Altamira. These materials have gently undulating surfaces, forming abrupt scarps in their terminal areas. The area adjacent to the Nevado del Tolima has a glacial model

Quaternary (Alluvial deposits-Qal)	They include the recent non-consolidated sediments transported as material dragged by the current of the Vermillion River; It represents 0.23% of the area of influence of La Colosa in the villages of Los Alpes, La Luisa, and La Paloma.

Source: Arango, 2014; Cortolima, 2021

Hydrography

For the Coello River Hydrographic Basin Planning and Management (Resolution 4532 of 2019), the hydrological element should be one of the main pillars in land planning since water resource is a decisive factor in the development of social and economic activities, as well as various systems immersed in a given territory. Eight hydrographic units comprise the Coello River's hydrographic subzone, and each contributes to the region's water supply and downstream area. Each of these rivers includes rural and urban areas with various water uses, including a domestic, agricultural, aqueduct, recreational, and industrial.

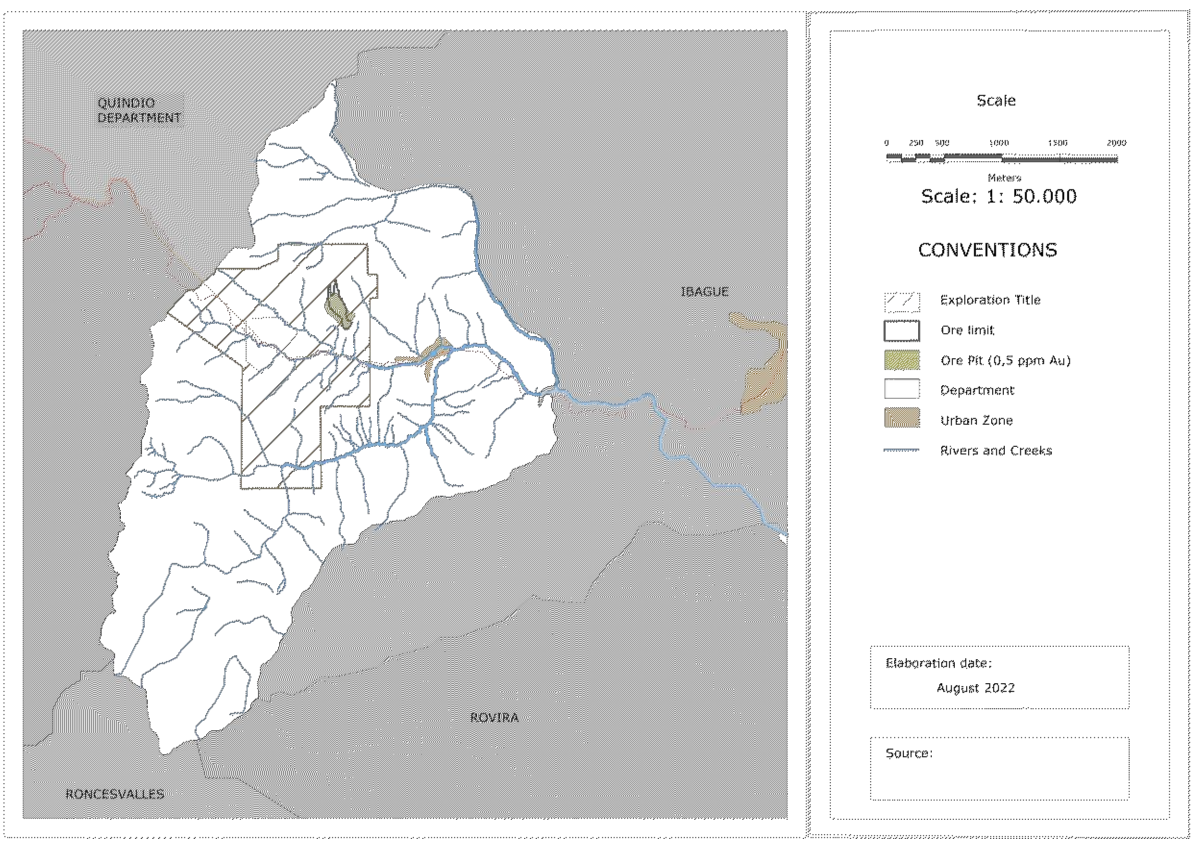
Table 13. Water uses in Basin Coello River

Water Uses in Basin Coello
Irrigation
Electric generation
Agricultural
Aqueducts
Livestock
Domestic
Industrial
Recreational
Human consumption
Flora and Fauna

Cajamarca is situated at 2750 (m.s.n.m), where the atmosphere, with saturated clouds, precipitates significant volumes of water, with average values of 102.11 mm/month and 1225.3 mm/year, are deposited on mountainous surfaces, with strongly inclined and slightly steep slopes, which causes the water to flow along 63 hydrographic micro-basins. Therefore, the municipality of Cajamarca stands out for being a dynamic territory in the regulation of the hydrological cycle, not only important for the municipality but also in the context of the Coello river due to the biophysical and climatic characteristics that possess. The hydrographic system of the municipality of Cajamarca belongs to the Coello River Hydrographic Subzone. The municipality of Cajamarca is covered by three hydrographic basins, of which the Anaime River stands out for its influence, which covers approximately half of the municipality.

> «The main basins are the Rio Anaime, the Rio Bermellon, and the Rio Toche. They originate at a high altitude, 3.200 meters above sea level, and Nevado del Tolima. The flow passes near the municipal capital of Cajamarca and Ibague and makes long tracks receiving tribute from other waters to flow into other rivers at lower altitudes, 1,700 meters above sea level». (Arango, 2014, p. 62)

Figure 30. Coello Wetlands map



A good water regulation in a basin is characterized by even in the greatest periods of drought, managing to maintain the flow of the main channel during all the months of the year without drying up. Additionally, it is indicated that the mechanisms that contribute most to water regulation in the Andes are associated with the "storage" of water in glaciers and ecosystems such as Andean forests, Paramos, and wetlands. The above mentioned implies that the degradation of Andean ecosystems leads to a change in the capacity for water regulation and the behavior of river flows in the short, medium, and long term.

The hydrological vulnerability of the hydrographic subzone shows that four (4) of its hydrographic units (Combeima River, Coello River section, Cocora River, and Gallego Creek) have a high category of hydric vulnerability, indicating deficiencies in ensuring the supply of the different formal and informal users in each of their basins. For the hydrographic units of Coello River and Cocora River, there is also a declaration of exhaustion of water sources, according to Resolution 427 of March 7, 1997, since it was evidenced that water concessions have been granted on the said source which reached or exceeded its available flow.

Physiography And Soils

Physiography refers to the analysis of the relation of climate, geology, morphology, and age of rock materials, hydrology, and indirectly biotic aspects, which strongly influence the formation and development process of soils and their suitability for land use and management.

The importance of physiography strongly influence the possibility of any soil exploitation, as well as the shape and location of human settlements and their infrastructure.

The analysis of the physiographies and soils that are present in the municipality of Cajamarca was carried out taking as a reference the General Study of Soils for the Department of Tolima (2004), prepared by the Agustín Codazzi Geographical Institute.

In Cajamarca, the most significant area is represented by high-grade slopes between 30.1 and 70%, with an extension of 28,034. 35 Ha, equivalent to 54.30% of the municipal area, is classified as very pronounced. In second place is the range of 12.1 to 30% slopes. In general terms, 93.33% of the territory is above a 12.1% slope (semi-undulate). The general average of slopes is 61%. (EOT, 2000, p.51).

There are soils with sandy and loamy textures with a reasonably deep A horizon that is dark brown to black; they are very deep soils, well-drained; pH is slight to moderately acidic, exchangeability is high to medium, and fertility is moderate. The municipality of Cajamarca is the only one that is entirely within the Greater Basin of the Coello River, with an area of 51,367.60 ha. Of this total, 64.88% has a slight current erosion, while 14.76% has a severe current erosion.

Next, table 12 presents the interpretation of the symbols that develop the description of each of the land units in the aforementioned study, table 13 identifies and measures the size of the different types of land units present in Cajamarca and Figure 31 graphically represents the distribution of said units in the municipality.

Table 12. Physiography variables

Variables	**Description**	**Symbol**
Landscape	Mountain	M
Weather	Pluvial subnival	A
	Very cold and very wet	G
	Cold humid and very humid	K
	Medium humid and very humid	Q
Erosion	Light erosion	1
Slope	Between 3 to 7%	B
	Between 7 to 12%	C
	Between 25 to 50%	E
	Between 50 to 75%	F
	Greater than 75%	G

Source: EOT, 2022, p.116

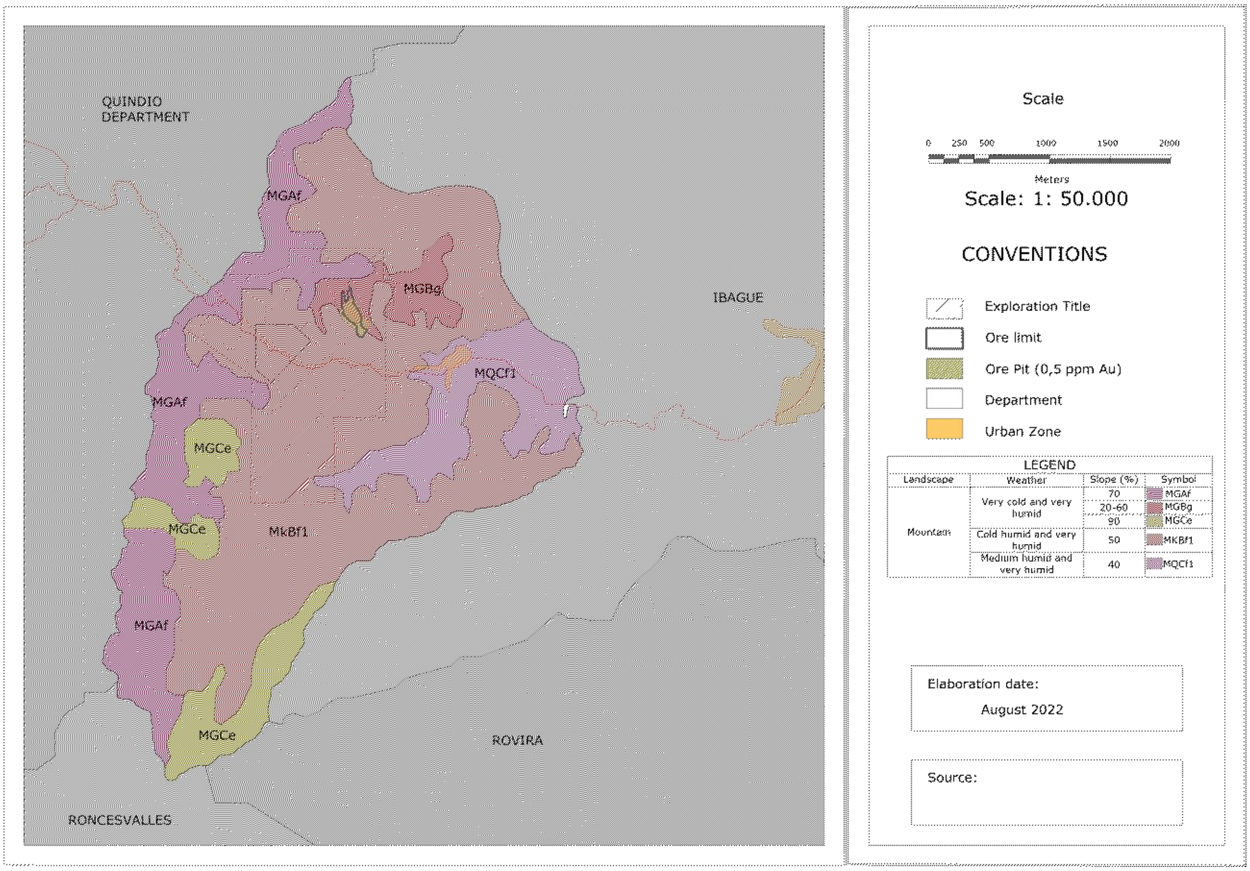
Next, the description of the legend of each of the physiography and soil units present in the municipality of Cajamarca is presented, as well as determining their size and the percentage of distribution.

Table 13. Soil characteristics

Soil	Characteristics	Percetage in the region
MKBf1	The largest unit within the cold, humid, and very humid climate, at altitudes of 2,000 to 3,000 m, with rainfall of 2,500 to 2,800 mm and 12 to 18°C temperatures registered. This unit corresponds to the relief of rows, Volcanic ash and metamorphic rocks, characterized by inclined longitudinal ridges, with steep flanks strongly broken to steep relief and long slopes. Slope phase of 50-75%, and slight erosion.	55,33%
MGAf	Slopes phase of 50 -75% with an area of 10,819.48 ha, equivalent to 5.87% of the basin, mainly located to the west and a small part to the north of the Bermellón river; another section is located in the southwest of the Toche river and a third part borders on the east with Combeima river, in areas influenced by volcanic ash. With strongly broken to steep topography and long, steep slopes. Soils have evolved from volcanic ash on igneous rocks and the andesites.	19,03%
MGCe	25-50% slope; It is found in a very cold, humid climate. The material is made up of volcanic ash deposited on andesites. The natural vegetation has been destroyed and initially replaced by potato crops and later by pastures for extensive cattle raising.	8,42%
MQCf1	Slope phase from 50-75%, moderate erosion. Metamorphic rocks, schists. Despite the steep slopes and the high susceptibility to erosion, agricultural activities are carried out, especially coffee, banana, sugar cane, arracacha, tree tomato, beans, and peas, on family farms.	8,83%
MGBg	Slope phase >75%. In some very localized sectors, there is slight hydric erosion. This area corresponds to the montane rainforest life zone; the natural vegetation is arboreal and herbaceous.	3,80%

Source: Cortolima, 2018

Figure 31. Soil Characteristics



Biotic factors

The geographic zone of the municipality of Cajamarca correspond with an important location of ecosystems such as the Páramo and the Andean forest, which, are nowadays subject to significant pressure caused by anthropic activities typical of unsustainable development. Therefore, it is necessary to study the biodiversity that lives today in the municipality and the types of ecosystem services they provide to extend the knowledge and importance of the distribution of fauna and flora in the region of Cajamarca.

Páramo´s

The Páramo´s are ecosystems of unique cultural and biotic wealth, with a high degree of flora and fauna species of particular importance and value, components that constitute an essential factor for ecosystem balance, biodiversity management, and the natural heritage of the basin and the country. «It is the ecosystem with the highest solar radiation in the world, which generates the richest mountain flora on the planet ». (EOT, 2022, p, 232.) They have soil covered with grasslands, wetlands, and peat bogs with the presence of particular species such as *frailejones.* In addition, it turns out to be a biological corridor for the region's fauna. As stated by Cortolima 2018 and Morales 2007, p.29 «In the entire Páramo area, there are around 3,400 vascular plants and 1,300 species of non-vascular plants».

The climatic conditions of the Colombian Páramo´s are very varied concerning rainfall, temperature variations, luminosity, duration of daylight, relative humidity, wind, soil features, and present vegetation. The Andean bear, the condor, and the puma, among other species, inhabit the páramos. «It has a high level of endemism, with approximately 70 species of mammals, 154 species of birds, and 90 species of amphibians». (IAvH 2011, cited by Cabrera and Ramirez, 2014 & EOT, 2022 p, 232).

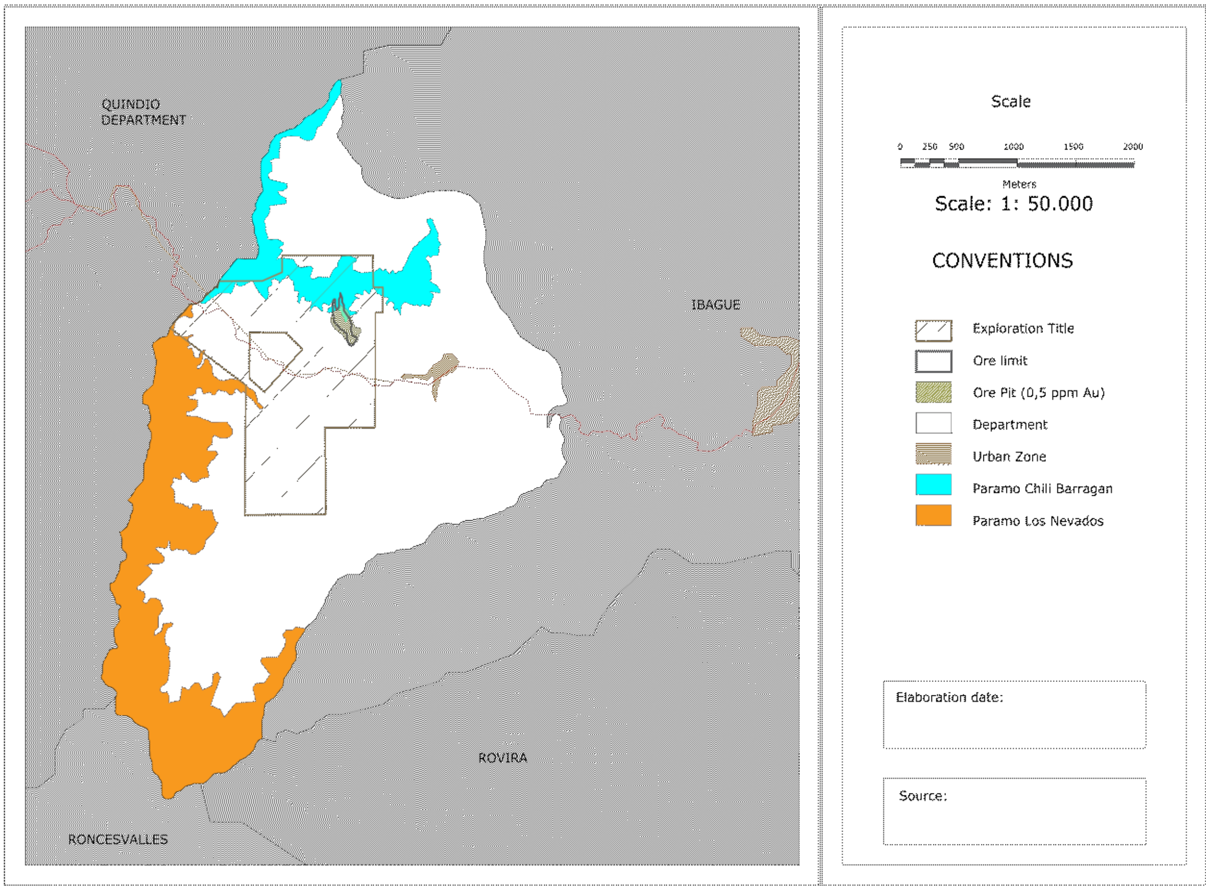
The Páramo are part of the submerges of the mountain ranges above the Andean forest, from 3,800 meters above sea level (locally 3,200 meters above sea level) and can be divided into sub-floors: sub- Páramo, proper Páramo, and super- Páramo. In the hydrographic subzone of the Coello River, two Páramo ecosystems are identified: Páramo Los Nevados and Páramo Chili – Barragán.

As can be seen, on the one hand, the paramos represent a part of great importance for the country, and on the other hand, it only generates a risk for the company by interfering with the realization of the project.
AGA 2020, p.7 add:

> «The delineation of the Los Nevados Páramo by Resolution 1987 is considered a risk to the Mineral Resource and is currently being refuted. This puts 13.99Moz of Mineral Resource at risk. The failure to grant environmental permits for site operations has hampered progress, which is why force majeure was accepted by the government».

At present 122,000 Hectares (6.3% of the páramos area) have been granted mining rights, despite the fact that this is illegal". (Colombia Solidarity campaign, 2011, p. 14).

Figure 32. Páramo´s Location within Cajamarca



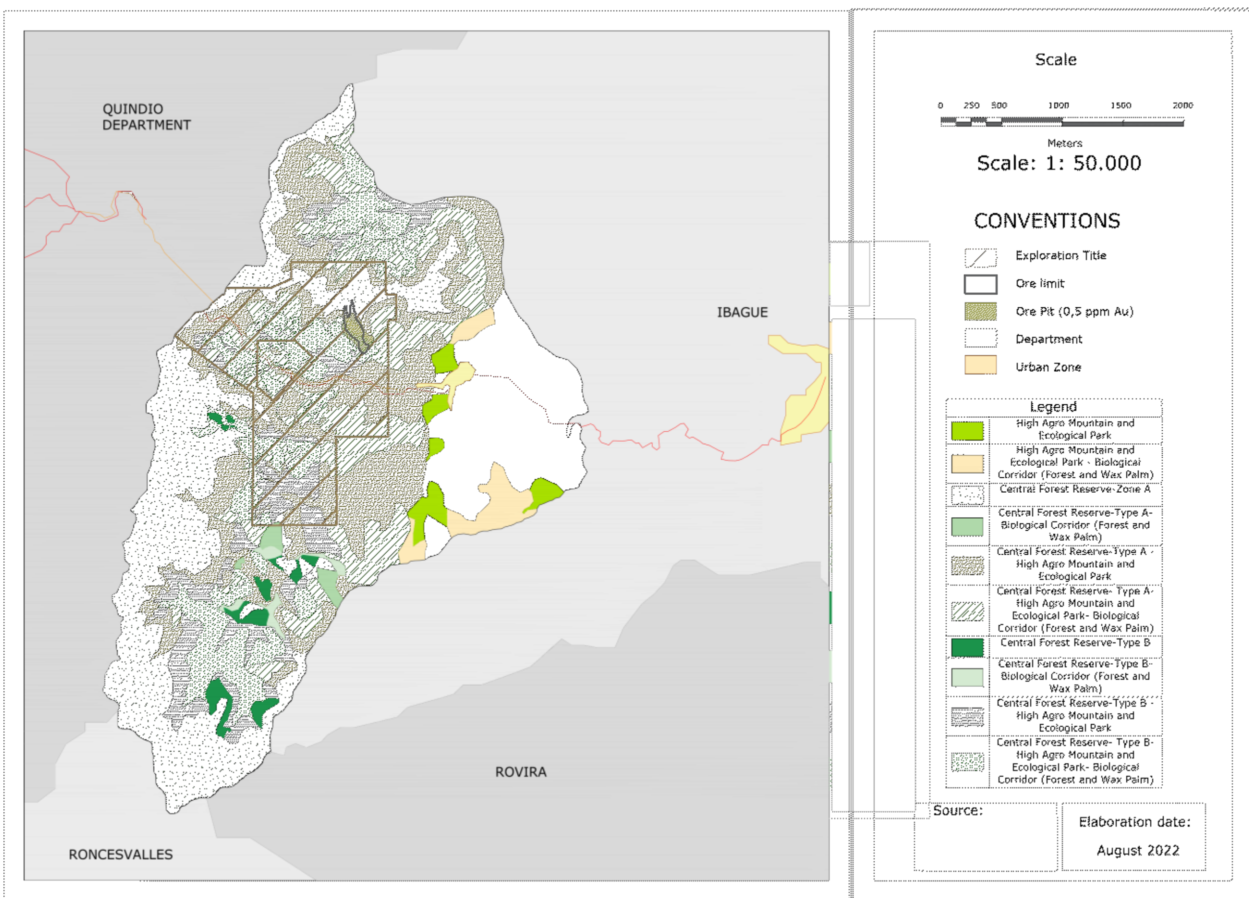
Source: Instituto Geográfico Agustin Codazzi [IGAC], 2015

Páramo Los Nevados: delimited by resolution 1987 of 2016, it is located between the departments of Quindío, Caldas, Risaralda, and Tolima with an approximate area of 133,665 ha.

Páramo Chilí-Barragán: delimited by resolution 1553 of 2016, it is located between the departments of Valle del Cauca, Quindío, and Tolima with an approximate area of 80,708 ha.

The páramos of Los Nevados and Chilí-Barragán extend from north to south, as a continuous strip on the central mountain range of the Andes, on the western side of the municipality of Cajamarca. In total, the two páramo complexes have an area of 11,883.34 hectares in Cajamarca, representing 23.05% of the municipal area.

Figure 33. Central Forest Reserve Zone



Flora

The variety of climatic floors, the integrity of the soil, and the optimal hydrological conditions present in the municipality of Cajamarca favor a comprehensive coverage of natural vegetation throughout its extension, mainly in the riparian zone of the natural drainages that covers a rate close to 35% of the municipal area.

According to a field study carried out by the La Colosa Environmental Consortium (2008), it was possible to estimate that the natural forests found within the area under study are characterized by being forests in the late or advanced successional state, whose individuals are distributed in Latizales (young, straight trees, about four to eight cm in diameter) and Futales (jungle trees with straight stems whose diameter exceeds twenty centimeters).

These are ecosystems in their climatic state in which some of their individuals have died and fallen to the ground forming several clearings inside; Species are tolerant to special and show a tendency towards homogeneity. In the high areas is present vegetation characteristic of the high Andean forest. Therefore, being an ecosystemic transition zone between the paramo and the high Andean forest, typical elements of these ecosystems are combined, forming an area of vital importance.

The complex climatic conditions within these ecosystems give rise to important forests as water regulators, whose undergrowth comprises species that fulfill this task, among which bromeliads stand out. Among other functions, these forests are protectors-producers due to the considerable number of environmental benefits that derive from them as regulators and protectors of water sources, biodiversity, landscape richness, and provide the habitat of many species of fauna in addition to being considered as carbon sinks.

Within the evaluated forests, important associations of Encenillo (Weinmannia pubescent), Sietecueros (Tibouchina lepidota), and Platero (Freziera Reticulata) were identified; These species are of great significance since they have acquired skills that allow them to live within this zone and are also important for the ecosystem since they have a high degree of dominance and their degree of competition concerning other species is considerable.

There is a high degree of vulnerability due to agricultural and livestock expansion. Therefore, these processes threaten species such as the Palma de Cera (Xeroxylum Quinduense). In the Potosí village are the most extensive wax palm forests (Xeroxylon Quinduensis), forming actual frames that exceed the crowns of grown trees. In the middle of the zone are livestock and agricultural activities with patches of quite intervened forests (EOT, 2000, p. 71).

Biodiversity

According to Fierro and Cabrera (2013) «Colombia is the country with the highest level of biodiversity in the world per square kilometer». Burial of headwater creeks by fillings causes permanent loss of ecosystems that play crucial roles in ecological functions such as nutrient cycling and production of organic matter for downstream food webs. In terms of biodiversity, Colombia has the most extensive number of species of birds and amphibians in the world, the second in species of flora, the third in reptile species and the fourth in mammal species.

Fauna

The municipality has three climatic floors, in which the faunal species are dispersed in different territories. The widest variety of mammals and birds are found in the Paramos and in the cold-humid mountain edges; Onfurtunately The species of fauna that inhabit this ecosystem are at risk of extinction due to the anthropic pressures to which they are tolerated, circumstances that relegate the few animals that are forced to protect themselves from hunting, captivity and its probable extinction. The faunal diversity of the area is subject to the movement of species. Therefore, these species may be in the area of influence but have moved away due to the anthropic activities carried out so far in the area.

Some representatives of the Páramo according to their common names are: Spectacled Bear, Andean Condor, Mountain tapir, Borugo, paramo eagle, Cuzumbo (Nasua) , Soche Deer, Horned Deer, Black Mirla.

«In the 515.75 Ha of possible mining exploration, a study commissioned by AGA has found 34 species of trees, more than ten species of mammals, 31 species of birds, 27 amphibians, and 24 reptiles. Many of these species are protected, including the Oak, the Wax palm, the Loggerhead palm, Lichens, Lamas, Orchids, the fox, Cusumbo, Guagua, Agouti Paca, Leptostrcaca Branickii, and the Herveo toad (Osornophryne percrassa) ». (Colombia Solidarity campaign, 2011, p. 25).

In other research sources, records made by the POMCA characterize the Coello River biodiversity; this document stands out the description of species as:

The Lepidoptera, which 286 species of diurnal butterflies identified, fishes with 65 species identified in the basin; the Herpetos are divided into 41 species of amphibians and 30 species of reptiles, respectively. Birds are the largest group, with 297 species. Finally, within the group of mammals, bats stand out with 50 species.

This variety of species, even at a broader level than the direct area of influence, demonstrates the high diversity and wealth of fauna in the area where the open-pit mining project is to be developed, indicating that its possible impacts will be significant and irreversible.

Political and administrative division.

The municipality has an area of 516.2 square kilometers, of which 0.2% corresponds to the urban area and 99.8% to the rural sector. The urban area consists of 12 neighborhoods (see Table 13) and the rural area by 42 villages.

Table 14. Neighborhoods of the Urban Area

Neighborhoods of the Urban Area			
1	La unión	7	Urbanización Manzanos
2	Las ferias	8	El Mirador el bosque
3	urbanizacion Ibanazca	9	El Evelio Gómez
4	Centro	10	Ciudadela Ismael Perdomo

5	20 de Julio	11	Urbanizacion El Jardín
6	El Bosque	12	Urbanizacion El Rosal

Source: Statistics Governacion del Tolima 2015, p.19

The inhabitants of the rural sector are currently organized in 42 villages. (see Table 14 and Figure 33)

Table 15. Rural Area Villages

Rural Area villages					
1	Altamira	15	La Ceja	29	Tunjos Alto
2	Arenillal	16	Cerrajosa	30	Tunjos Bajo
3	Bolivia	17	La Despunta	31	La Plata - Monte Bello
4	Cajamarquita	18	La Esperanza	32	Pan De Azúcar
5	El Aguila	19	La Fonda	33	Potosí
6	El Brasil	20	La Judea	34	Recreo Alto
7	El Cedral	21	La Leona	35	Recreo Bajo
8	El Diamante	22	La Luisa	36	Rincon - Placer
9	El Espeio	23	Cristales - La Paloma	37	San Lorenzo Alto
10	El Oso	24	La Playa	38	San Lorenzo Bajo
11	El Rosal	25	La Tigrera	39	Santa Ana
12	El Tostado	26	Las Hormas	40	La Cucuana
13	La Alsacia	27	Las Lajas	41	Planadas
14	Bolívar	28	Los Alpes	42	La Estrella

Source: Statistics Governacion del Tolima 2015, p.19

Figure 34. Cajamarca Villages Map

Source: Statistics Governacion del Tolima, 2015, p.17

The red region correspond to the Urban comprised the center area, the additional colored regions correspond to the Rural regions

Demography

During the last three censuses, it is evident that the growth is not noteworthy. Observing the behavior of the period that includes the last three (3) censuses (1993, 2005, and 2018) carried out by the DANE (national administrative department of statistics), corresponding to a range of 25 years, it is concluded that the population of the municipality tends to decrease; except for the growth of 0.35% corresponding to the period from 1993 to 2005. It should also be noted that the population in the municipality of Cajamarca continues to decrease since the figures given by DANE, the population in 2019 was 18,443.

The intercensal growth rate shows negative values which indicates that the emigration variable is significant due to the limited opportunities for the inhabitants, who seek access to a better quality of life in nearby cities such as Ibagué, Pereira, Armenia, and Bogota including from rural to urban, where the population finds advantages and better opportunities for their well-being.

In the census of 1993, the population of Cajamarca decreased by 13.2% from the previous census, going from 19,325 inhabitants to 18,701 and presenting a greater concentration of inhabitants in the rural area, which allows us to infer that the population is in a process of urban transition. The presence of the population in the rural sector provides it with an agricultural vocation since it is in the countryside where this activity takes place.

Table 16. Evolution of the total population from 1993 to 2018

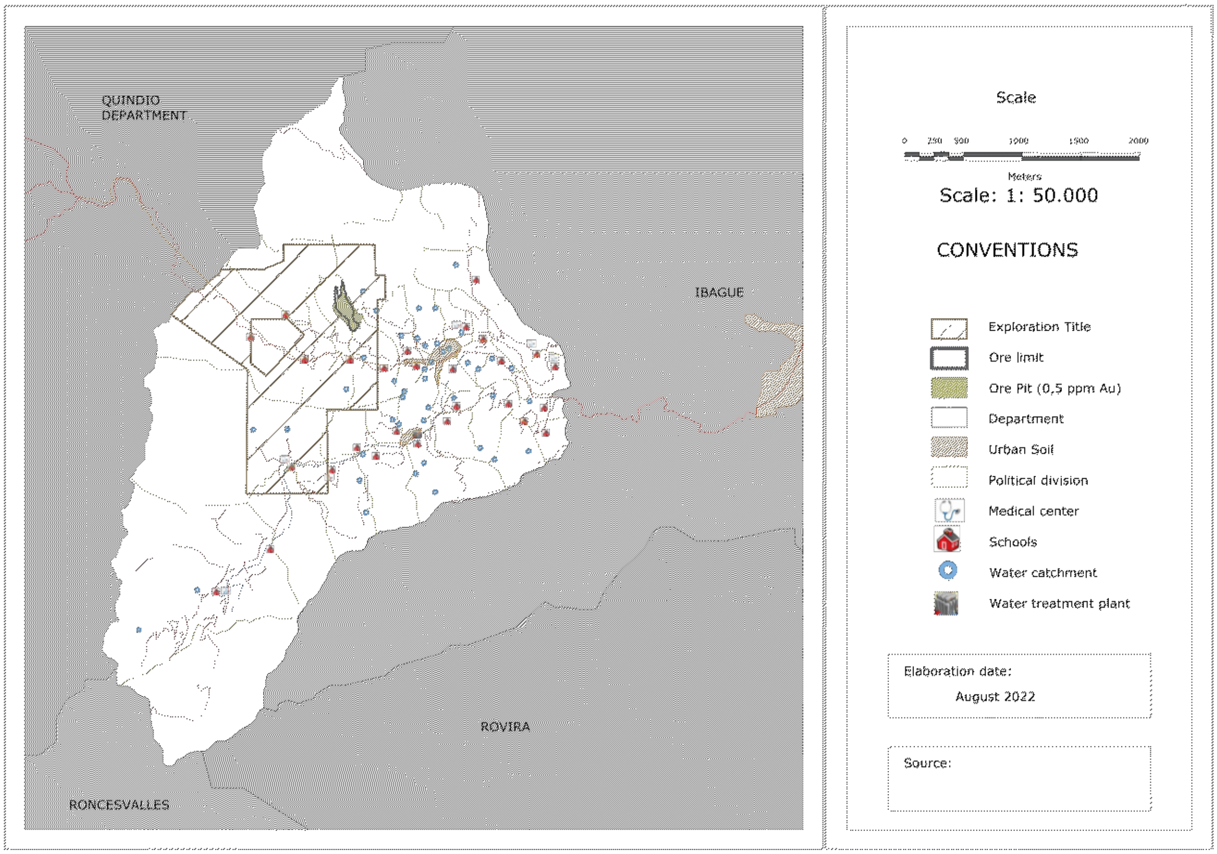
Censuses	**1993**	**2005**	**2018**
Urban zone	7,876	9,264	9,461
Dispersed rural and populated centers	10,825	10,237	9,010
Growth rates	-0.59	0.35%	-0.42
Total	18,701	19,501	18,471

Source: EOT, 2022, P.538

As known, the municipality of Cajamarca has an agricultural and livestock vocation, where the majority of the population works in the field with a notable characteristic that a high rate is informal workers. Therefore, they do not contribute to social security, which evidences the meager percentage of formal workers, ranging from 4 to 6% of the total population in the analyzed period (2022-2016). According to the Tolima Vision 2025, cited by EOT,2022 p. 440 the municipal unemployment rate will be 43% by 2014.

For the current year, 2022, in the Municipality of Cajamarca, it can be determined that 36 people live per km2. However, this varies depending on the location within the rural or urban area, close to a populated center or remote area.

Figure 35. City equipmentCity equipment



The word "equipment" in terms of territorial planning, the word " equipment " refers to the different types of physical infrastructure installed or required that fulfills specific functions related to improving the residents' quality of life. This type of infrastructure, in mention, is purely public.

Water catchment:

The contributions of the volume of water that are made from the municipality of Cajamarca to the hydrographic subzone of the Coello River are crucial, "Only the hydrographic subzone of the Bermellón River has an average flow of 7.57 m3/sec, which is equal to a water catch of 18.02 liters/Km2. This condition of flow maintenance has made the water resource permanently demanded by the inhabitants of the municipality for different uses as human consumption, domestic, industrial, and agricultural." (EOT, 2022, p.178).

The Cajamarca hydrographic system supplies the urban and rural aqueducts for the domestic consumption of the population of the municipality, Only for human consumption in urban and rural land, forty-five (45) catchment points and two hundred and twenty-nine (229) concessions for multiple uses have been identified.

Educational and health facilities:

Rural facilities operate differently from those located in the urban sector since the conditions of the road infrastructure, the distribution of the population in the territory, the changes in elevation between geographical points that make up a route, and the state of the climate, among others, directly influence their operating conditions.

Health equipment:

An educational facility satisfies the education and training needs of the territory's population. In the Municipality of Cajamarca, there is only one first-level care hospital that provides full coverage to the urban and rural areas, provides a level of primary medical care with hospitalization, the provision of rooms and equipment, and is in relatively good condition.

In its rural territory, Cajamarca has eight (8) health posts. However, only the one in Anaime is in operation due to its physical conditions; the activities for which they were initially conceived cannot fulfill their function, mainly its physical conditions are in an advanced state of deterioration, accessibility is complex, and the conditions of the road infrastructure make it very difficult for passengers to transfer. Notably, in the village of La Ceja, the situation has an additional aggravating factor; this area does not have electricity, a fundamental factor for the development of the activity required in that space.

The health facilities were manifested as one of the most acute needs of the territory in this aspect, the high costs of traveling to other sectors, the difficulty in assigning medical appointments lead to to the result of the closure of the health centers in the villages.

Schools:

The municipality currently has six (6) Educational Institutions that provide preschool, primary, and secondary education services; two (2) of them are located in the urban center, one (1) in the township of Anaime, and two (2) in the rural area. These institutions have 33 headquarters; 90% are in the rural sector and 10% in the urban area. In rural facilities, the educational offer is limited to primary education, so those inhabitants who wish to continue with their primary and secondary education cycles must move to the urban area of the municipality or neighboring municipalities. Most buildings are in good condition and have enough space for students.

Table 17. Equipments inventory

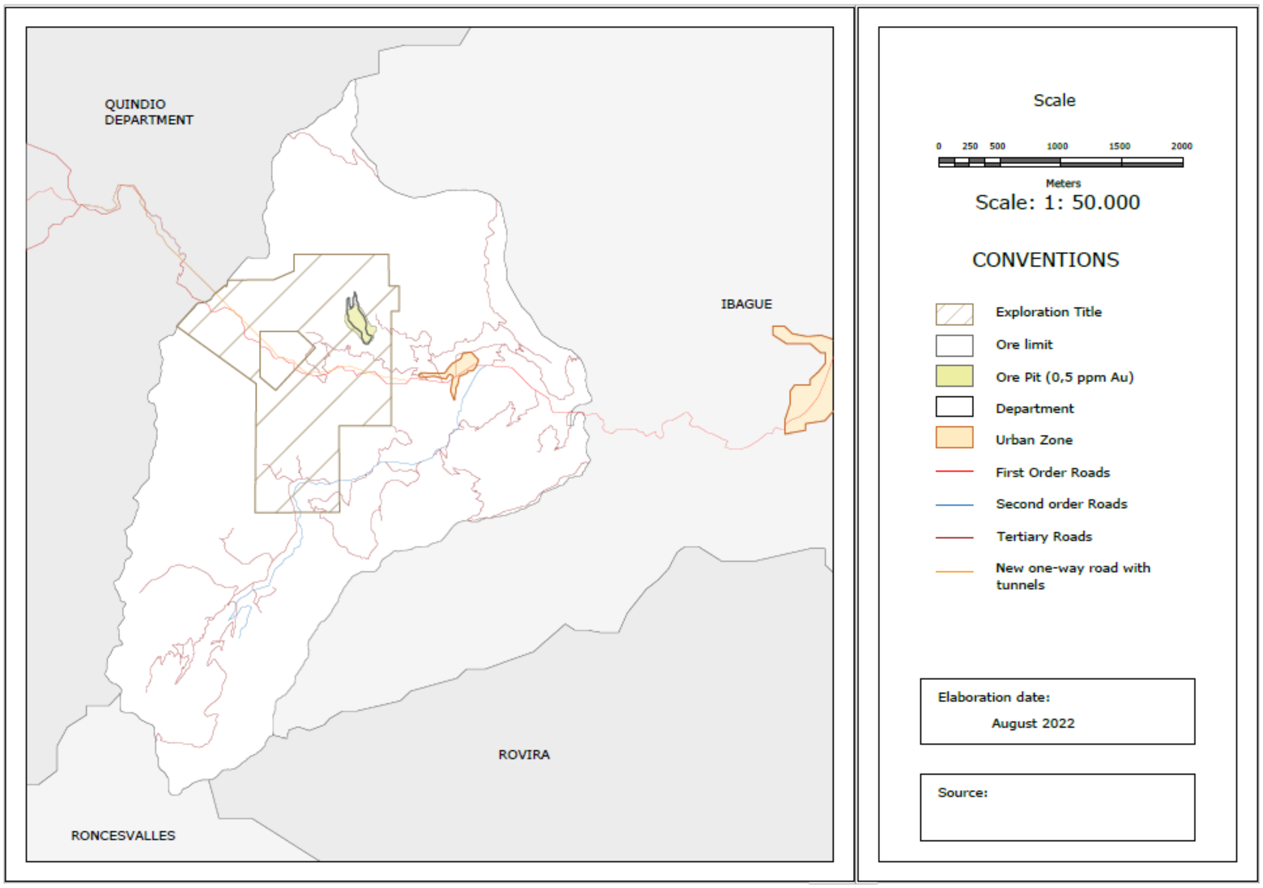
Equipment	Inventory
Health equipment	Health posts Blood banks Hospitals Clinics Sanatoriums Centers and house of rehabilitation Clinical laboratory
Educational equipment	Elementary school High school Kindergartens

Transportation Infraestructure:

In the identification, quantification and classification of roads in the municipality of Cajamarca, there is mainly a gap in the classification of rural roads that affects the functionality of the road layout and the articulation of mobility within the territorial arrangements. The territorial authorities are not able to project the road system and plan interventions in road corridors that provide solutions to rural mobility needs and mitigation of impacts and damages caused by roads in mountainous areas at risk of flooding and landslides.

Regarding the state of the road network in the region and the concept of regional communication, it is noted that the municipality of Cajamarca is located at the western end of the department of Tolima, becoming a municipality adjacent to the department of Quindío, as well as a transitional municipality between the capitals of Armenia and Ibagué, forming an urban-regional corridor that, due to its construction, has exceeded its capacity for current traffic flow.

Figure 36. Transportation Infraestructure



The classification of the municipal road corridors is made in three categories:

First-order, structuring road axis: these are roads that primarily support national flows of goods and people between Bogotá and Buenaventura, and secondarily support regional flows between Ibagué and Armenia, as well as flows in between.

In November 2021, the entire project connecting Cajamarca to Calarca was inaugurated, a project with 25 tunnels and 31 viaducts crossing the Central Mountain.Range This project promises to optimize the connection between the port of Buenaventura del Pacifico and the center of the country, a project that represents a historic change in the country's mobility and the flow of exports to and from the country's port, the most important port in Colombia. The road runs in the west-east direction of the country. From Calarca to Cajamarca

Secondary Roads: These are roads intended for the movement of goods and people between the center of the region and the municipality of Anaime and the surrounding villages. It fulfills the function of internal communication between the villages along its route and provides good traffic conditions.

Third-order local roads: these are a series of roads for vehicles and pedestrians that facilitate communication between villages and rural properties and through which agricultural products characteristic of the municipality are transported; they generally have a poor state of construction and maintenance.

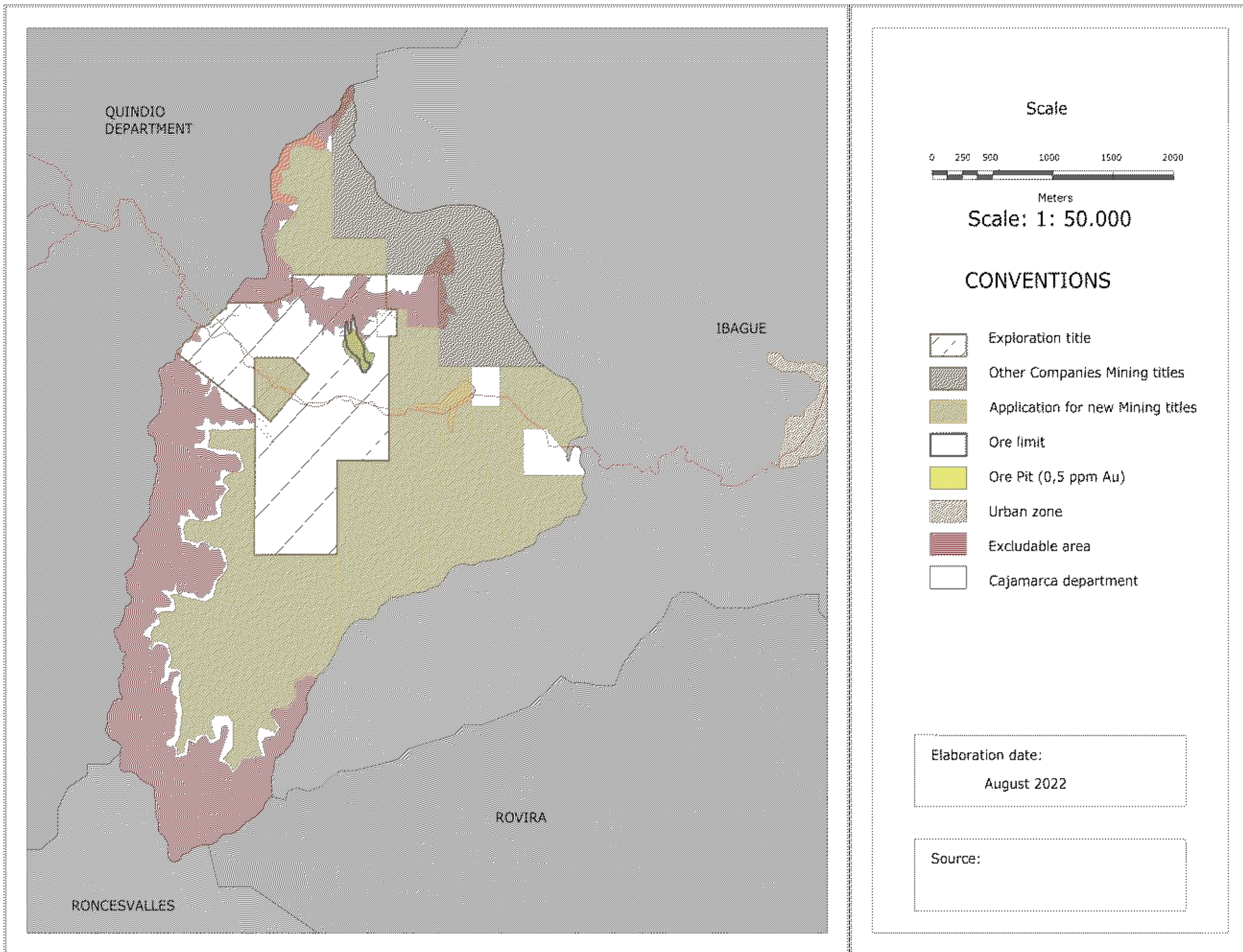
It is noted that most of the rural roads of third order have an obvious deterioration due to the erosive effect of climatic factors, which localizes a problem in the lack of complementary works for the management of water on the road surfaces, leading to the loss of the surface layer as the surface material is deposited by the action of rainfall

In addition, there is evidence of high risk for the population traveling along these rural corridors, identifying critical points related to the crossing of water bodies, most of which do not have works related to bridges, pontoons or overpasses that ensure the passage over these sections.

Mining Concessions

According to information from the ANM (National Mining Agency), "in Colombia, to establish, declare and prove the right to explore and exploit state-owned mines, a concession contract must be obtained," and this is "a contract between the State and an individual to carry out, the studies, works, and exploration work for state-owned minerals that may be found within a given area. This title and its development through the concession contract are divided into phases, generally divided into Exploration, Construction, and Assembly and Exploitation.

Figure 37. Mining Conssesions



In this sense, the gold potential of the municipality is ratified by the number of current mining titles and the request for new titles that overlap any missing area of the municipality that, in turn, coincides with the areas identified with gold mining potential. Today, 4 valid mining titles are identified: EIG-163, 0047-73, GLN-095, and CG3-145. In addition to the current mining Titles, information was consulted on the Request for Mining Titles with a deadline of January 15, 2022; In this consultation, 8 requests for mining titles were identified.

In conclusion, it can be seen that mining titles in force, such as the applications for mining titles, are located throughout the municipality, except for mostly the area corresponding to the Paramo ecosystems, which are represented on the ANM map as Excludable Areas.

Crops and land use

The survey of Coverage and Use of the land corresponds to the analysis of the different natural and anthropic processes that occur or are carried out on the soil of the Municipality of Cajamarca; the information acts as a basis for other applications, commonly called: Index of Hydrological Protection IPH, Attitude of Use, Conflicts of use, besides others. The vegetation cover comprises forests, pastures, Páramo vegetation, and semi-annual and permanent crops. The soil use study carried out by the EOT allows identifying 17 Types of Current Land Use. (See Table 16)

The ecosystem of Cajamarca has been drastically affected by anthropic action which is reflected in the decrease in forested area due to the extension of agricultural frontier. This modification causes the destabilization of the soils and at rainy seasons, increase the risk of flooding, erosion, crop losses and leveling of houses, disasters that together affect the economy of the Municipality.

The most extensive coverage of the Municipality of Cajamarca corresponds to forest cover with 52,4% of the total area (see Table 17). The gallery forests are highly intervened in several sectors, such as the Anaime and Bermellón river canyons. In some cases, the abrupt change of forest cover for pastures is observed on river banks and streams. There are also significant areas of mixed cover units, such as mosaics of crops, pastures, and natural spaces (18.91%), and other more superficial covers, such as clean pastures (11.54%), destined for livestock activity.

Table 18. Legend of cover and land use of the municipality of Cajamarca EOT

Soil type	AREA Ha	%
Continuous urban tissue	137.20	0.27%
Discontinuous urban tissue	16.10	0.03%
Clean grasslands	5,947.45	11.54%

Wooded grasslands	3,717.65	7.21%
Weedy grasslands	49.36	0.10%
Crop mosaic	268.18	0.52%
Mosaic of grasslands and crops	1,968.38	3.82%
Mosaic of grasslands, crops and natural spaces	9,749.54	18.92%
Mosaic of grasslands with natural spaces	28.11	0.05%
Tall dense forest	5,802.12	11.26%
Tall open forest	11.18	0.02%
Fragmented forest with secondary vegetation	177.71	0.34%
Gallery and riparian forest	21,205.07	41.14%
Dense grassland	1,779.07	3.45%
Dense shrubland	678.09	1.32%
Open bush	5.49	0.01%
Tall secondary vegetation	2.47	0.00%
	51,543.17	100%

Clean pastures:

This coverage includes the lands occupied by clean pastures with coverage greater than 70% with the performance of anthropogenic management practices (cleaning, liming, and fertilization)

Mosaic of crops, pastures, and natural spaces:

In this unit, the areas of crops and pastures occupy between 30% and 70% of the total surface of the unit. Natural spaces are occupied by natural forests, secondary or transitional vegetation, and other undisturbed or little-transformed areas.

High-dense forest:

Cover dominated by typically arboreal elements, which form a continuous crown layer (canopy) whose tree cover area represents more than 70% of the total area of the unit and which, on average, have a higher canopy height at 15 meters.

Gallery and riparian forest:

It refers to the covers of tree vegetation located on the margins of permanent or temporary watercourses. This type of coverage is limited by its breadth since it borders watercourses and natural drainage.

Potential use of the soil

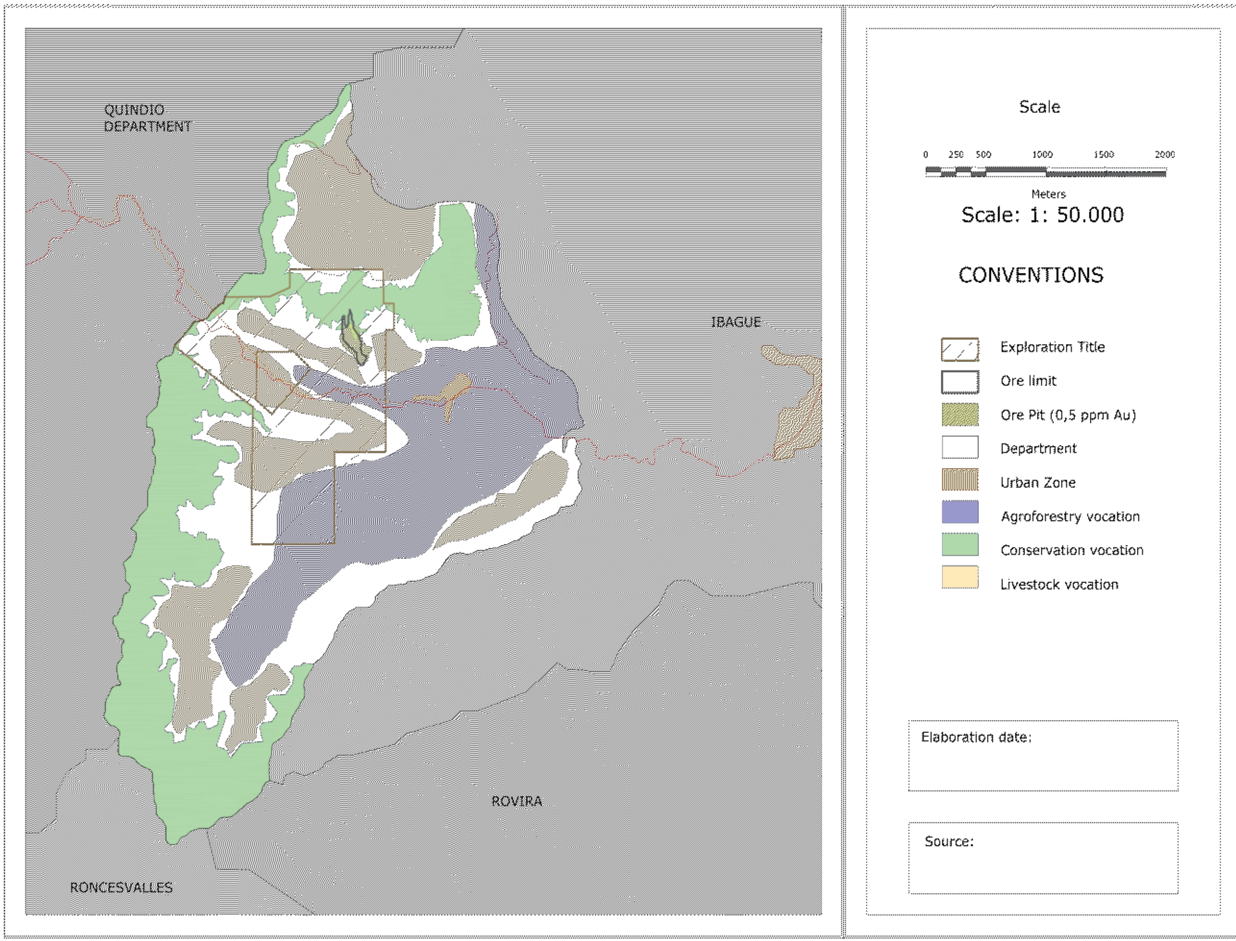
The vocation of the soil is the most appropriate use to evaluate land condition given to this resource based on the natural capacity to support the land use, with sustainability characteristics evaluated on a biophysical basis.

Agroforestry Vocation: These lands have unique characteristics (climate, relief, parent material, soils, erosion), they must be used under combined systems where agricultural, livestock, and forestry activities are harmoniously mixed.

Conservation Vocation: It refers to lands that, due to their biophysical characteristics and ecological importance, must be preserved, thus guaranteeing the social, economic, and cultural well-being of humanity as the Paramos or the Forest Reserve Zone

Livestock Vocation: It refers to the economic exploitation carried out by man on grazing animal species such as cattle, sheep, and horses, among others.

Figure 38. Potential use of the soil



Anthropogenic hazards

Land use conflicts

In the study of the La Colosa Environmental Consortium, it is evident that the continuous disposal of anthropic filling materials resulting from drilling platforms excavations in the western sector of the Quebrada La Colosa increased the destabilizing forces in this area and resulted in the infiltration of rainwater and runoff, deteriorating subsoil conditions. In addition, the materials at the foot of the slope were removed to adapt the access road to the area of interest, leaving the materials of the upper slope without support, constituting a trigger element for movements of the slope.

> «The study area of the La Colosa is affected by surface movements of a translational and rotational nature and soil flows, which involve heterogeneous fill materials, volcanic ash, and a thickness of residual material, a product of the alteration of schists, diorites, and pyroclastic deposits. The rate of movement is variable since movements whose displacement speed has been very fast to creeping processes with prolonged apparent speed are observed. Old translational and rotational landslides were observed that occurred very fast and affected the structure of the access road to the platforms and camps». (Arango, 2014, P. 76)

The environmental planning of the land ought to plan with instruments defined by law, which include, aquifer and watershed management plans, Paramo's zoning, plans for protected areas, and land-use programs. These decisions of conservation or potential use on a geographic space demarcate the ordering of the territory, superimposing functional configurations (roads, networks, physical constructions) and socioeconomic structures (productive sectors, recreation spaces, culture, among others). Environmental and territorial ordering processes must be based on technical studies and respond to legal requirements, with the necessary agreement with a multitude of social and institutional actors. However, it is not always in this way and mining titles, urbanization, and antropogenic changes in the land are done in a manner that is not harmonized with the pre-existing territorial and environmental planning processes.

Contemplated in the following replication in the territories as: The destruction of the forest within the zone, the growing inequality of urban zones, deterioration of health as a result of inadequate separation of industrial zones with residential zones, triggering environmental and social conflicts that generate new violence, besides others.

Land use conflict regarding mining

One of the land use conflicts is evidenced in the following information demonstrating that mining titles have been given despite the human settlement in the area; this means that people use the water resource within areas of titles and mining activity. The water concessions are of all kinds: aqueducts, agriculture, human consumption, and domestic; Likewise, figure 37 shows the location of the water concessions based on their uses and their relationship with the areas of mining titles in force in the municipality.

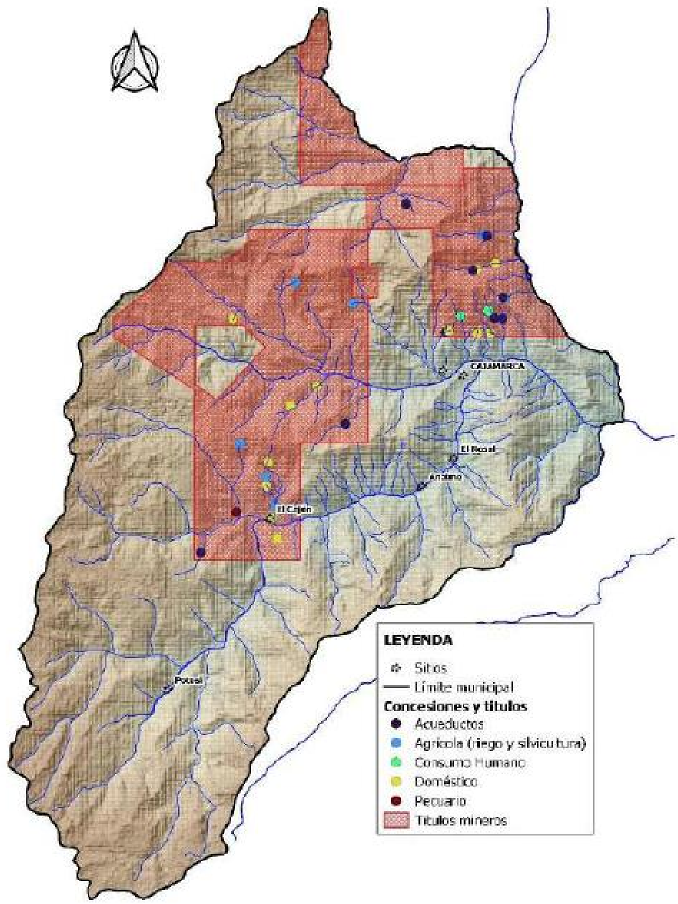
Without considering that the construction of infrastructure works such as homes, roads, and buildings, which occupy areas surrounding rivers and wetlands, reduce the capacity to regulate flood and avalanche events. On the other hand, the mega-mining of precious metals that use polluting substances such as mercury, arsenic, and lead, dangerously affects the water's biodiversity and the health of the people who use it.

Table 19. Water concessions and relation with mining titles in force in the municipality of Cajamarca

UTILITY	TITLES	CONCESSIONS	LITRES/SECONDS
ACUEDUCTS	EIG-163	2	8.24
	GLN-095	7	43.62
AGRICULTURAL (IRRIGATION AND FORESTRY)	EIG-163	5	24.27
	GLN-095	2	3.26
HUMAN CONSUMPTION	GLN-095	2	0.57
DOMESTIC	EIG-163	7	1.91
	GLN-095	5	0.98
LIVESTOCK	EIG-163	1	150
TOTAL		31	232.85

Source: EOT, 2022, p.168

Figure 39. Water concessions and relation with mining titles in force in the municipality of Cajamarca



EOT, 2022, P.168

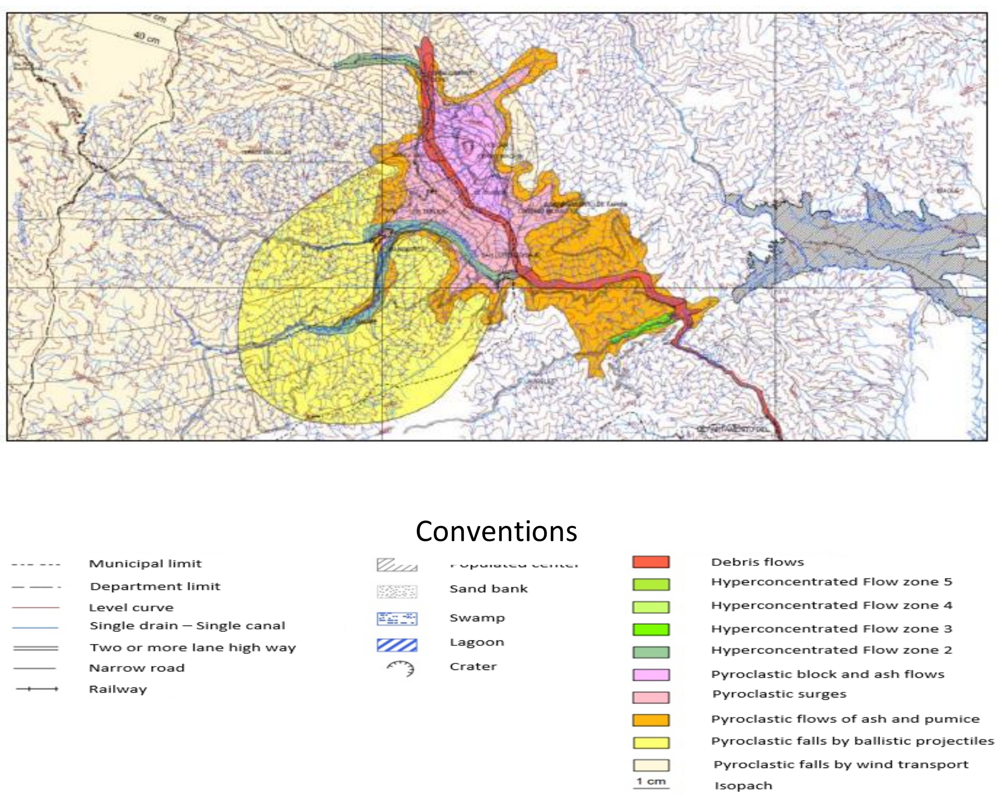
Natural hazards

The categorization of natural hazards that occur in the sector, according to the aspects of terrain slope, climate, and geology in the municipalities that are part of the Coello River Basin, includes the most frequent phenomena, such as mass movement processes, volcanic and seismic activity.

Volcanic hazard

The Cerro Machín volcano has tremendous explosive potential. Due to its chemical composition, magnitude, and great extension of its deposits, it is classified as one of the volcanoes with the most significant potential for damage in Colombia, whose possible activity could intensely disturb, for a long time (months to years), a very strategic region for the economy. The type of volcanic hazard by pyroclastic flows is the most significant potential for damage. These flows are present around the dome and cover 240 km2 of the cone, present in Cajamarca, the town center of Anaime, the municipality of Ibagué, Corregimiento of Coello, Toche, and Tapias, covering areas where about 1 million people live.

Figure 40. Evaluation of the potential threat of the Cerro Machín Volcano due to pyroclastic falls.



Source: Colombian Geologic Service [SGC], 2002

Mass removal processes

Erosion processes act on the different rock units of the municipality of Cajamarca, along steep slopes, influenced primarily by gravity. Rock falls, debris flows, and scour processes are also part of this category. The existing mountainous reliefs in the area show high susceptibility to erosion processes, with precipitation, rock typologies, and vegetation cover as the primary influences.

Rocks of the Cajamarca group are composed mainly of schists, located in the most humid areas where they are easily weathered, resulting in thick levels of Alterites which are susceptible to downfall either by saturation or due to the generation of earthquakes, factors added to the high slopes. Instability problems have appeared indistinctly in some sectors of the municipality. They have generally manifested along the road network and near urban centers, as in the case of Cajamarca and Anaime. The most unstable sectors are located throughout the escarpment surrounding the urban area towards the Anaime and Bermellón rivers, where the deposits are involved.

Along the Bermellón and Anaime rivers, there are processes of undermining in the escarpment surrounding the municipality's urban area, a situation that aggravate landslides condition in this sector. This undermining is also observable along some terraces adjacent to the Anaime River, where there is a predominance of materials of alluvial and colluvial-alluvial origin.

Seismic Hazard

The Volcanological Observatory of Colombia (1992) evaluated the Seismic Threat of earthquakes within a radius of 200 kilometers centered in the capital of each department. This analysis concludes that the following magnitudes could be expected for the Municipality of Cajamarca: Effective peak velocity: 0.24 g, effective peak acceleration of 0.20 g, which would classify the Municipality as an intermediate to high seismic hazard. Likewise, according to the map of threat zones NSR-10 (decree 926 of 2010), the Municipality of

Cajamarca is located in the intermediate seismic hazard zone. Due to earthquakes, rockfalls may occur on steep mountainsides, whose materials can obstruct riverbeds generating debris flows.

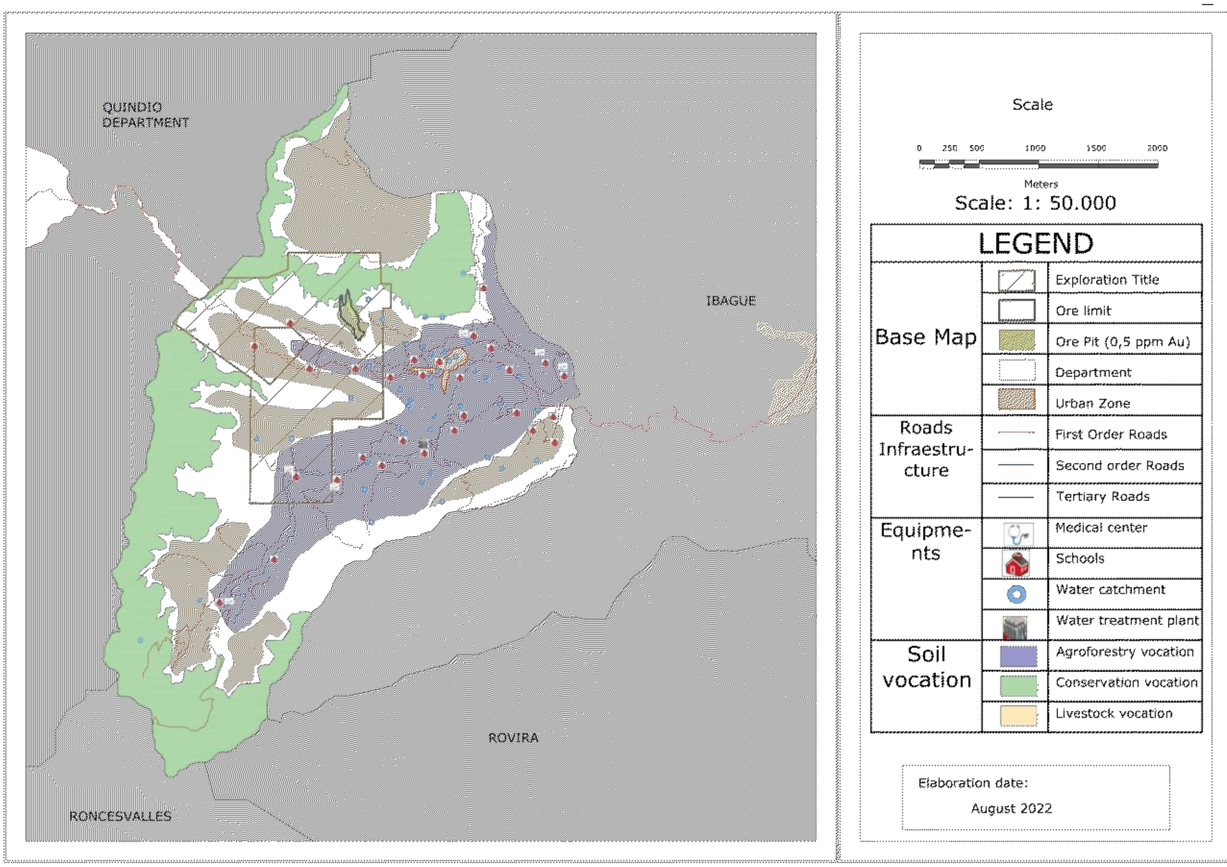
According to the EOT of Cajamarca (2000), the Municipality presents NE structures associated with compressive type tectonic patterns. The development is owed from the Cretaceous to the Quaternary period with the development of large reverse and transformational type faults, heavily linked to the orogenic processes of the uplift of the current mountain ranges that have resulted in complex tectonics. This situation allows fracturing and jointing planes, which favor the accelerated decomposition of the rock and the development of mass movements of different magnitude.

MAP OVERLAY DESIGN AND INTERPRETATION OF THE LAND

One of the main objectives of this project is to obtain relevant biophysical information on the territory to superimpose some of the maps and be able to read the territory's current state, understand its expansion trend, and predict future land changes. In this case, it is decided to superimpose Equipments, Road infrastructure, and Land vocation maps. These three maps are chosen because they allow us to visualize the enlargement tendency of the land.

It is also evident how the equipments follow the course of the roads; in the same way, the agroforestry vocation, which, as previously mentioned, it is a soil vocation that can be shared by different systems, whether agricultural, livestock or forestry, which renders these lands more flexible for different uses in the future. Up to now, the development of the territory has occurred gradually, and it is linked to the extension of roads (first to third-grade roads). As the possibility of enlarging or creating roads, activity develops around it.

Figure 41. Maps overlapping



As a first step towards declaring the future transformation of the territory, it is important to study the role that mining plays in structuring the territory.

Mining, forms of urbanization and transformation:

Mining plays an essential part in structuring the territory. However, different mining scales and operations develop diverse relationships between the region and urban expansion. For this reason, studying the changes in urban centers influenced by mining projects is essential. As Gonzales, 2017, p.2 states «The creation of mining projects has given rise to multiple processes of change in the territory as the expansion of cities near the mines, new enclaves, involuntary resettlements, new population centers, a decline of certain cities, etc».

Mining and analysis:

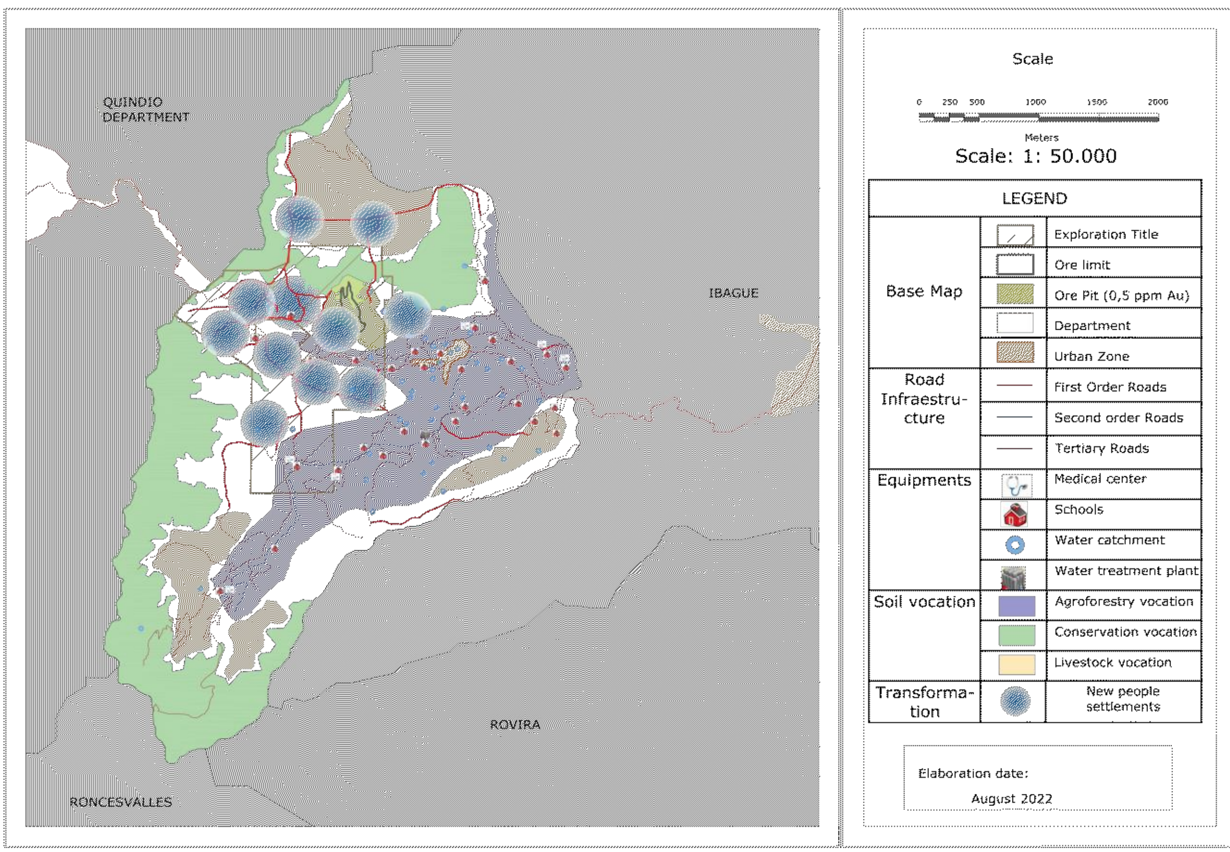
Cajamarca is known for being an articulating center of a rural area but has become a functional center for the particular needs of mining units located near this city; despite the fact that mining activity is currently suspended, mining activity can be reflected in changes in urban morphology, development of territorial networks migration processes triggered by the attraction of economic activities.

Mines are usually in hard-to-reach and geographically challenging places far from city centers; therefore, mining and territories involve relationships beyond the influence of a single municipality but imply some influence in larger territory spaces. In this sense, Bryceson & MacKinnon (2012) propose the concept of "mineralized urbanization," which they define as "the influence of mineral production and commodity chains on urban growth and settlement patterns at local, regional, and national scales." This means that the impact of mining activities occurs at multiple levels of the territory.

From the above information, it is possible to infer a upcoming settlement of people around the mining area and the enlargement of the actual urban area, which would revolve around mining activity, thus migration of people in the region is designed as can be viewed on Figure 42, a map formulated with blue circular areas.

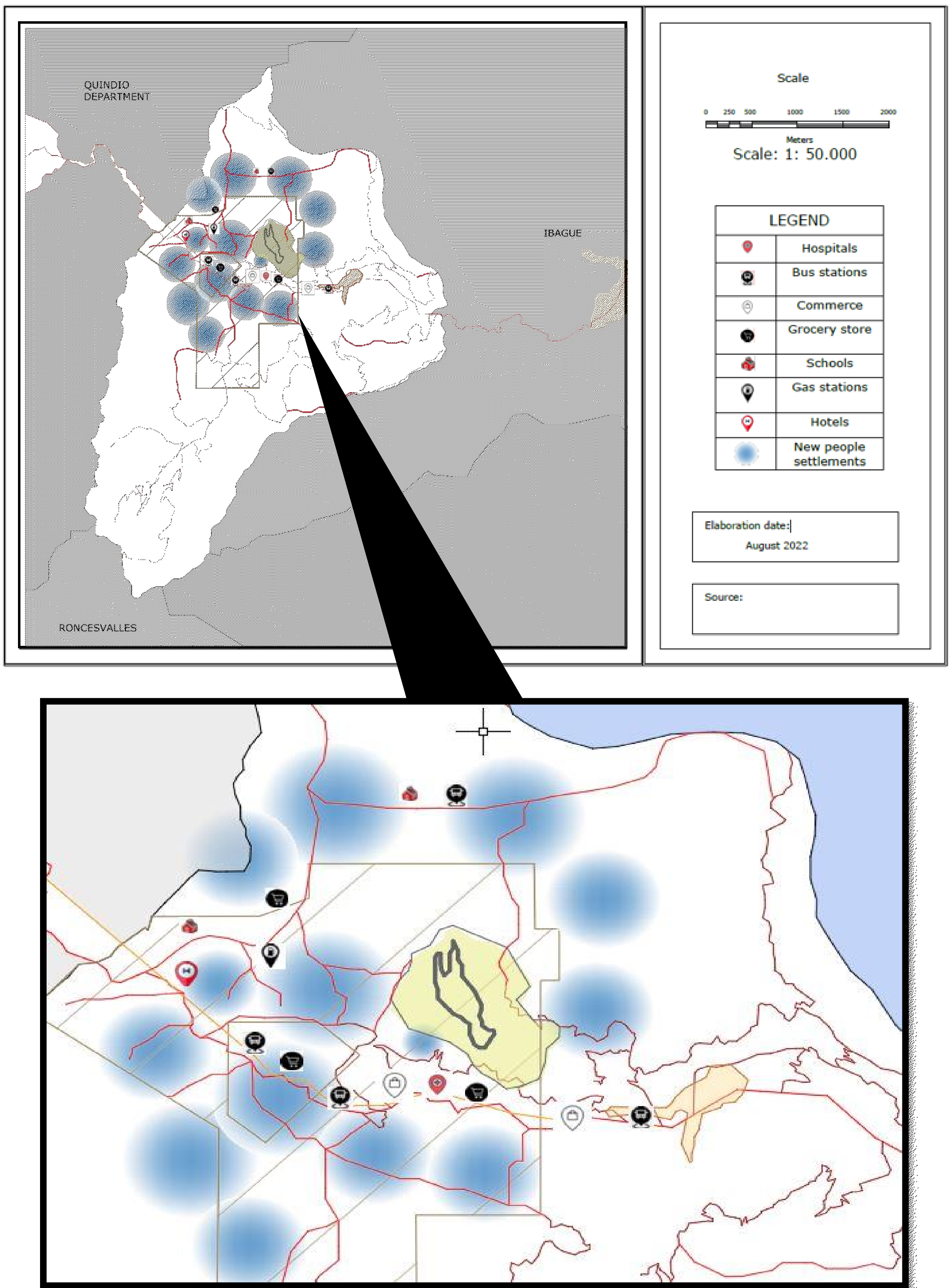
These areas of future settlements mainly cover the areas surrounding the mine since it is the directly disturbed territory, another outcome is also the creation of new roads since it is essential for the transit of workers, merchandise, and reactivation of trade and human activity, therefore new roads are designed to connect the previous road network with new ones expanding significantly the road coverage of the region. Historically, there have been different configurations of the relationship between mining and urban extension. There have been cases of urbanization models directly linked to mining as colonial mining centers and towns to other models in which companies do not create new urban spaces but are linked to pre-existing urban systems and use elements of the territory that may be functional to them.

Figure 42. Maps overlaping with urban transformation



Finally, to complement the settlements of the people and the expansion of the road network, the reactivation of human activity is expected; that is, surely, to meet the needs of the new people who will arrive in the territory, the region should provide opening hotels, restaurants, transport stations to allow access to the mine for workers, the outset of trade and grocery stores in the zone, these are some of the basic needs that must be covered for the new incoming population. To finalize figure 43 shows the map of the area that exclusively contains the new settlements of people and the region's service.

Figure 43. New people settlements and services in the region



Similar case studies:

The city of Potosi in Bolivia was a city whose morphology was directly conditioned by the mining activity and the social structure of the inhabitants (indigenous workers and enslaved people), with its origins due to the Andean Spanish colonial regime. According to Contreras 1982, "the mining city was a colonial product par excellence”. The evolution of the techniques of extraction and transformation of minerals led to the development of the city's utility infrastructure, such as water supply infrastructure and a network of roads. Consequently, several other urban centers developed based on productive or commercial activities that enabled the supply of Potosí.

Another typical in the 20th century, an industrial mining model characterized the space of the central Andes. The towns of Cerro de Pasco mine located and La Oroya, the refinery location, were established through the activities of a company with North American capital, Cerro de Pasco Copper Corporation (CPCC). It was a decisive historical moment when open pit mining replaced underground mining, and Peru's central railroad was built, essential in connecting these towns to the port of Callao, Lima. Despite the arrival of a multinational and the expected development for the region, the central Andean region remains the most industrialized mining region, being also one of the most polluted regions, where environmental damage is among the most severe in the world. The urban production model that accompanied the development of this region was that of an industrial workers' settlement, where working life is closely linked to daily life. Agricultural activity was replaced by mining.

Data from the 2007 census show that Shiracmaca, Peru has a significant percentage of the population with a migrant background and that the population reports mining as its main occupation. The rate of people with a migrant background in Shiracmaca in 2007 was 14.41% (INEI, 2007), higher than in the other villages surrounding the city.

CONCLUSIONS

The exposure of a region like Cajamarca to a mining megaproject requires specific measures to be taken regarding land use planning since it is necessary to allocate areas for new housing units and commercial development in a planned way. In addition, it is essential to work on adapting the infrastructure that provides public services so the demands of the new dynamics the territory will face can be satisfied.

The change in land use can generate a change in the productive orientation of the region as a competition between mining and agricultural activity currently occurring in the area, affecting the food security of the current and future population. People will change their labor orientation, dedicating instead to mining work, exposing the region to the loss of agricultural capacity; government intervention measures should be provided, where the development of cooperative projects are promoted to maintain the production of the main products that are grown in the region since this Cajamarca is known for being an agricultural exemption for the country.

Among the significant environmental impacts that were identified in the development of the investigation are: Regarding the soil and subsoil, it is clear as a result, the loss of soil structure and contamination by chemical substances, which, consequently, will alter the physicochemical and microbiological characteristics, affectation of surface and underground waters in a very significant way. Alteration in air quality, mainly due to the increase in particulate matter and gaseous compounds. An increase in noise and vibrations will result from energy sources and heavy vehicle engines. Undoubtedly, one of the most severe impacts will be on the landscape due to the changes in relief to which the region will be subjected. Ecosystems represent a strategic function in the provision of ecosystem services, such as provisioning services, regulation services, cultural services, and support services. Necessarily, the development of the project must consider a cost-benefit analysis and the way to mitigate, compensate, reduce or prevent the negative impacts that may be generated.

An essential point about mining is its finite temporality. Mines have a limited life span, depending on the deposits' abundance and depletion. Likewise, mining development is directly linked to global markets and international mineral prices. This directly impacts the local area influenced by mining projects to the extent that any potential gain is always temporary and uncertain. A second point has to do with the role of the State in the administration of natural resources and the possibility of using them as an impulse for development since local conditions are fundamental and often decisive, in Latin America, mining development tends to take place in areas far from large cities and, therefore, it is more associated with secondary cities in predominantly rural areas with a lack of sufficient knowledge for the arrival of a multinational to exploit its resources.

The areas of influence of a mine cannot be calculated by the area of the mining title. The Area of Direct Influence (AID) includes the Area of Punctual Influence (AIP) that corresponds to the area requested for the subtraction of the reserve (515.75 Ha.) and where the exploitation is intended to be carried out by the company, plus the Area of Local Influence (AIL) that corresponds to the villages of the municipality where said mining area is located, which are: La Luisa, La Paloma, and El Diamante, which correspond to 1,191.73 Ha. The second zone, named Area of Indirect Influence (AII), corresponds to the other villages of Cajamarca, including the township of Anaime and the center of the municipality; therefore, it is not possible to assess the exact affectation in terms of a single region or the affectation of an entire department or country.

If the mine restarts its activities, the inhabitants and the government must invest in taking precautionary measures and demand the necessary care and amendments from this multinational. It is known that it is impossible to return to the environmental condition prior to the start of the mine; however, agreements must be reached where the well-being of the community and ecosystems are privileged. It can be evidenced after the evaluation of maps that the community of Cajamarca will have a drastic and rapid change in its territory, way of life, and subsistence. How the mining company and the government articulate the resources to be exploited will be an essential condition in how the system develops humanely and proportionally the capacity of the land.

ACRONYMS

AGA:	AngloGold Ashanti
AGAC:	AngloGold Ashanti Colombia
AMD:	Acid Mine Drainage
AMSL:	*Above Mean Sea Level*
ANFO:	Ammonium nitrate/fuel oil
AIDS:	Acquired Immune Deficiency Syndrome
Au:	Gold Chemistry Symbol
CFRZ:	Central Forest Reserve Zone
CIS:	Carbon In Solution
DANE:	National administrative department of statistics
EIA:	Environmental Impact Assessment
ELAW:	Environmental Law Alliance Worldwide
EOT:	land use scheme
ETP:	Territorial ordering scheme
FRZ:	Forest Reserve Zone
GIRH:	Integrated water resources management
Ha:	Hectares
HCN:	Hydrogen cyanide
IDEAM:	Institute of Hydrology, Meteorology and Environmental Studies
IGAC:	Agustín Codazzi Geographical Institute

IMF:	International Monetary Fund
IIED:	International Institute for the Environment and Development
m.a.s.l:	Meters above the sea level
MAVDT:	Ministery of Environmental, Housing and Territory Development
MAM:	Multiple account matrix
Mha:	Million hectares
Moz:	Million Ounces
POMCA:	Plans Organization and Management of Hydrographic Basins
PFS:	Pre-feasibility study
PND:	National Development Plan
RGB:	Red, Green and Blue Wavelenghts
SWIR:	Short Wave Infrared
USD:	United States Dollar equals
TSF:	Tailings Storage Facility
VSL:	Value of Statistical Life
WCED:	World Comission on Environment and Development

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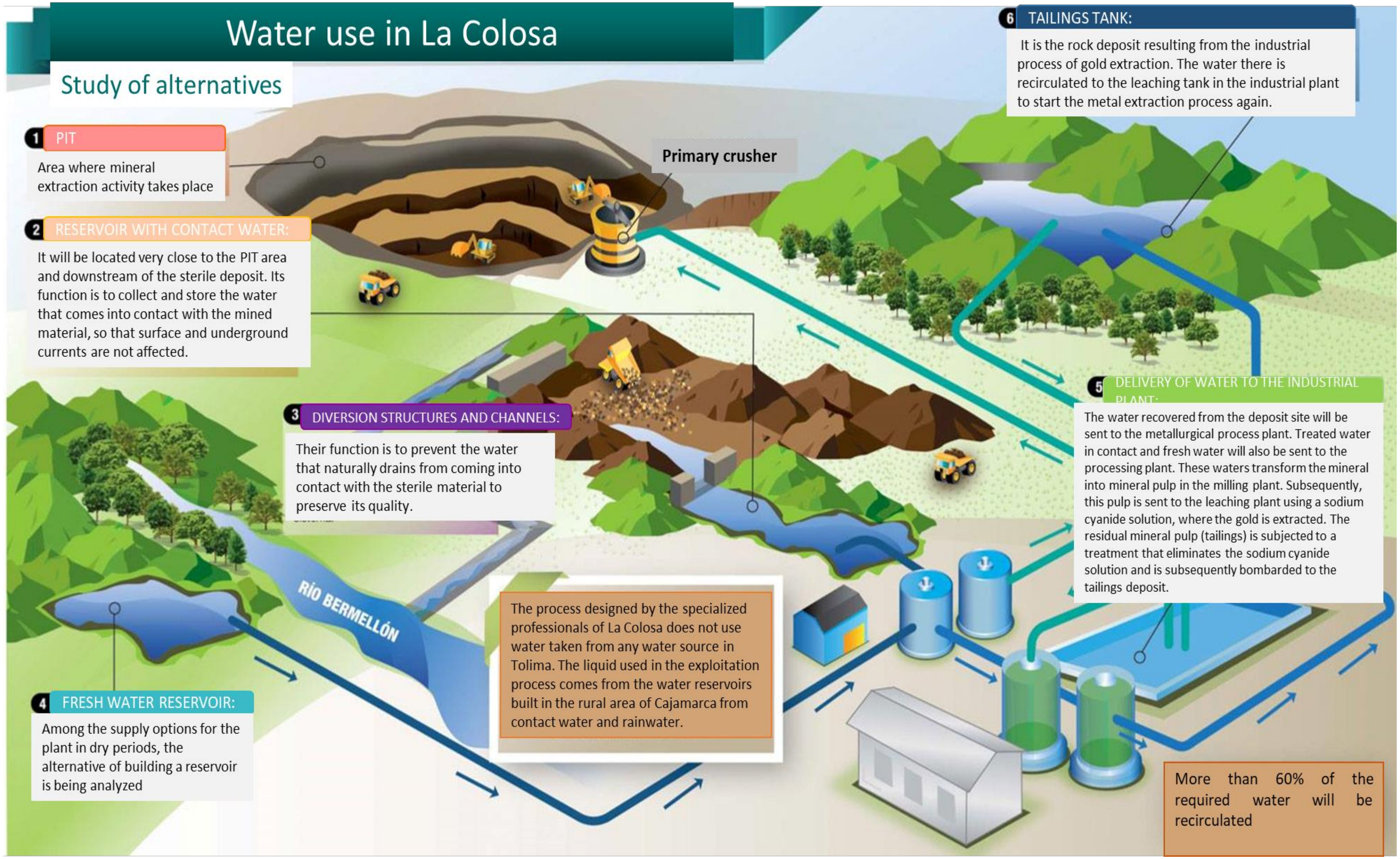
Annex 1


Water use in La Colosa
Study of alternatives
1 PIT
Area where mineral extraction activity takes place
2 RESERVOIR WITH CONTACT WATER:
It will be located very close to the PIT area and downstream of the sterile deposit. Its function is to collect and store the water that comes into contact with the mined material, so that surface and underground currents are not affected.
Primary crusher
6 TAILINGS TANK:
It is the rock deposit resulting from the industrial process of gold extraction. The water there is recirculated to the leaching tank in the industrial plant to start the metal extraction process again.
3 DIVERSION STRUCTURES AND CHANNELS:
Their function is to prevent the water that naturally drains from coming into contact with the sterile material to preserve its quality.
5 DELIVERY OF WATER TO THE INDUSTRIAL PLANT:
The water recovered from the deposit site will be sent to the metallurgical process plant. Treated water in contact and fresh water will also be sent to the processing plant. These waters transform the mineral into mineral pulp in the milling plant. Subsequently, this pulp is sent to the leaching plant using a sodium cyanide solution, where the gold is extracted. The residual mineral pulp (tailings) is subjected to a treatment that eliminates the sodium cyanide solution and is subsequently bombarded to the tailings deposit.
RÍO BERMELLÓN
The process designed by the specialized professionals of La Colosa does not use water taken from any water source in Tolima. The liquid used in the exploitation process comes from the water reservoirs built in the rural area of Cajamarca from contact water and rainwater.
4 FRESH WATER RESERVOIR:
Among the supply options for the plant in dry periods, the alternative of building a reservoir is being analyzed
More than 60% of the required water will be recirculated