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Quantitative and Qualitative Assessment of the "El Sexmo" Tourist Gold Mine (Zaruma, Ecuador) as A Geosite and Mining Site

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Abstract: Zaruma is host to the "El Sexmo" tourist mine, the galleries of which extend below the city, and its exploitation dates back to precolonial times. The mining boom created important development in the area, but informal mining also emerged causing environmental issues and safety problems. This study presents a qualitative and quantitative assessment of the "El Sexmo" Tourist Mine in the context of its potential as a tourism geosite and mining site. The methodological stages included: (i) The process and systematization of the general mine information and its surroundings; (ii) the assessment of the geological and mining interest of the mine, through GAM and Brilha method; and (iii) description and proposal of action strategies through Delphi analysis and a Strengths, Weaknesses, Opportunities, and Threats (SWOT) matrix. Based on the results of the quantitative evaluation, the high values in the educational, scientific, and tourist aspects of the two applied methodologies, show the mine as a potential geosite and mining site with added cultural value. In addition, the quantitative assessment in correspondence with the qualitative analysis, allowed to propose improvement strategies to take advantage of the geological resources and mining identity of the area, as an alternative that strengthens the infrastructure of the mine and consolidates the geotouristic development of the area.

Keywords: geotourism; geosite; mining site; Zaruma; El Sexmo; tourist mine

1. Introduction

Mining activity generates positive impacts on the economy and development of surrounding communities around the influence area of mineral deposits, it also produces negative effects on the economic, ecological, and aesthetic aspects [1–4]. Once mineral exploitation ceases, these productive zones become abandoned areas, and different post-mining reclamation methods are proposed to rescue these areas [5]. Outstanding initiatives include solar power plants in inactive open-pit mines (sustainable energy) [1], theme parks (creation of green areas) [6], underground museums [7], and tourist mines (geological, mining, and cultural heritage) [8].

Some tourist mines represent an example of mining geo-heritage due to the peculiar characteristics that can be used for education, research, and geotourism, and in particular, these places retain historical issues that are closely related to such as cultural aspects, thus constituting a means to approach mining activity in a sustainable way.

Around the world, there are mines that are part of UNESCO (United Nations Educational, Scientific and Cultural Organization) World Cultural Heritage and UNESCO Global Geoparks declared regions. An example of World Cultural Heritage mines are the salt mines of Wieliczka and Bochnia (Poland), whose galleries have hundreds of kilometers with works of art, underground chapels, and statues sculpted in salt that reflect the mining activity developed in Europe from the 13th to the 20th century [9]. In 1978, the Wieliczka salt mine was declared a UNESCO cultural heritage site and later, in 2013, the Bochnia mine was added to the UNESCO World Heritage List as an extension of the Wieliczka salt mine inscription [9,10]. On the other hand, an example of a mine belonging to the UNESCO Global Geoparks is the diamond mine of the Yimengshan Geopark (China) where the largest kimberlite-type diamonds in Asia were extracted during the active phase of the mine. In addition, the mine was the source of the first primary diamond discovered in China [11]. Minas Gerais, Mariana, Tiradentes, Sabara, and Diamantina in Ouro Preto (Brazil), as well as the El Teniente mine in Sewell town (Chile) are some of the gold mining references [12].

Geo-heritage or geological heritage has been defined by Brilha [13] as those elements of in situ and ex situ geodiversity (abiotic elements of nature's diversity) that have exceptional scientific value. Brilha [14] made a list of the main types of geo-heritage in 'UNESCO Global Geoparks' (UGGs) based on the Information Available at the UNESCO Website (127 geoparks' websites), some types of geo-heritage in UNESCO Global Geoparks (UGG) are geomorphology, glacial and ice age, karst, landforms, mining, palaeontological, stratigraphical, tectonics, and volcanological types. Examples of geoparks linked to mining geo-heritage are: Parco Geominerario della Sardegna (Italy), the Tuscan Mining Park (Italy), Comarca Minera (Mexico), Idrija (Slovenia), and central Catalonia (Spain). Mining geo-heritage is a concept directly related to geo-heritage [15] and is part of one of the specific anthropogenic geo-heritage categories [12].

In Ecuador, the term 'geological heritage' or 'geo-heritage' was recently unknown. However, in the wake of the creation of the Ecuadorian Geopark Committee (CEG) in February 2019 and the official declaration of the Imbabura Geopark as a UNESCO Global Geopark in April 2019, which is the first geopark in Ecuador [16] and the seventh geopark to be recognized in South America, the dissemination of the subject has gained increased attention in Ecuador in recent years. Several geopark project initiatives have emerged, such as the Tungurahua Volcano Geopark project, Napo Sumaco Geopark project, Santa Elena Geopark project [17], Galapagos, Puyango Petrified Forest [18], Jama Pedernales, and the "Ruta del Oro" (Gold Route) project [15].

Diverse authors have assessed sites with geological interest using methods based on parameters or criteria (scientific value, educational value, cultural value, scenic/aesthetic values, ecological value, potential use value, recreational value, degradation risk, economic value, tourism value, protection, and functional value, etc.) [19–26].

From the known evaluation methods, two quantitative methods have been selected in this study, considering the different evaluation approaches: (i) The geosite assessment model (GAM), based on a preliminary physical evaluation of geosites and (ii) the Brilha method, which evaluates elements of geodiversity. For instance, the Vrdnik mine, an abandoned coal mine consisting of 26 underground mine shafts up to a depth of 280 m, was a geosite evaluated by the GAM (geosite assessment method) and was part of the first Serbian national park, Fruška Gora Mountain [27]. Another example is the Sierra Mágina Natural Park, located in the south-center of Jaén, Spain, where five sites were evaluated with the Brilha method. The evaluation included Sierra Mpage Karst, which obtained moderate ratings in terms of scientific (300 points), didactic (220 points), and tourism interests (205 points), with a low degradation risk (75 points), which qualifies it as a site of geological interest [28].

In a previous phase of the Academic Research Project, the Spanish Inventory of Geological Places of Interest (IELIG, acronym in Spanish) methodology was used for the consideration of a list of potential geosites and mining sites identified in the Zaruma-Portovelo area (27 sites were previously assessed). The "El Sexmo" Tourist Mine obtained the highest score for its scientific, academic, and tourist interests [15]. With a desire to strengthen the assessment of this site of geological and mining interest, the GAM and Brilha method are used.

Is it possible that the approach and promotion of a tourist mine through enhancement and development strategies of technical and integral mining with consideration of Sustainable Development Goals (SDGs) can become a reference methodology or process for geotourism in the context of a geopark project?

Considering the problem currently (subsidence due to illegal underground mining activity) facing Zaruma and looking for an alternative that enhances the geomining values and its relationship with culture, the aim of this study is to evaluate the "El Sexmo" Tourist Mine as an agent of geotourism and development linked to Sustainable Development Goals (SDGs) through the detailed assessment of its geological and mining interest based on internationally recognized methodologies to proposal of strategies that optimize their use in the context of geological and mining heritage.

1.1. Study Zone

The mining city of Zaruma is located in the southwest of Ecuador, in the upper part of El Oro Province (Figure 1a,b). Zaruma has a strong mining tradition, and it was declared a cultural heritage site of the Ecuadorian State in 1999 [29]. Since 1998, Zaruma has been on UNESCO's tentative list of candidates as a World Heritage Site [30]. Zaruma has a characteristic architectural style (19th century wooden buildings) and lies in a geomorphological landscape featured by steep slopes (Figure 1c). The foundation of the city was on underground galleries due to the existence of an important epithermal-type gold deposit [31]. The "El Sexmo" Tourist Mine is linked to the underground gallery system (Figure 1b,d), whose exploitation ceased because the ore extraction was no longer secure when it transformed into an urban area. Since 2005, the mine has become a tourist complex [32] and it is the oldest mine in Ecuador, whose exploitation dates back to precolonial times. Zaruma city distinguishes the mine for its cultural and geological wealth, and it is an icon of the beginnings of the mining activity in Ecuador. Currently, the area is at high geological risk as it has suffered from subsidence since 2016 due to illegal underground mining activity [33].

1.2. "El Sexmo" Tourist Mine History

The "El Sexmo" Tourist Mine is a mining monument (Figure 1d), a synonym of history, culture, and development. The remarkable structural aspect of the galleries provides evidence of the working conditions of the miners of the 15th century [34]. During the 1880–1896 period, the company Great Zaruma Gold Mining had estimated reserves of 8.40 g/t Au and 5.90 g/t Ag in the Sexmo–Miranda system [35]. Currently, a segment of 500 m of the mine is used for tourism development.

The origin of the "El Sexmo" Tourist Mine dates back five centuries in the mining history of Ecuador, when the golden bonanza season in Zaruma took place in the second half of the 16th century and the first of the 17th century [36]. The gold boom in the region marked this epoch to such an extent that it made the city of Zaruma one of the main economic sources of Spanish America and the royal audience of Quito [30]. At that time, the Inca Empire established the Zaruma–Portovelo district, and history mentioned that the gold extracted from Zaruma's mines was the reward to rescue the Atahualpa Emperor [37].

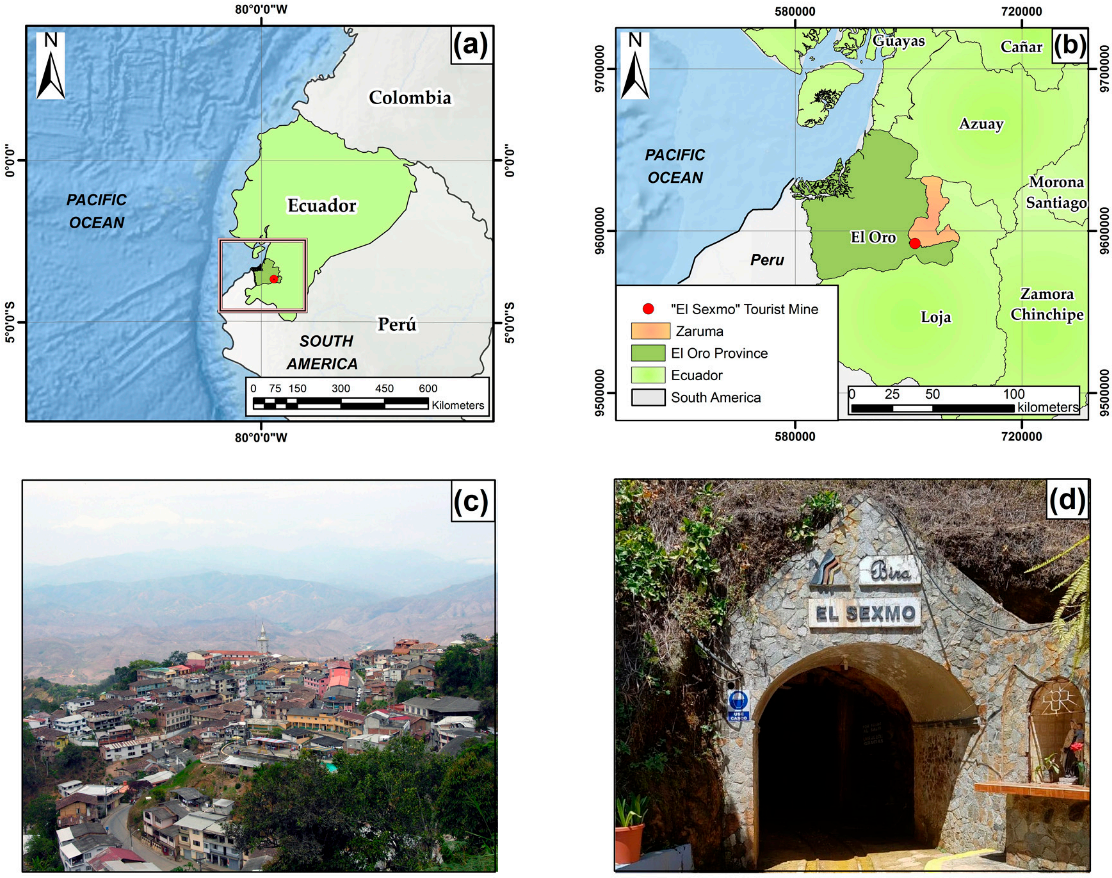

Figure 1. (**a**,**b**) Location of the study area. (**c**) Panoramic view of the Zaruma city. (**d**) "El Sexmo" Tourist Mine.

During the first colonial period, the mining activity operated under a schedule of rotating labor days imposed on the indigenous community; this was known as the system of "mitas" and was proposed by Toledo in 1573 [38–40]. As a result of this cycle, the increase in mineral production gave rise to a historic event in one of Zaruma's mines, the discovery of "pepa de oro", a gold nugget, whose weight was more than three pounds. The gold nugget was given as a gift to Philip II King of Spain, and in gratitude, the King reduced the one-fifth real tax, a percentage that was paid from the extraction of precious metals, to one-sixth (sexmo, in Spanish). The tax was one-sixth of the profits obtained from the deposits and the origin of the mine´s name, i.e., "El Sexmo" [36]. However, extreme labor conditions and the proliferation of epidemics became obstacles to the progress of mining and led to the first crisis in the district [36].

In the late 19th century and during the first half of the 20th century, with the exploration of the German geologist Teodoro Wolf in 1876 [41], investment capital from foreign companies began in Zaruma. In 1880, the first company, the English Zaruma Gold Mining Co. Limited, was in charge of the exploitation of the "El Sexmo" Tourist Mine [36]. Then, the South American Development Co. (SADCO) remained in the country from 1896 to 1950 [42–44]. Later, "Compañía Industrial Minera Asociada" (CIMA, acronym in Spanish), whose shareholders were the Zaruma municipality (52%) and corporate workers (48%), oversaw the mining operations. However, the latter declared bankruptcy in 1978 [42–45]. Currently, due to the depletion of minerals available for safe extraction, the "El Sexmo" Tourist Mine is inactive, and the company "Bira Bienes Raíces S.A." (BIRA S.A., acronym in Spanish) turned it into a tourist mine in 2005 [32].

1.3. "El Sexmo" Tourist Mine Services Offered to Visitors

The services offered by the mine to its visitors are the following: (i) Video of the "El Sexmo" Tourist Mine history, (ii) Underground Tour, (iii) Gift Shop, (iv) Special Exhibitions, (v) Coffee Shop, (vi) Hanging Bridge, and (vii) Viewpoint. It is an amazing tourist experience that helps tourists learn about the mining history of the area, to see objects related to former mining activities, and to learn about its geological context of mineralization, with the main attraction consisting in the underground tour (Figure 2).

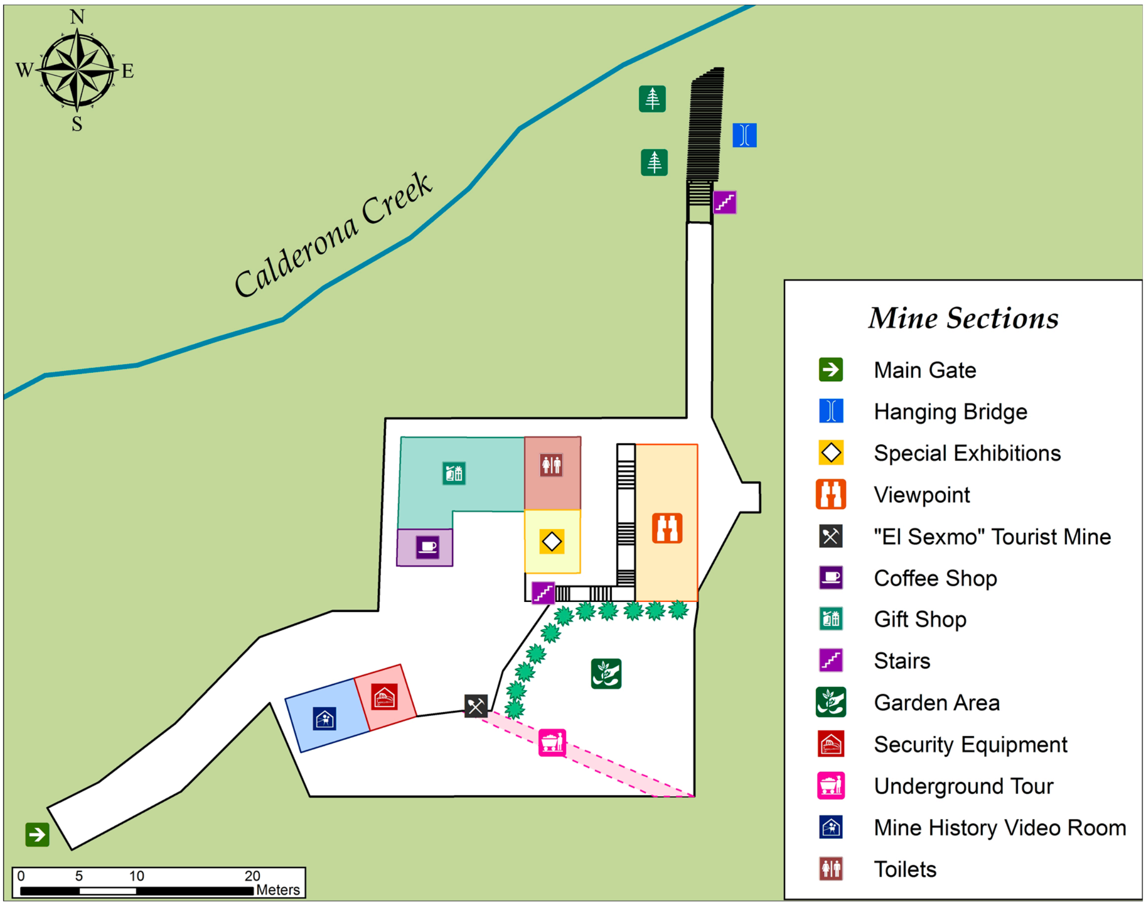

Figure 2. Map of the "El Sexmo" Tourist Mine.

The tour begins in a room where it is possible to see a 10 min long video of the history of the mine and where it is possible to admire photos from 1890 to 1900. After the mine history video, the staff provides personal protective equipment for underground tours and gives a talk about mine safety measures. Visitors then navigate inside a 500 m long underground tunnel. This is on slippery ground due to a constant trickle of water, and there are numerous dummies simulating the work of the miners (Figure S1a,b in the Supplementary Material) and other artisanal and small-scale gold mining elements.

In the underground tour of the mine, it is possible to observe different geological elements such as (i) supergenic alteration on tabular and centimetric quartz veins (Figure S2a in the Supplementary Material) hosting possible disseminated gold and other base metal minerals, (ii) sections of the weathered orebodies characterized by green and brown patinas of Cu and Fe oxide minerals (Figure S2b in the Supplementary Material), (iii) highly fractured andesite host rock (Figure S2c in the Supplementary Material), and finally (iv) formation of stalactites of approximately 30 cm in length generated by leaching of pyrites in contact with water and oxygen (Figure S2d in the Supplementary Material).

Some minerals such as quartz, pyrite, tiny fragments of gold extracted from the mine, and other minerals of the area are exhibited on the superficial tourist complex (Figure S3a–c in the Supplementary

Material), where tourists can buy souvenirs made by local people (Figure S3d in the Supplementary Material). Finally, visitors can enjoy a coffee shop (Figure S4a in the Supplementary Material), experience the view of the valley below and of the surrounding mountain features (Figure S4b in the Supplementary Material), and see flora species of the area through a small hanging bridge (Figure S4c in the Supplementary Material).

2. Geological Setting

The "El Sexmo" Tourist Mine is part of an intermediate sulphidation vein system of Au ± Ag ± Cu [31], have been related to propylitic, argillic, silica, and sericitic alterations type [42,46–48], and that is regionally located in the extension of the southwestern segment of the Miocene metallogenic belt (mineral deposits from the Azuay–El Oro district) in Ecuador [49] (Figure 3a). This district contains tertiary granitoids [50], such as the Cangrejos–Zaruma intrusive complex [49]. The complex has an ESE tendency near the Piñas–Portovelo regional fault, and it is hosted in volcanic rocks of the Oligocene–Early Miocene Saraguro Group.

Within the Azuay–El Oro district, there are several epithermal mineral deposits of the Miocene, such as Zaruma–Portovelo [51,52] (Figure 3b), where there is important structural control of the Palestina and Piñas dextral faults. The faults have a NW–SE trend, where the Palestina fault marks the northern limit of the Zaruma–Portovelo mineral field, and the Piñas fault comprises the southern limit and separates the Saraguro group from the El Oro metamorphic complex [53,54]. Consequently, the structural dynamics have favored the formation of dilating spaces for the location of vein assemblages (Figure 3b), where gold mineralization occurs [46,55] and associated minerals (pyrite, chalcopyrite, sphalerite, galena, bornite, hematite, tetrahedrite, molybdenite, quartz, and calcite) identified in different studies [55–57]. These vein systems have been established in three mineralized domains: N–S, NE–SW, and NW–SE, and the Sexmo fault represents one of the structures of the NE–SW domain [42].

The geology within the study area is formed of metamorphic, igneous, and sedimentary rocks ranging from the Precambrian-Paleozoic to the Quaternary age [55]. The oldest rocks are made up of Tahuín group metamorphic rocks [46], separated from the Andesites and basaltic andesites of the Celica formation (Cretaceous) by the Piñas fault [58]. The rhyolites and rhyolitic tuffs of the Tarqui formation (Mio-Pliocene) unconformably overlain all these units, followed by numerous subvolcanic rhyolite dikes and stocks (Riolitas de Zaruma Urcu, Quaternary) which crosscut the volcanic units. Finally, along the Amarillo and Calera rivers are the Quaternary alluvial and colluvial deposits [59] (Figure 3b).

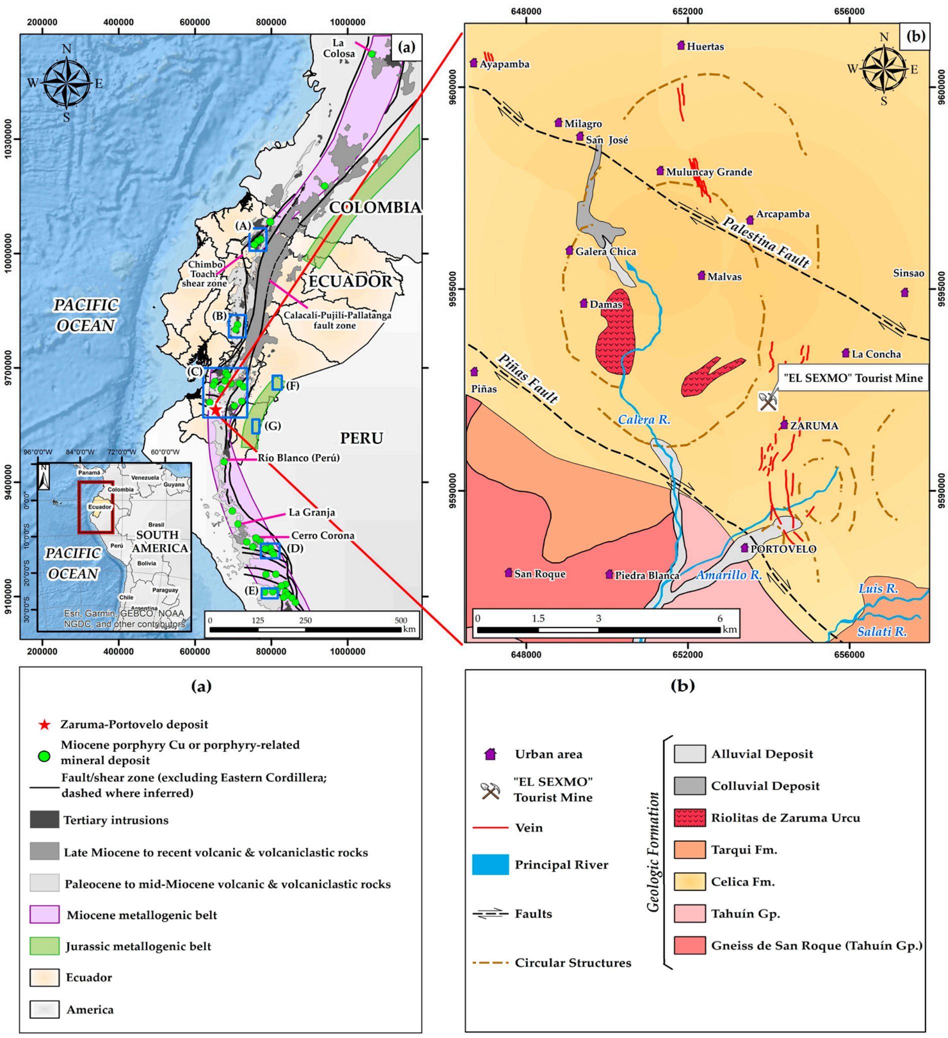

Figure 3. (**a**) A simplified metallogenic map of the NW of the South American margin and location of the Zaruma–Portovelo deposit. Abbreviations: (A) Imbaoeste district (Cuellaje, Junín (Llurimagua)); (B) Bolívar district (Telimbela, Balzapamba); (C) Azuay-El Oro districts (Chaucha, Gaby-Papa Grande, Quimsacocha, Tres Chorreras, El Mozo, Cangrejos, Portovelo-Zaruma); (D) Cajamarca mega-dristric (incl. Yanacocha, Michinquillay); (E) Quiruvilca district (incl. Lagunas Norte); (F) Pangui distric (Mirador, Fruta del Norte); (G) Nambija district, (**b**) The geological setting of the Zaruma–Portovelo mining field and its main structures, veins, geological formations, and the location of the "El Sexmo" Tourist Mine. Adapted from [42,49].

3. Methodology

The methodology used in this study comprised three stages (Figure 4): (i) A detailed inventory of the historical, cultural, tourist, and geological information of the study area; (ii) assessment of the interest and importance of the "El Sexmo" Tourist Mine with two different evaluation methods; and (iii) definition of strategies that optimize the use of the mine using the Delphi and strengths, weaknesses, opportunities, and threats (SWOT) analysis.

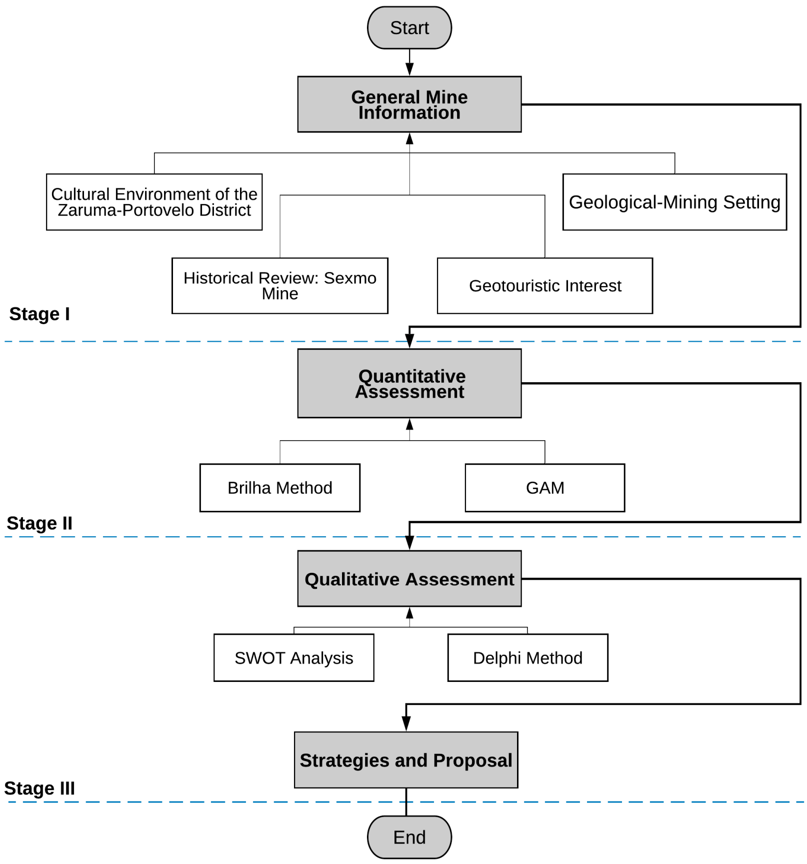

Figure 4. Flowchart of the methodology used in this study.

3.1. First Stage: General Mine Information

In the first stage, the researchers carried out an integral analysis of the characteristics of the mine studied. The process consisted of the collection of historical and cultural information (e.g., [15,30,32,35–37,39,41,43,45]). In addition, the mining geological context of the mine and its setting was defined based on previous studies [31,42,46,49–55] as a basis for subsequent assessment. The potential geotouristic interest presented by the study area was described. Specifically, this phase comprised the use of databases and synthesis of the information in scientific publications, divulgation work, project reports, data collection through interviews, and surveys administered to native people in the industry, former miners, etc. Finally, the study included a review of the regional and local geology of the district of the "El Sexmo" Tourist Mine, mineral deposits, mineralization, and the geological context of the area.

3.2. Second Stage: Quantitative Assessment

Within this phase, assessments were made of the study site using two methodologies, the GAM [26] and Brilha method [13], carried out by three anonymous geoscientific experts with knowledge in geology and mining and professional experience in the area. The information obtained was stored digitally to facilitate its data processing. Next, the parameters that consider each one of the methods used are detailed by means of a schematic and summary presentation of these.

3.2.1. The Geosite Assessment Model (GAM)

The GAM assesses the potential geosite based on two groups of indicators: Main and additional. The first group comprises three indicators: Scientific/educational (VSE), scenic/aesthetic (VSA), and protection (VPr) values. The second group includes functional (VFn) and tourist (VTr) values. In total, there are 12 subindicators of main values and 15 subindicators of additional values that are rated from

0 to 1, according to the parameters in Table 1, with the GAM assessment resulting from the application of Equation (1):

$$\text{GAM} = \text{Main values (VSE + VSA + VPr)} + \text{Additional values (VFn + VTr)}. \quad (1)$$

The results of the GAM assessment are illustrated in a matrix, where the X axis corresponds to the main values and the Y axis to the additional values. This matrix is divided into nine fields (zones) and, according to the rating, the geosite is included in the GAM matrix for interpretation [26].

Table 1. The geosite assessment model (GAM) showing the indicators of the main values and the additional values [26].

<table>
<tr><th colspan="4">Geosite Assessment Model (GAM)</th></tr>
<tr><th colspan="2">Indicators/Subindicators</th><th colspan="2">Indicators/Subindicators</th></tr>
<tr><td rowspan="6">Main Values</td><td>Scientific/Educational values (VSE)</td><td rowspan="6">Additional Values</td><td>Functional values (VFn)</td></tr>
<tr><td>1. Rarity
2. Representativeness
3. Knowledge on geo-scientific issues
4. Level of interpretation</td><td>1. Accessibility
2. Additional natural values
3. Additional anthropogenic values
4. Vicinity of emissive centres
5. Vicinity of important road networks
6. Additional functional values</td></tr>
<tr><td>Scenic/Aesthetic values (VSA)</td><td>Touristic values (VTr)</td></tr>
<tr><td>1. Viewpoints
2. Surface
3. Surrounding landscape and nature
4. Environmental fitting of sites</td><td rowspan="3">1. Promotion
2. Organized visits
3. Vicinity of the visitors' center
4. Interpretative panels
5. Number of visitors
6. Tourism infrastructure
7. Tour guide service
8. Hostel service
9. Restaurant service</td></tr>
<tr><td>Protection values (VPr)</td></tr>
<tr><td>1. Current condition
2. Protection level
3. Vulnerability
4. Suitable number of visitors</td></tr>
</table>

3.2.2. The Brilha Method

This method allows valuation by establishing: (i) Scientific Value (SV), (ii) Use Educational Potential (UEP), (iii) Potential Tourism Use (PTU), and (iv) Degradation Risk (DR). Each criterion is represented by different indicators that are rated from 1 to 4. The final evaluation of each criterion is the weighted sum of the indicators based on their respective scores and a predefined variable weight, as shown in Table 2 [13].

Table 2. Criteria and indicators used for the quantitative assessment of geosites [13].

Brilha Method				
Indicators/Subindicators		**Values**	**Weight**	
Scientific Value (SV)				
A. Representativeness		1–4	30	
B. Key locality			20	
C. Scientific knowledge			5	
D. Integrity			15	
E. Geological diversity			5	
F. Rarity			15	
G. Use limitations			10	
Total			**100**	
Use Educational Potential (UEP) and Potential Tourism Use (PTU)		**Values**	**Weight**	
UEP	**PTU**		**UEP**	**PTU**
A. Vulnerability		1–4	10	10
B. Accessibility			10	10
C. Use limitations			5	5
D. Safety			10	10
E. Logistics			5	5
F. Density of population			5	5
G. Association with other values			5	5
H. Scenery			5	15
I. Uniqueness			5	10
J. Observation conditions			10	5
K. Didactic potential	K. Interpretative potential		20	10
L. Geological diversity	L. Economic level		10	5
	M. Proximity of recreational areas			5
Total			**100**	**100**
Degradation Risk (DR)		**Values**	**Weight**	
A. Deterioration of geological elements		1–4	35	
B. Proximity to areas/activities with potential to cause degradation			20	
C. Legal protection			100	
D. Accessibility			15	
E. Density of population			10	
Total			100	

The total assessment of the risk of degradation, as shown in Table 3, aims to establish priorities in the action plan of any site and to propose strategies for necessary improvement [13].

Table 3. Considering the final value, the degradation risk (DR) can de classified into three classes: Low, moderate, and high [13].

Total Weight	Degradation Risk
<200	Low
201–300	Moderate
301–400	High

3.3. Third Stage: Qualitative Assessment

In this stage, the researchers applied a Delphi method [60,61] to collect, analyze, and understand information on the current potential of the mine and to design improvement plans. The process included interviews with four anonymous experts in the area. Moreover, the experts completed a questionnaire based on five aspects: (i) Quality of services offered by the geological site, (ii) the aesthetic appearance, (iii) prominent qualities, (iv) proposed improvement, and (v) geosite deterioration.

The ideas collected were used as a reference for a SWOT analysis. Next, a SWOT analysis [62] of the "El Sexmo" Tourist Mine and its surroundings was applied. The SWOT analysis was developed to determine the potential of the area in a more ambitious future project and to propose initiatives for the efficient and effective use of the mine and its environment. This stage was carried out with the participation of members of the public and private sectors of the area of interest. Finally, as a product of this third phase, specific alternatives for optimizing the "El Sexmo" Tourist Mine were defined. This was performed as an interpretation and analysis of the processes described above and, in some cases, as an estimate of improvements that could occur.

4. Results

4.1. General Mine Information

Data of the annual visits to the mine (2014–2017) showed a clear upward trend in the number of visits, and the peak number of visits was reached in 2016 (Figure 5). Registration of local and international visitors showed that "El Sexmo" Tourist Mine had more than 35,000 visits (on average about 9000 visits per year) during the last four years. The estimation indicated the average visit duration in the mine per tourist was an hour and a half (25 min of introductory talk, 45 min of visiting inside the mine, and 20 min of sightseeing).

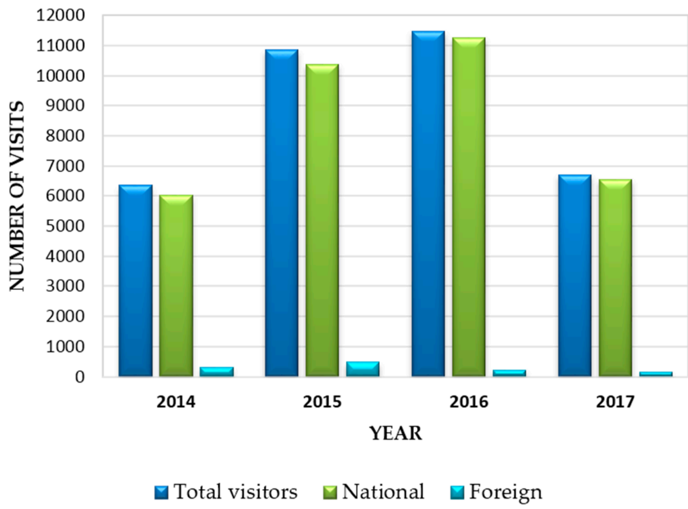

Figure 5. Annual visit data of the "El Sexmo" Tourist Mine.

Although the number of current visits to the mine and their duration indicated that the mine is a relevant tourist destination in the area, it is possible to improve these figures through an increase in the supply of possible activities to extend the duration of the visits. However, the undermining and sinking of a school in Zaruma [33] in December 2016 provided evidence of the damage caused by illegal mining in the area. This incident led to the decree of the State of Exception of the site, and the tourist mine had to close from September to December 2017. Hence, the monthly trend of visits changed negatively that year (Figure 6).

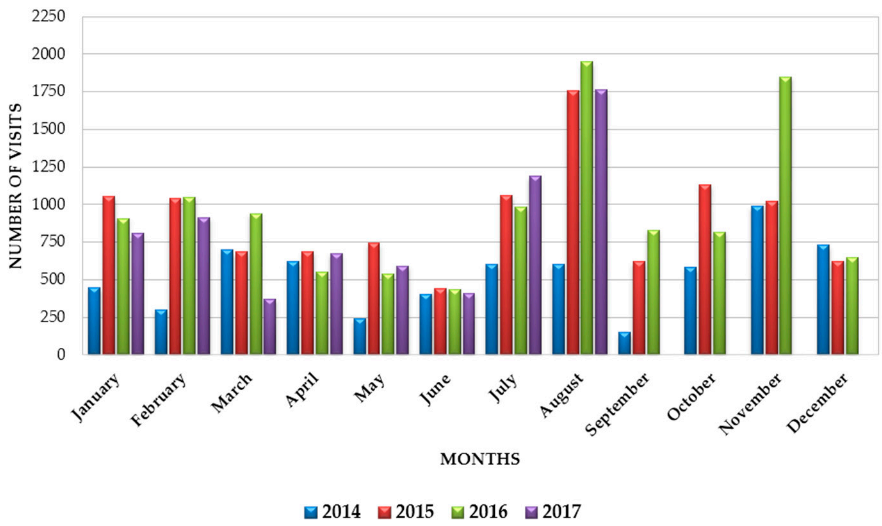

Figure 6. Monthly visit data of the "El Sexmo" Tourist Mine.

The information processing of the mine and its setting, besides serving as a basis for applying the geological-mining interest assessment methods, focused on dissemination materials. Specifically, schemes/posters/panels were made with summarized information on the historical evolution of the mine. Moreover, the information about the geography and geology of the mining area (Figure 7) was incorporated.

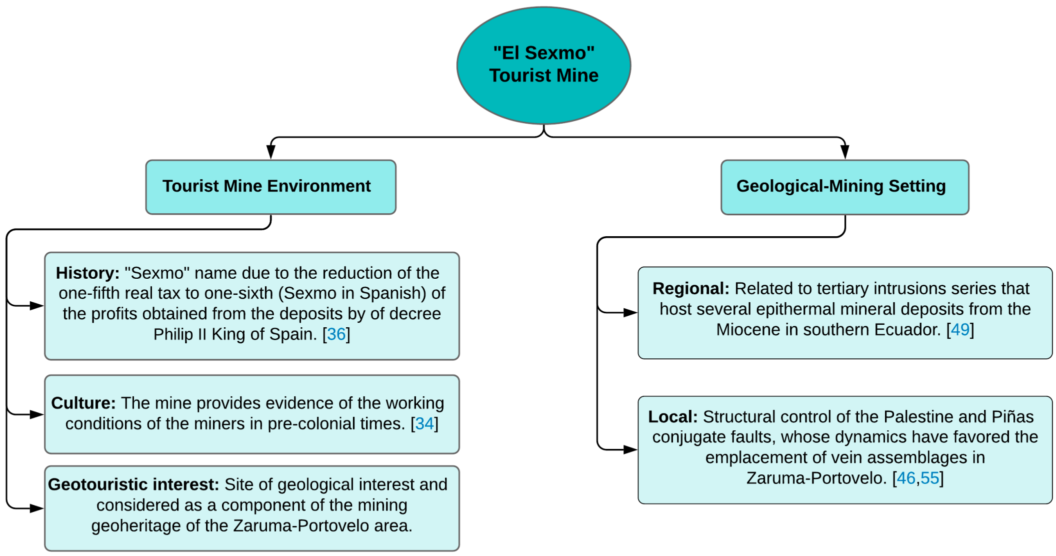

Figure 7. Summary scheme of the characteristics of the "El Sexmo" Tourist Mine and its setting.

4.2. Quantitative Assessment: GAM and Brilha

This section shows the main characteristics of the geological and mining interest site, considering the scientific, educational, and tourist value, degradation risk, and the scenic/aesthetic value, according to parameters assessed in the GAM [26] and Brilha method [13] (Table 4).

Table 4. Description of the main indicators assessed by the GAM and Brilha method.

Values	Indicators/Subindicators	Description
Scientific Value	Representativeness	The mine is a symbol of artisanal mining identity of Zaruma city, recognized as the first mine of the area. It has unique geological characteristics, highlighting the rosary-style veins belonging to part of a regional vein system: Nicole, Gaby, and Octubrina, of hydrothermal origin with a predominance of sulphides and the presence of gold, belonging to the Zaruma–Portovelo intermediate sulphuration deposit. Its average orientation is N-S, associated with the trend of regional fracture of the NW–SE direction (Palestina and Piñas Fault). It is also possible to visualize the city and its unique geomorphological landscape with very steep slopes.
	Geological diversity	It has a high scientific interest; the mineralogical aspect stands out as the primary geological interest, whereas the intrusive, geomorphological, hydrological, petrological, tectonic, landscape, and artisanal exploitation techniques are secondary interests.
	Key locality	The site of geological interest is a good example of mineralization in the south of the country, near the mine is the trend of mineralization formed by the structural dynamics of the Piñas and Palestine faults, which have favored the formation of dilating spaces for the location of vein assemblages with gold content.
	Scientific knowledge	There are studies by universities that have been published in national and international impact journals under different themes (geological, economic, tourism, and cultural).
	Integrity	The good state of conservation of the site allows us to visualize the veins present with mineralization; at the beginning of the tour ("bocamina"), the mine presents stabilization with concrete and drains, which prevent detachment by water and fracture action in the massif.
	Rarity	The regional mineralogical environment is identified as epi-mesothermal; however, in the study area, the minerals present indicate a uniquely epithermal environment. The site of geological interest is the only one recognized as a founder of artisanal mining in Ecuador. This mine has characteristics of the development of artisanal mining in the precolonial times, as well as stories of Spanish mining.
	Use limitations	The mine allows studies of scientific interest after requesting the necessary permits. It is a site of geotouristic interest that collaborates and maintains a relationship with the scientific community.
Potential Educational and Touristic Uses	Vulnerability	The site is in proximity to areas with illegal mining, an anthropic activity that has caused subsidence events in Zaruma, such as the sinking of the "La Inmaculada Fe y Alegría" school and surrounding houses.
	Accessibility	The site is located less than 900 m from a Zaruma urban center by paved road (Estimated duration: 3 min per car and 15 min on foot).
	Use limitations	The mine tour is free (no need to pay an entrance fee); operating hours: Monday–Sunday (8:00 to 16:00), and the site has no limitations for use by students and tourists.
	Safety	The site provides personal protective equipment such as a helmet and rubber boots for underground tours; the mine entrance is reinforced concrete and is drained to ensure its stability. Additionally, there is an account mobile phone coverage, and the mine is located less than 1.5 km from emergency services.
	Logistics	Lodging and restaurants for groups of 50 persons are less than 15 km away from the site.
	Density of population	The site is located in a municipality with 37.14 inhabitants/km^2 [63].
	Association with other values	An illustrative example of the cultural heritage of Zaruma town is the "El Sexmo" Tourist Mine; the site reflects mining activity carried out in precolonial times, and it is the oldest mine in Ecuador. The mine is named after the king, due to the historic event of a reduction of the fifth real tax by one-sixth by decree of Philip II King of Spain in gratitude for the discovery of "pepa de oro" (gold nugget), whose weight was more than three pounds. In addition, the site shows the good side of mining as one of the initiatives of reclamation in a post-mining environmentally friendly and sustainable way.

Table 4. *Cont.*

Values	Indicators/Subindicators	Description
	Scenery	The site is currently used as a tourism destination in national campaigns such as field visits by universities (e.g., ESPOL Polytechnic University) by students of mining and geology engineering, in addition to visits organized by groups of students from local secondary and elementary schools.
	Uniqueness	The site shows unique and uncommon features in Ecuador due to the mine being an artisanal and small-scale gold mining example that keeps aspects of the cultural heritage of the mining area.
	Observation conditions	All geological elements are observed to be in good condition.
	Didactic potential	After the mine history video, visitors navigate inside a 500 m long underground tunnel on slippery ground along the railway that hauled tons of ore out of the mine, wearing equipment used by geologists and miners, attempting to understand the difficult work of miners (artisanal and small-scale gold mining in SW Ecuador) as they learn about the mining history of the area, objects related to former mining activities, and the geological context of hydrothermal alterations in one type of rock (igneous rock). The information can be easily understood by students with different educational levels.
	Geological diversity	The site has more than three types of geodiverse elements that occur in the site (mining, intrusive, geomorphological, hydrological, petrological, tectonic, landscape, and artisanal exploitation techniques).
	Interpretative potential	The site presents artisanal and small-scale gold mining elements in a very clear and expressive way to all members of the public.
	Economic level	The average of the Zaruma Canton of unsatisfied basic needs (NBI) referring to the poor population is 75.9% and that of the nonpoor population 24.1%. In other words, nine out of 10 parishes have a poor population in excess of 60%, and one parish in a nonpoor population exceeds 60% [63].
	Proximity of recreational areas	The site is located less than 5 km from recreational areas and tourist attractions (Zaruma Center Historic, Zaruma Municipal Museum, Shrine of the Virgen del Carmen, Zaruma Urcu hill, Calvario hill, a coffee shop, and Zaruma's traditional meals).
Degradation Risk (DR)	Deterioration of geological elements	There is a possibility of deterioration of secondary geological elements.
	Proximity to areas/activities with potential to cause degradation	The site is located less than 1 km from a potential degrading area/activity.
	Legal protection	The mine lacks legal support, which ensures sustainability and validity, but it is located within a new area of exclusion of mining activity delimited under the urban area of the city of Zaruma according to the Ministerial Agreement 2019–0050-AM.
Scenic/ Aesthetic values	Viewpoints	The mine has a main gate with a sign displaying its name that can be seen from at least two vantage points.
	Surface	The underground tunnel is 500 m long, and the surface zone of the mine (mine history video room, gift shop, hanging bridge, viewpoint, and coffee shop) has an approximate area of 1300 m^2.
	Surrounding landscape and nature	Tourists can enjoy a spectacular view of the valley below and of the surrounding mountains.
	Environmental fitting of sites	The site fits perfectly with the natural environment of the study area.

4.2.1. GAM Results

This section shows the evaluation of the "El Sexmo" Tourist Mine with the GAM [26]. The main values (scientific–natural) show a high degree in its VSE (3/4) and VPr indicators (3.5/4) and moderate in VSA (2.5/4), with a low value in the surface subindicator due to the limited size of the geosite (Table 5). An additional (anthropogenic) value has high scores in its VFn indicators (5.75/6) and VTr (6.25/8). Considering the total of the main and additional values, this methodology places the mine in the Z_{33} field, as shown in the matrix of Figure 8.

Table 5. Evaluation scores for each indicator of the main and additional values of the GAM [26] applied to the "El Sexmo" Tourist Mine.

Geosite Assessment Model (GAM)					
Values	**Indicators/Subindicators**	**Score**	**Values**	**Indicators/Subindicators**	**Score**
MAIN VALUES	**Scientific/Educational values (VSE)**		ADDITIONAL VALUES	**Functional values (VFn)**	
	1. Rarity	0.5		1. Accessibility	1
	2. Representativeness	0.75		2. Additional natural values	1
	3. Knowledge on geoscientific issues	1		3. Additional anthropogenic values	1
	4. Level of interpretation	0.75		4. Vicinity of emissive centres	1
	(VSE) Total	**3.00**		5. Vicinity of important road network	0.75
				6. Additional functional values	1
	Scenic/Aesthetic values (VSA)			**(VFn) Total**	**5.75**
	1. Viewpoints	0.5		**Touristic values (VTr)**	
	2. Surface	0		1. Promotion	1
	3. Surrounding landscape and nature	1		2. Organized visits	0.75
	4. Environmental fitting of sites	1		3. Vicinity of the visitors' center	0.25
	(VSA) Total	**2.5**		4. Interpretative panels	0.5
	Protection (VPr)			5. Number of visitors	0.5
	1. Current condition	1		6. Tourism infrastructure	0.75
	2. Protection level	1		7. Tour guide serve	0.75
	3. Vulnerability	0.5		8. Hostel service	1
	4. Suitable number of visitors	1		9. Restaurant service	0.75
	(VPr) Total	**3.5**		**(VTr) Total**	**6.25**

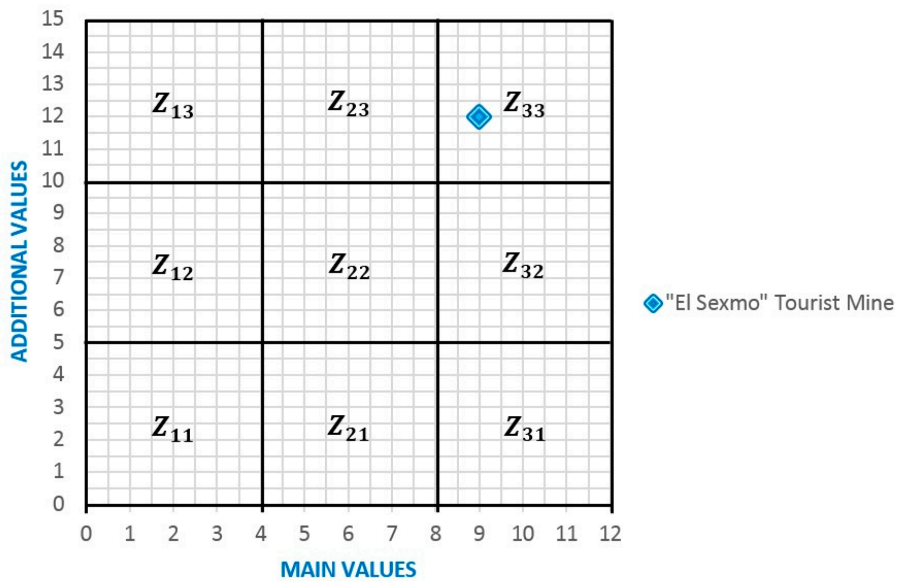

Figure 8. Position of the "El Sexmo" Tourist Mine as a result of the assessment with the GAM [26].

4.2.2. The Brilha Method Results

The parameters evaluated by the Brilha method [13] indicated high values for the scientific (340/400 points), tourism (340/400 points), and educational (330/400 points) indicators. However, the value obtained for the parameters of the degradation risk indicator (250/400 points) indicated a moderate degradation risk, as detailed in Table 6.

Table 6. Criteria indicators used for the quantitative assessment of the "El Sexmo" Tourist Mine by [13].

Brilha Method				
Indicators/Subindicators		**Values**	**Weight**	
Scientific Value (SV)				
A. Representativeness		4	120	
B. Key locality		2	40	
C. Scientific knowledge		4	20	
D. Integrity		4	60	
E. Geological diversity		4	20	
F. Rarity		4	60	
G. Use limitations		2	10	
Total			**340**	
Potential Educational and Touristic Uses		**Values**	**Weight**	
UEP	**PTU**		**UEP**	**PTU**
A. Vulnerability		3	30	30
B. Accessibility		3	30	30
C. Use limitations		4	20	20
D. Safety		4	40	40
E. Logistics		4	20	20
F. Density of population		1	5	5
G. Association with other values		4	20	20
H. Scenery		4	20	60
I. Uniqueness		3	15	30
J. Observation conditions		4	40	20
K. Didactic potential	K. Interpretative potential	4 4	80	40
L. Geological diversity	L. Economic level	4 1	40	5
	M. Proximity of recreational areas	4		20
Total			**330**	**340**
Degradation Risk (DR)		**Values**	**Weight**	
A. Deterioration of geological elements		2	70	
B. Proximity to areas/activities with potential to cause degradation		1	20	
C. Legal protection		3	60	
D. Accessibility		4	60	
E. Density of population		4	40	
Total			**250**	

4.3. The Delphi Method Results

Based on the questionnaires, the "El Sexmo" Tourist Mine and its surroundings have relevance as a place of visit due to the location, access, available services, and, mainly, the great historical importance. Moreover, the results highlighted the geological and mining interest. However, the anthropic activities and natural phenomena have increased the risk of degradation. As the mine is an example of recovery of mining spaces for geotourism, it is necessary to consider actions for preserving this heritage. Both cultural and historical aspects provided an opportunity for sustainable development of the sector (geotourism). The proposed ideas were the basis for the development of the SWOT analysis.

4.4. The SWOT Matrix

The SWOT matrix was developed from the data obtained from the Delphi method and the focus group of community members and municipal authorities during the workshop "Geotourism Perspectives in the upper part of El Oro province, Zaruma–Portovelo". The workshop allowed the use of participatory methodologies for recognizing "El Sexmo" as a site of great historical and cultural relevance with great potential if promotional strategies are carried out. Furthermore, a recommendation for the mine protection plan arose, as its conservation is vital to disseminate and maintain the site representativeness of the mining identity. The SWOT summary of the study area is presented in the Table 7.

Table 7. Strengths, weaknesses, opportunities, and threats (SWOT) matrix of the "El Sexmo" Tourist Mine.

Internal Environment / External Environment	Strengths	Weaknesses
	S_1. "El Sexmo" Tourist Mine, a symbol of mining identity. **S_2.** Strategic location. **S_3.** It has a variety of services of a tourist mine such as free underground tours, free surface tours, gift shop, special exhibitions, and a mine history video. **S_4.** Area of geological-mining interest (geosite potential).	**W_1.** The parking service and roads of the geosite and the place are limited. **W_2.** The mine does not present a virtual tour, and there is no official website of the site. **W_3.** There is a lack of a recreational park for children as a learning tool. **W_4.** Limited educational and scientific publications.
Opportunities	**Strategies: Strengths + Opportunities**	**Strategies: Weaknesses + Opportunities**
O_1. Support the creation of a geopark. **O_2.** Use the mine as an example of environmental awareness projection for cultural and natural conservation through tourism. **O_3.** Invest in basic services and road infrastructure. **O_4.** Exploit the mine as an alternative for the scientific/educational interest, tourism, and economic development of the area.	**$S_1.O_1$.** Bolster the recognition of several geosites in the study area and the creation of a geopark proposal. **$S_1.O_2$.** Boost an innovation project for the mine to be considered an official geosite mining site. **$S_4.O_1.O_3$.** Adapt the surrounding conditions for the repowering of the geosite. **$S_3.O_1.O_4$.** Promote the "El Sexmo" Tourist Mine as a technical, social, environmental, and cultural example.	**$W_1.O_3$.** Redesign the road infrastructure taking advantage of underground spaces as parking spaces for visitors. **$W_3.O_4$.** Complement the services offered by the mine, implementing spaces that encourage child participation and scientific/educational development. **$W_4.O_4$.** Promote the site (geosite) through informative and scientific publications that involve the scientific–social–business nexus.
Threats	**Strategies: Strengths + Threats**	**Strategies: Weaknesses + Threats**
T_1. High degradation because it is located near illegal mining activity, which has caused damage to the urban infrastructure. **T_2.** Deterioration due to natural events. **T_3.** The high density of abandoned underground spaces with the possibility of becoming tourist attractions in the study area would cause the mine to lose its uniqueness. **T_4.** It lacks full legal support, which ensures its sustainability and validity.	**$S_1.T_1.T_4$.** Protect the tourist mine as an identity of Zaruma in the inventory of the Tourism and Heritage Ministry. **$S_2.T_2$.** Generate studies/stabilization works for the mine due to its natural conditions. **$S_1.T_3$.** Promote a program of innovation strategies that add value to the site.	**$W_1.T_3$.** Take advantage of abandoned underground spaces for parking. **$W_2.T_3$.** Create a web page with virtual visitors to strengthen tourism activity. **$W_4.T_1.T_2$.** Develop scientific publications to identify the possible threats to anthropic and natural events.

4.5. Initiatives and Proposals

As a global result of the assessments and analysis of the "El Sexmo" Tourist Mine, the researchers proposed some specific and general initiatives that could be carried out in the study area. These include the following:

- The official presentation of the evaluation work of the "El Sexmo" Tourist Mine as a site with potential for local authorities (Zaruma City Council) for the achievement of official recognition as a UNESCO Global Geopark. In addition, the strategies derived from the SWOT analysis will be delivered in detail as a reference for developing initiatives to take advantage of this important resource.
- The definition of complementary activities to those currently offered at the "El Sexmo" Tourist Mine. Specifically, the creation of a gold-panning zone in the facilities, creation of informative panels of the geological and mining interest of the mine and the locality, and the organization of periodical visits of students from schools and colleges. A general estimate of the increase in the average tourist visit duration time, with the materialization of the proposals described above, would reach 100% (from one and a half to three hours).
- The development of a detailed inventory and evaluation proposal of other locations with potential to be considered as geosites (e.g., Cerro de Arcos) and mining sites (e.g., Magner Turner Mineralogical Museum) in the Zaruma and Portovelo municipalities [15]. A general estimate of the increase in the average tourist view visit duration in the area, with the inclusion of two additional points of interest would mean having a visit offered for one full day.
- Scientific support for the initiative to create a geopark that would be called "Ruta del Oro" (Gold Route) that has its starting point at the "El Sexmo" Tourist Mine, which also includes 27 sites of

geological and mining interest in its proposal. This initiative would be based on previous studies that already addressed this possibility (e.g., [15,64]). This initiative would mean being able to offer a broader visit to achieve at least a couple of days' worth of visitation possibilities, with the corresponding economic benefit for the involved stakeholders.

5. Interpretation of Results and Discussion

Based on the methodology for performing the qualitative and quantitative assessment to define "El Sexmo" Tourist Mine as a geosite or mining site, the study allows exposing the geological, historical, and cultural environment that surrounds the mine. Moreover, it addresses the need for alternative routes of economic development. Carrión Mero et al. [15] carried out a previous assessment of a group of geological places of interest (27 sites), where the "El Sexmo" Tourist Mine obtained the highest score for its scientific, academic, and tourist interest and highlighting the mineralogical and historical attraction of the gold mining operation. Thus, the assessment work presented in this study with the GAM [26] and Brilha method [13] (Table 5) presents similar results to the estimates obtained by [15] using the García–Cortés assessment methodology [19].

Despite having high additional values (functional and tourist), it is essential to monitor these values to analyze the consequences of tourism development by increasing the number of visits and assessing the possible threats to the mine, such as the deterioration of the mine and the natural environment in which it is located. Thus, the data would provide information for planning according to the load capacity and reality of the site.

The high scores obtained for the SV, PEU, and PTU with the Brilha method [13] show that the study area represents an important geological feature with aesthetic relevance, which makes it a destination for research and scientific knowledge at an international level (Table 6). Regarding the total assessment of the DR, it presents a moderate risk of degradation due to natural or anthropic events, with little legal protection and proximity to areas with illegal mining, where the secondary galleries of the mine could be used as an alternate access, contributing even more to the problems of illegal exploitation that the study area is currently experiencing. As there is a high probability of man-induced degradation, strategies that reduce the risk and enhance the mine as an alternative for geotouristic development are essential. In addition, through the assessment methodology, one of the lowest values obtained was that of the economic level of the sector. This parameter influences the quality of tourism services provided by Zaruma city and its surrounding areas, which could be reflected in the number of tourists.

The results of the assessments with the GAM and Brilha method provided data for the Delphi qualitative analysis where geoscientific experts highlighted the importance of the mine as an example of a mine closure plan and the recovery of abandoned underground spaces. Moreover, the analysis suggested that the geotourism alternative would boost the initiative of the "Ruta del Oro" (Gold Route) Geopark project.

Considering the point of view of the community and the previous analysis of experts, the SWOT matrix provided information to propose strategies that complement the services offered by the mine (Table 7). Among those services, the study highlights the implementation of spaces aimed at child participation as a didactic tool and the creation of a gold-panning zone (activity of the mining culture of the area), as well as the installation of information panels of geological and mining interest. Moreover, another idea is to take advantage of one of the main weaknesses of the place (limited parking spaces) by using inactive tunnels as parking lots.

Finally, it is essential to incorporate a virtual visit that strengthens and increases the influx of the tourism sector to disseminate information of the site nationally and internationally and to consider the registration of annual visits (Figures 5 and 6).

6. Conclusions

The methodologies for the assessment of geological and mining points of interest allowed for a correct characterization and evaluation of the study area under different parameters that include high values for the educational, scientific, and tourist aspects. Therefore, the "El Sexmo" Tourist Mine has high value as a geological and mining heritage, which makes it an icon of the geotourism of the sector. These characteristics add a cultural and positive value to the mining activity as a solution to the existing problem. The researchers analyzed the types of anthropic threats (illegal mining in urban areas) and natural threats (landslides and deterioration of the massif by water leaks) that the geosite faces to reinforce aspects of protection and conservation.

As the study area was classified as a geosite and mining site of considerable relevance, the SWOT and Delphi analyses were fundamental techniques. The "El Sexmo" Tourist Mine was highlighted as a symbol of the mining identity of Ecuador and a point of geological and mining interest. However, the analysis presented the illegal mining activity, road infrastructure, and limited scientific and tourist dissemination as weaknesses. Under these conditions, the solution strategies proposed are as follows: (i) Promote the "Ruta del Oro" (Gold Route) Geopark project, (ii) include the mine as a recognized geosite, (iii) to redesign the road infrastructure of the sector, and (iv) implement a disclosure system through scientific manuscripts and virtual advertising.

Based on the general report of annual visits of approximately 9000 visitors per year, this study and its proposals for protection and improvement could increase the number of visitors to approximately 12,000 people per year. Consequently, the results of this study will boost tourism, knowledge, and economic activity, which will promote the sustainable development of geotourism in the sector. Finally, given the current limited strategies of the mine, a modification in the communication routes could give excellent results in the educational and geotouristic sectors.

Supplementary Materials: The following are available online at http://www.mdpi.com/2079-9276/9/3/28/s1, Figure S1: Services in "El Sexmo" Tourist Mine. (a,b) Underground tour, Figure S2: Underground tour. (a) Quartz vein with copper sulphides lixiviated to copper sulphates (green hue). (b) Rock massif with presence lixiviation of oxides and hydroxides of iron and copper sulphides. (c) Wall rock (andesite) with fractures. (d) Mine tunnel with stalactites (iron oxides and hydroxides stalactites), Figure S3: Superficial tourist complex. (a–c) Special exhibitions and (d) Gift Shop, Figure S4: Superficial tourist complex. (a) Coffee Shop, (b) Viewpoint, and (c) Hanging bridge.

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