

Proposal for a Mining-Touristic Route in Parque Minero Industrial Mochuelo Bajo, Bogota. A Look from the Environmental, Social and Productive Factor



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ABSTRACT

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Minerals extraction processes are the foundation on which industrial societies are sustained. In Bogotá, the park Mochuelo Bajo emerges as an area of clay exploitation for the production of construction materials. This article aims to discover the geo-touristic potential of the area through the Integrated Approach for Assessing the Geotourism method. In addition, the investigation proposes the creation of a possible tourist route and the analysis of opportunities, strengths, weaknesses and threats in the area, in order to implement this proposal and to calculate the cost of the tour. The methodology consisted of a mixed approach with an exploratory scope, using as data sources, interviews, tours of the area, non-participant observation and secondary data, which were collected from the mines as well as from the inhabitants of the study area and in official information sources. The results obtained indicate the mining proposal has a high potential and so, the possible threats and weaknesses could be handled through administrative controls. Additionally, it was possible to locate a route with five areas to be intervened, and where the importance of clay in production processes, the different materials obtained from this, as well as the industrial evolution in the sector is highlighted.

1. INTRODUCTION

Tourism is a traditional activity of the human being. According to the World Tourism Organization (UNWTO) [1], there are different types of tourism including cultural, rural, adventure, health, wellness, medical, business, gastronomic, hiking, educational, sports, coastal, maritime and internal waters. Same as these types of tourism, the concept of geo-tourism has been constituted for the last three decades [2] and this focuses on financing and promoting the conservation of geo-sites, where it's possible to identify landscapes and geological materials, whether it's in place or in museums [3]. This can be categorized according to different studies in three areas: 1) Tourism based in geodiversity, which main focus is to protect the different types of mining geo-tourism elements. 2) Geo-inheritance or ecology heritage, which protects cultural history and industrial progress of mining sites and number 3) which combines the two approaches [4].

It is possible to recognize different current mining-touristic development projects, with a focus on geological heritage protection, being mining-tourism, in post-extractive scenarios, the most widely known for its impact on local development [5]. In fact, mining-touristic development, which highlights mining history, manages to sustainably recover areas by promoting their reconstruction, the recuperation of the territory's identity and economic recovery, preventing those areas from becoming ghost towns [6-12]. Moreover, there can be found mining touristic processes that address active mining and the mining industry. Owing to research conducted by Ghazi et al. [8] in Iran's mining sites and by Beretić et al. [13] in Sardinia's geo-

mining park, the importance of tourism development in active mines is recognized. For instance, this plays a major role in economic and environmental sustainability, as well as in the rural and territorial development. As a result, tourism promotes the interaction between parties willing to make alliances and common agreements with a view to collective well-being.

In Colombia, there are different geo-sites which have promoted development based on mining-touristic proposals. As an example of this, Zipaquirá's Salt Cathedral which has gained an important role at a national and regional level, thanks to the religious and cultural identity surrounding it; this in spite of the mining activity which dates to pre-Columbian times. This park of the salt, allows tourists to observe the inside of the miner route, which give the visitor the opportunity to experience the process of salt extraction, by the use of tools specially meant for this [14]. Eighteen (18) km from Zipaquirá, is the salt mines of Nemocón, which have developed processes of mining and gastronomic tourism, highlighting the importance of heritage and geological inheritance recognition, as well as the necessity to integrate mining tourism with gastronomic and local development aspects [15]. At the north side of Colombia, in la Guajira, one can find other types of active mining tourism, linked to carbon extraction. This is the case of Cerrejón, a Colombian company which has explored the implementation of touristic spaces, where they call attention to the importance of including indigenous communities of their scope, with the purpose of creating employment which could be sustainable in time, as well as spotlight the region's cultural richness [16].

Along with the interest of creating mining tourism spaces in Colombia, it's possible to identify some studies in which the potential of the development of geo-touristic spaces has been studied. Delgado and Pantoja [17] conducted a project which aimed to propose a gold route for the town of Tambo-Nariño, where, through the visit to 15 places, the mining heritage could be highlighted, as well as the rich biodiversity, culture and history. In the same field as this, there is another project carried out by Vásquez et al. [18] who created a proposal to mark the route of the emerald, emphasizing on their analysis, a proposal of tour packages costs for the development of this one. This research was conducted, with the purpose of creating a mining-touristic proposal in the Parque Minero Industrial El Mochuelo, located in Bogotá D.C, which activity is dedicated to the extraction of clayish materials for that would allow to: 1) assess the mining-touristic potential in the area, 2) identify the places that would make part of the route 3), identify opportunities, strengths, weaknesses and threats to be taken into account in the possible implementation of the route and 4) make an estimate of the mining-touristic tour fee. From this moment and forth, the document will be divided in four sections being these: Materials and Methods (where the method and procedures implemented in the investigation will be described), the field of study, (where there will be a description of the chosen area and its importance in the demarcation of a mining-touristic route), the results, (where the findings for each of the objectives are to be reported) and finally the conclusions and recommendations, where the most significant results will be reviewed.

2. MATERIALS AND METHODS

The research was based on a mixed method and qualitative analysis, which permitted the obtention of descriptive data and different characteristics, key to the consolidation of the mining touristic proposal. Furthermore, from a quantitative perspective it was sought to assess the tourism potential through the use of scales and likewise the tour amount was estimated. In what refers to the method, it is known that the field of investigation is emergent and exploratory to different countries and therefore, there exist multiple methodological approaches based on objectives that seek the implementation of geotourism processes. In this paper, the approaches addressed in the research projects conducted by Kubalíková [19] and Singh and Ghosh [4] were taken into consideration; these helped to establish the potential for the consolidation of the tourism proposals, by means of a descriptive analysis. This approach implies advantages when identifying tourism potential in the chosen areas, as well as at the moment of determining the aspects to be intervened to increase potential. However, there is presence of gaps in the perspective of the supply as opposed to tourism demand; these are objectives to be reviewed in another investigation.

The sources of information for the creation of the study, take into account qualitative information, such as documents obtained in field, conversations with different companies from the MIP Mochuelo, visits and pictures from the area. Furthermore, secondary quantitative information was processed, in order to make the economic analysis related to the fee to be paid when making the route tour. Data processing was made based on the method proposed by Kubalíková, [19] and Singh and Ghosh [4], under which qualities are analyzed, with the aim of evaluating tourism potential, strengths,

opportunities, threats and weaknesses, so as for them to be addressed and reinforced prior to the proposal implementation. Additionally, a spatial data processing was performed for the proposed route and for such purpose the software ArcCatalog 10.8 was implemented. The methodological approach implemented in this research is summarized in Figure 1.

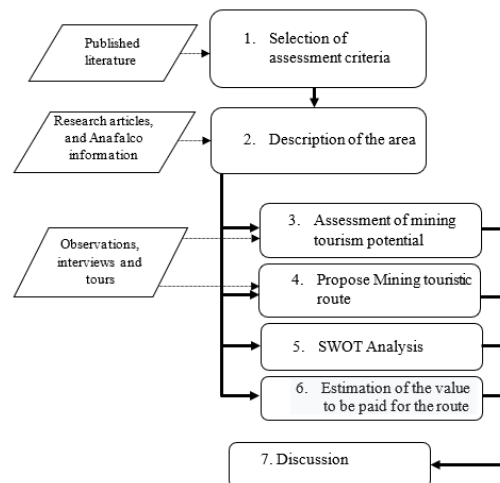


Figure 1. Methodological framework

2.1 Selection of the method for the definition of touristic potential

Although the evaluation of mining-touristic potential is an area of knowledge in recent exploration, during the last decade, different methods to evaluate geo-touristic methods in different areas have risen [4]. In order to identify this potential in the MIP Mochuelo in Bogotá, the research was conducted based on Kubalíková [19] methodology, which proposes a qualitative evaluation of the potential in the area, through the analysis of interdisciplinary categories that evaluate the geological, geomorphological, ecological, hydrological, historical, cultural scientific and conservative potential of an area. This methodology has been implemented by researchers such as Doucek and Josef [20], Ésik et al. [21], Kubalíková et al. [22], Paskova et al. [23], Paskova and Josef [24], Welc and Miśkiewicz [25] in countries such as Poland, Brazil, Czech Republic and Hungary.

According to Kubalíková [19] this methodology is divided in three phases: 1) Describing in detail the mining geo-sites, 2) evaluating geographic sites and 3) proposing a synthesis of management and conservation measures. In the case of this research, this methodology was adapted and proposed, in addition to what is stated by the aforementioned author, a mining touristic route indicating the strategic points to be visited by the tourists. Moreover, a fee to be paid for taking the tour was fixed with the purpose of making the mining-touristic proposal viable. (Figure 1) This methodology allows for the disruptive innovation in the mining sector by addressing geotourism in the area; a sector not yet developed by this industry. For mining companies, this sets low standards which would highlight the implemented productive innovations and lead those, which are still to make a step towards ecological transition, to efficiency. In the same way, this would allow to strengthen the relationships between all parties (mining sector, the government, surrounding communities and society in general – tourists) by generating new sources of income and promoting, in a long term, the

sustainability of the tourism proposal. Finally, by carrying on this project it is possible to raise awareness of ecological heritage conservation, by highlighting the importance of clay since pre-Columbian times and the need to keep on using products derived from it.

2.2 Methodological focus description

The first part related with the detailed description of the mining geo-morpho sites, counts with nine parts of analysis. Each of those has different descriptive factors (24 in total) which allow the complete identification of the area, as well as of some aspects that allow to recognize the touristic potential of the place (Table 1).

The second aspect taken into account in Kubalíková's methodology [19] is the assessment of the mining site. At this point, it is necessary to consider this methodology proposed in 2017, takes into consideration aspects such as the geo-educational value that is not of the interest of this investigation. For this reason, the adaptation from Singh and Ghosh [4] in Table 2 is the one to be used. In such adaptation, evaluation is conceived through seven guiding questions in the areas of, geo-touristic attraction, accessibility, security, touristic infrastructure, vantage points and visibility, touristic guide and access permissions. Each of these questions had three possible answers, which address feasibility scenarios for the mining proposal. Answer A, gives the highest potential, answer B, shows a moderate potential and answer C presents the lowest potential for the proposal development by realizing aspects

that could be limiting and that should be improved for touristic development.

Considering the criteria adapted by Singh and Ghosh [4] based on Kubalíková, [19] a quantitative assessment criterion is established in each of the questions for Table 3. This one has an evaluation scale that ranges from 1 to 5, which by being added would result in a score of 35 in the best scenario and 7 in the worst one. Based on this scale, by adding up the obtained scores, it was possible to consolidate a scale to establish and average mining touristic potential. (Low – medium – high).

The proposed elements at a methodological level, in addition to what has already been formulated by Kubalíková, [19] are, the consolidation of a mining-touristic route as well as the estimate of the cost of the routes path. The first one, which refers to the route itself, was addressed after having realized the importance of establishing a tour that would allow the recognition of the geodiversity as well as of the relevant geo-sites in clay exploitation, which is a methodological aspect considered as relevant by researchers such as Carrión-Mero et al. [26]. Furthermore, in order to know the diversity of industrial processes, which make part of the brick factories history, visits to different companies part of the MIP El Mochuelo were made. These visits were made by prioritizing 3 companies among the 32 from the mining complex, which had different kilns that would respond to the industrial processes in the clay processing, as well as in the construction materials production. This had the purpose of having a better understanding of each process, as well as of showing the changes in the productive sector in mining.

Table 1. Attributes that describe the potential of the geo-touristic area

Attributes	Description
General information	<ul style="list-style-type: none"> Name Location
Geological settings	<ul style="list-style-type: none"> Geological unit/lithology Petro-graphical features Mineralogical features Paleontological features
Geomorphological settings	<ul style="list-style-type: none"> Main landforms (quarry/pity/underground mining landform) Other landforms, especially those induced by anthropogenic activity Processes (Both past and ongoing, processes that can be observed on the site)
Ecological characteristics	<ul style="list-style-type: none"> Description of ecosystems, its connection to the landforms and processes, specific features
Hydrological and hydrogeological	<ul style="list-style-type: none"> Original features or those that originated by anthropogenic influence (e.g., water bodies appearing on the bottom of mining spaces)
Historical and cultural characteristics	<ul style="list-style-type: none"> Geohistorical importance (e.g., testimony about the last periods, or about the in the past, the evidence of social/ economic/industrial changes) Artistic importance (e.g., inspiration for artists, often photographed site, appearance of the site in poetry or prose, contemporary art, myths – both old and new) Use of the material (e.g., stone from the quarry used for buildings, monuments and walls, material is typical of certain area)
Conservation aspect and current use/status of the site	<ul style="list-style-type: none"> Current activity (still active mining/quarrying or revitalization and restoration activities) Environmental change
Scientific aspects	<ul style="list-style-type: none"> Scientific importance (e.g., stratigraphical or paleogeographical importance, the existence of scientific papers about the site, using the site as a traditional excursion locality or site important for geological mapping)
Tourist/Visitor aspects	<ul style="list-style-type: none"> Accessibility Safety (e.g., danger of rockfall, landslides, hidden underground spaces with a risk of collapsing) Visibility of the site Presence of tourist/recreational and other similar facilities (e.g., marked paths, tourist shelters, catering services in proximity) Transport facilities (e.g., stop of public transport nearby, possibility to get there by car) Number/intensity of visits (e.g., the site is visited by people very rarely, the site is visited and used frequently) Products related to the site (products promoting the site or product/issues/events bearing the name of the site)

Source: Adapted from Kubalíková [19] and Singh and Ghosh [4]

Table 2. Evaluation criteria for mining geo-tourism potential

Questions	Status
Geo-touristic attraction: Are there any geo-tourism attractions present?	(5) There are diverse geo-touristic sites in the area, consolidated through time and tradition. (4) There is one geo-touristic site, consolidated through time and tradition in the area. (3) There is one geotourism site which has been present in the area for short time (2) There is presence of geological sites with tourism potential but yet to be exploited. (1) There is no geological attraction in the area.
Accessibility: Is the site accessible or is the access limited/restricted?	(5) Both the area and the mine are totally accessible. (4) It is possible to access the area and the mine without difficulty. (3) There is full access to the area but with some access restrictions to the mine (or vice versa) (2) There is limited access to the area and the access to the mine is limited or intermittent. (1) Due to geological features, the area is inaccessible and so is the mine.
Safety: Are there any phenomena that can endanger the visitor?	(5) As per inactivity in the mine or any other endogenous/exogenous factors, the mine does not pose any risk that could affect the tourists' safety. (4) Although the activity in the mine can lead to risks as a result of endogenous/exogenous factors, these can be controlled and may not pose any risk to tourists' safety (3) Due to the activity in the mine, its productive processes or any endogenous/exogenous factors, there is presence of multiple risks that could pose a risk to the tourists during the tour, but which could be prevented with the implementation of minimal controls. (2) Owing to the activity in the mine, its productive process or any endogenous/exogenous factors, there are multiple risks that could threaten the tourists' safety during the tour and which could be prevented with the implementation of major controls. (1) Because of the activity in the mine, its productive process or any endogenous/exogenous factors, there exist multiple risks that could threaten the tourists safety and that cannot be prevented.
Tourist infrastructure: Are there any tourist facilities nearby? (Transport – parking place, catering, shelters, marked paths)	(5) There are different facilities such public transport which reaches the area periodically, cafeterias, parking lots, demarcated routes and lodging. (4) There are facilities that permit the access to the area, such as public transport and most of the services for tourism are offered (cafeterias, parking lots, demarcated routes and lodging) (3) There is infrastructure that allow to access the area; public transport is limited but frequent and there are also some services offered to tourists (cafeterias, parking lots, demarcated routes and lodging) (2) There are limitations to access the area. Public transport is limited and there are no places offering services to tourists. (1) There is no touristic infrastructure to get access to the area. There is no public transport nor places offering services to tourists.
Viewpoints and visibility: Are there any viewpoints from which the site can be observed?	(5) There are multiple viewpoints that permit the observation of the geo-site and all of them can be easily accessed. (4) There are multiple viewpoints that allow for the observation of the geo-site and some of them can be easily accessed. (3) There are some viewpoints and the access to them is difficult or limited. (2) There is/are one or few viewpoints and the access to them is difficult or impossible. (1) There are no viewpoints
Tour guide: Is there any tour guide available who can assist the visitors?	(5) There are different inhabitants of the area who are available and count with the technical knowledge to serve as tour guides. (4) There are some inhabitants of the area or some third parties who are available and count with the technical knowledge to serve as tour guides. (3) There is presence of some third parties who are available and count with the technical knowledge to serve as tour guides. (2) There are some inhabitants of the area or some third parties who are available but count with little technical knowledge to serve as tour guides. (1) There is no people (inhabitants or third parties) who are available or count with technical knowledge to serve as tour guides.
Permission guideline: How tough is it to get permission to visit the site?	(5) Access to the area is totally allowed. (3) There is no permission to get access to the area, however, it is possible to obtain it without much difficulty. (1) There is no permission to access the area nor can it be easily obtained.

Source: Adapted from Kubalíková, [19] and Singh and Ghosh [4]

In the case of the methodology to estimate the cost to be paid for the route tour, a reference costs analysis was taken into account, by considering four places in Colombia where mining tourism had already been developed. Some reference costs related to transportation from Bogota to the place of interest, internal transport (within the mine), food, beverages, tourist orientation, access to the mine, museum, elements of self-protection and biosecurity were evaluated.

The proposed elements at a methodological level, in addition to what has already been formulated by Kubalíková, [19] are, the consolidation of a mining-touristic route as well as the estimate of the cost of the routes path. The first one, which refers to the route itself, was addressed after having realized the importance of establishing a tour that would allow the recognition of the geodiversity as well as of the relevant geo-sites in clay exploitation, which is a methodological

aspect considered as relevant by researchers such as Carrión-Mero et al. [26]. Furthermore, in order to know the diversity of industrial processes, which make part of the brick factories history, visits to different companies part of the MIP El Mochuelo were made. These visits were made by prioritizing 3 companies among the 32 from the mining complex, which had different kilns that would respond to the industrial processes in the clay processing, as well as in the construction materials production. This had the purpose of having a better understanding of each process, as well as of showing the changes in the productive sector in mining.

Table 3. Quantitative estimate of geo-touristic potential

Touristic potential assessment scale	Touristic potential qualitative scale	Observation
7 - 16	Low	5 or more questions have a low touristic potential score of 1. This means different management and intervention strategies are to be implemented.
10 - 15	Medium	At least 5 questions have a potential of 3. This identifies some limitations in the touristic process consolidation; however, it also presents opportunities for the implementation of the mining-tourism proposal.
16 - 21	High	At least 4 questions must have a high touristic potential of 5. This scenario shows the greatest number of opportunities for the development of the mining-tourism project.

Source: Created based on the adapted methodology Singh & Ghosh [4] from Kubalíková [19].

In the case of the methodology to estimate the cost to be paid for the route tour, a reference costs analysis was taken into account, by considering four places in Colombia where mining tourism had already been developed. Some reference costs related to transportation from Bogotá to the place of interest, internal transport (within the mine), food, beverages,

tourist orientation, access to the mine, museum, elements of self-protection and biosecurity were evaluated.

3. STUDY AREA

Colombia is a biodiverse country, characterized by its mining deposits which earned it the recognition for having a variety of materials such as coal (fifth largest exporter in the world), precious minerals such as gold, silver and emeralds, metallic minerals such as nickel, copper, iron and manganese, and some other non-metallic minerals such as salt, sands, clay, limestones, among other materials [27].

Nowadays in Colombia, there are mining tourism proposals for minerals such as coal, salt, gold and emeralds [14, 17, 18]. However, up to the present times there is no consolidated mining tourism proposal for clays. This research focuses in highlighting the extractive process of clay, seeking through tourism the conservation of cultural and geological heritage, considering clay extraction is an essential part of pre-Columbian culture. It is possible to find examples of this in the indigenous community called “Muisca”, who would not only use this material to make pots, spoons, molds or crucibles, but who also viewed it as important part of the support technology for goldsmithing [28]. In addition to that, it is aimed to call attention to the historic memory of the industrial evolution in Colombia, especially in the production of bricks and clay products. The MIP Mochuelo is a place where the productive reconversion process can be observed, from the transformation of brick kilns since 1960 to the present times.

IMP Mochuelo is located in Bogotá-Colombia, as well as in Soacha (located in the state of Cundinamarca). The mining-touristic proposal is to be carried out in the IMP Mochuelo in Bogotá’s jurisdiction, at the south-east area in Ciudad Bolívar – Mochuelo Bajo. The IMP’s Mochuelo productive activity specializes in clay extraction as a supply for the production of multiple construction materials (Figure 2). This is an industrial complex in which brick companies are concentrated (production of different construction materials from the extraction and molding of clay), and these have been active since 1960 and have continued to consolidate and evolve at an industrial level [29].

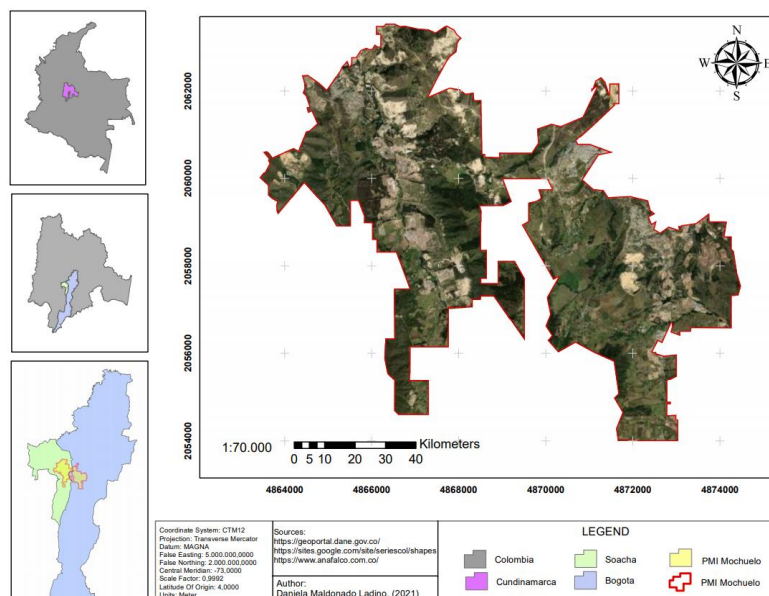


Figure 2. Mochuelo Bajo location in Bogotá City and in the town of Soacha, Colombia

Table 4. Description of the IMP Mochuelo mining touristic area

Attributes	Description
General information	<p><i>Name:</i> Parque Minero Industrial Mochuelo Bajo</p> <p><i>Location:</i> Bogota (Colombia), Ciudad Bolívar and town of Soacha (bordering Bogota to the east), in Mochuelo Bajo.</p>
Geological settings	<p><i>Geological unit/lithology:</i> Sinclinal de Usme, the presence of two regional faults is evidenced (Quiba y Buenavista faults), and a thrust fault (El Mochuelo fault).</p> <p><i>Petro-graphical and mineralogical features:</i> The mineralogic composition of the formation in the polygon of the mining industrial park, registers concentrations of more than 85% of clay minerals, mostly represented by kaolinite, smectite and illite. Other minerals such as silicates, sulfates and oxides show little presence in the area.</p> <p><i>Mineralogical features:</i> It's constituted by red, purple and grey colored variegated clay stones, rich in iron, arranged in poorly consolidated powerful banks</p> <p><i>Paleontological features:</i> Quaternary glacial-fluvial type deposits and residual soil, accumulated due to the regional ice from Pleistocene.</p>
Geomorphological settings	<p><i>Main landforms:</i> Wavy relief with an erosion of 15% to 25%</p> <p><i>Mezofoms and microforms, especially those induced by anthropogenic activity:</i> The anti-tectonic development in the mining activity has caused alterations which have modified the geo-forms. There are also some other processes of hydric and eolic erosion due to the exposition to those agents. This has led to the formation of the geotechnically unstable areas, as a result of the formation of grooves, gullies and fractures</p> <p><i>Processes:</i> Mining exploitation has been taking place since 1960; prior to this, the area was mainly used for farming by following the dynamics of the rural soil.</p>
Ecological characteristics	<p><i>Description of ecosystems, its connection to the landforms and processes, specific features:</i> The landscape is known for having grass, low stubble, crops and paddocks, as well as cultivated and gallery forests. This terrain includes landfills, mining extraction areas, as well as growing settlements. The scope of MIP Mochuelo has some strategic ecosystems which are of important conservation, among which can be found the restauration corridors Encenillales de Pasquilla, Río Tunjuelo, Encenillales del Mochuelo, and the moor Las Mercedes-Pasquilla.</p>
Hydrological and hydrogeological	<p><i>Original features or originated by anthropogenic influence:</i> The superficial sources of water are: Tunjuelo river and the following streams: La Orquita, San Gil, Mochuelo, Limas, Trompeta, Puente Blanco, Puente Tierra, Ajos, Aguas Calientes. These are located in areas where some of the brick companies make use of water Wells in times of little rain.</p>
Historical and cultural characteristics	<p><i>Geohistorical importance:</i> Mining activities in the area have been taking place since the decade of 1960, Prior to this it was mainly used for farming, following this way, the general dynamics for rural soil use in Colombia. The MIP Mochuelo as an industrial complex, dedicated to brick production, was consolidated and technified through the National Association of manufacturers of bricks and clay products (ANAFALCO, for its acronym in Spanish), which since 1991 has been promoting efficiency in the production of different clay derivates. ANAFALCO in representation of the 32 associates it's made up of, supplies Bogota with 17,5% of the bricks production, key in the country's construction industry.</p> <p><i>Use of materials:</i> Clay which is extracted from mines, is used as the main supply for the production of bricks, blocks, grates, structural bricks, tiles, tablets and GRES pipes, all of which are essential supplies in construction.</p>
Current use/status of the site	<p><i>Current activity:</i> The area currently divides the land in 4 categories: Area of clay exploitation (which comprises the main mining exploitation with a use of 36.78% of the land), secondly, there is farming use with a 39% of land use, thirdly there is the construction material exploitation with a 13,40% of land use and finally the exploitation of different materials which is equivalent to the 11,76% of land use.</p> <p><i>Environmental change:</i> At an environmental level there have been changes in the landscape, due to the activities that have been carried on as well as to the exploitation of the land in the last 60 years. There has been displacement of different animals species as well as loss of plant life. Changes at a hydric level have been moderate. Air quality is the one which has suffered the greatest impact, as a result of the use of coal for brick kilns functioning, as well as of the noise made by the machinery used in the mines.</p>
Scientific aspects	<p>Different research studies have been conducted in Parque Minero Industrial El Mochuelo, which have different intervention objectives. Some of these focus on recognition and on the proposition of technological reconversion and innovative production in the brickyards. It's also possible to identify other research related to the socio-environmental impact of the MIP El Mochuelo, in the surrounding communities. Furthermore, these areas have been of the interest of government entities related to mining exploitation, reason why the mineralogic properties of the land in the area have been studied.</p>
Tourist/Visitor aspects	<p><i>Accessibility:</i> The MIP El Mochuelo, can be easily reached by the mean of the road Mochuelo in Ciudad Bolívar. Additionally, it is located in the urban Area of Bogota at 40 minutes from downtown.</p> <p><i>Safety:</i> This has to do with risk control (physical and mechanic) to which visitors might be exposed due to the production dynamic in the factories.</p> <p><i>Visibility of the site:</i> The place is recognized in the city as an important place for bricks production in Bogota.</p> <p><i>Presence of touristic/recreational and other similar facilities:</i> The place is known as a cycling way and is used during holidays as a place for making route climbing, thanks to the area's topography. This means a good development opportunity for the people living in UPZ 63 Mochuelo, since they have installed resting places, as well as cafeterias and restaurants for the tourists.</p> <p><i>Transport facilities:</i> There is public transportation in the area of the MIP El Mochuelo and the condition of the access roads is adequate for most of the route</p> <p><i>Number/intensity of visits:</i> Since the area is normally used for cycling, this leads to constant visits from people from outside the area.</p> <p><i>Products related to the site:</i> There are artisans who make sculptures and different elements with clay.</p>

Sources: Alcaldía local de Ciudad Bolívar [9]; Alcaldía local de Ciudad Bolívar [10]; Alcaldía Mayor de Bogota [30]; ANAFALCO [29]; Castillo and Montana [31]; Instituto Colombiano de Geología y Minería [32]

This area, which is located in the Bogota's suburban perimeter, counts with the climatic and eco-systemic characteristics of the city's weather, which are descriptively and specifically developed in Table 4.

According to the Kubalíková's [19] methodology, in its first point to address touristic potential, the nine attributes that characterize the IMP El Mochuelo are described (Table 4) by highlighting the geological relevance of the clayish deposits, its importance in the construction sector and the touristic opportunities, evidenced during the tours made in the area that was being studied.

4. RESULTS AND DISCUSSION

The results of this research are analyzed in four segments: 1) Evaluation of the mining-touristic potential; 2) proposal of a mining-touristic route; 3) SWOT analysis of the mining-touristic proposal and 4) economic analysis of the possible fee for making the route tour.

4.1 Assessment of mining tourism potential

The evaluation of the mining-touristic potential was conceived qualitatively and was implemented by considering the information obtained in the field through the conversations with the brick companies as well as with those with

ANAFALCO (Table 5) The results allow to identify that most of the evaluated aspects have a high touristic potential (5 out of 7), some others a medium one (1 out of 7) and is the aspect related to the existence of current geo-touristic attractions the one that shows low potential; this corresponds to a matter which established whether there are any current geotourism attractions. The computation of the data through the scale in Table 3 showed a score of 28, which according to the scale would result in a high touristic potential. This considers some difficulties or obstacles, but shows significant opportunities and strengths of greater relevance.

4.2 Mining-touristic route

In order to demarcate the mining tourism route, 15 mines out of the 32 which currently operate in MIP Mochuelo were visited. After a tour of the mines and following the conversations held with the parties in charge of each one of them, as well as with the directors of ANAFALCO, three mining stations and two pedagogical stations were chosen. The former ones were selected with the purpose of knowing about the history of the bricks sector; its evolution, its importance for Bogotá in terms of production and its contribution to the construction field in the country. The latter ones, were chosen with the aim to motivate biodiversity and geological heritage conservation processes, besides the understanding of the importance of clay (Figure 3).

Table 5. Evaluation of the geo-touristic potential in the MIP El Mochuelo

Questions	Status	Remarks
Geotourism attraction: Are there any geo-tourism attractions present?	(2) There are geological sites that could be touristic but which have not yet been exploited.	Currently there is no initiative to develop mining-tourism in the MIP.
Accessibility: Is the site accessible or is the access limited/restricted?	(5) The area and the mine are totally accessible.	The access roads are in good condition since this is a way through which the finished product (bricks, blocks, tiles, etc) is shipped. Moreover, this is the access road to the Quiba and Pasquilla paths.
Safety: Are there any phenomena that can endanger the visitor?	(3) Owing to activity in the mine, its productive process or any endogenous/exogenous factors, there are multiple risks that could threaten the tourists' safety but which could be prevented with the implementation of minimal controls.	In regards to safety, it is to be constantly checked, considering there is regular operation of kilns which could lead to physical or mechanical risks for visitors.
Tourist infrastructure: Are there any tourist facilities nearby? (transport – parking place, catering, shelters, marked paths)	(4) There are facilities that permit the access to the area, such as public transport and most of the services for tourism are offered (cafeterias, parking lots, demarcated routes and lodging)	There are already some existing facilities, but there are some others to be created following the consolidation of the initiative. <ul style="list-style-type: none"> - There are established access roads as well as public transportation to get to the area. - The parking places are subject to availability. (It depends on the place to visit) - In what refers to the places to rest and have food, people can go to the following neighborhoods Lagunitas, Los Paticos, Barranquitos y La Esmeralda, where there are restaurants and cafeterias. - The roads are unmarked and without signs.
Viewpoints and visibility: Are there any viewpoints from which the site can be observed?	(4) There are multiple viewpoints that allow for the observation of the geo-site and some of them can be easily accessed.	There are many viewpoints, however, not all of them allow the free access. Still, one of the marked points in the mining-touristic route is considered to be a viewpoint from which the city can be observed.
Tour guide: Is/are there any tour guide(s) available who can assist the visitors?	(5) There are different inhabitants of the area who are available and count with the technical knowledge to serve as tour guides.	Companies are looking forward to welcoming tourists and show the advances in the production process. Furthermore, ANAFALCO offers to provide tour guides.
Permission guideline: How tough it is to get permission to visit the site?	(5) Access to the area is totally allowed.	There is not only authorization but also willingness to tour the mine facilities and show the production process.

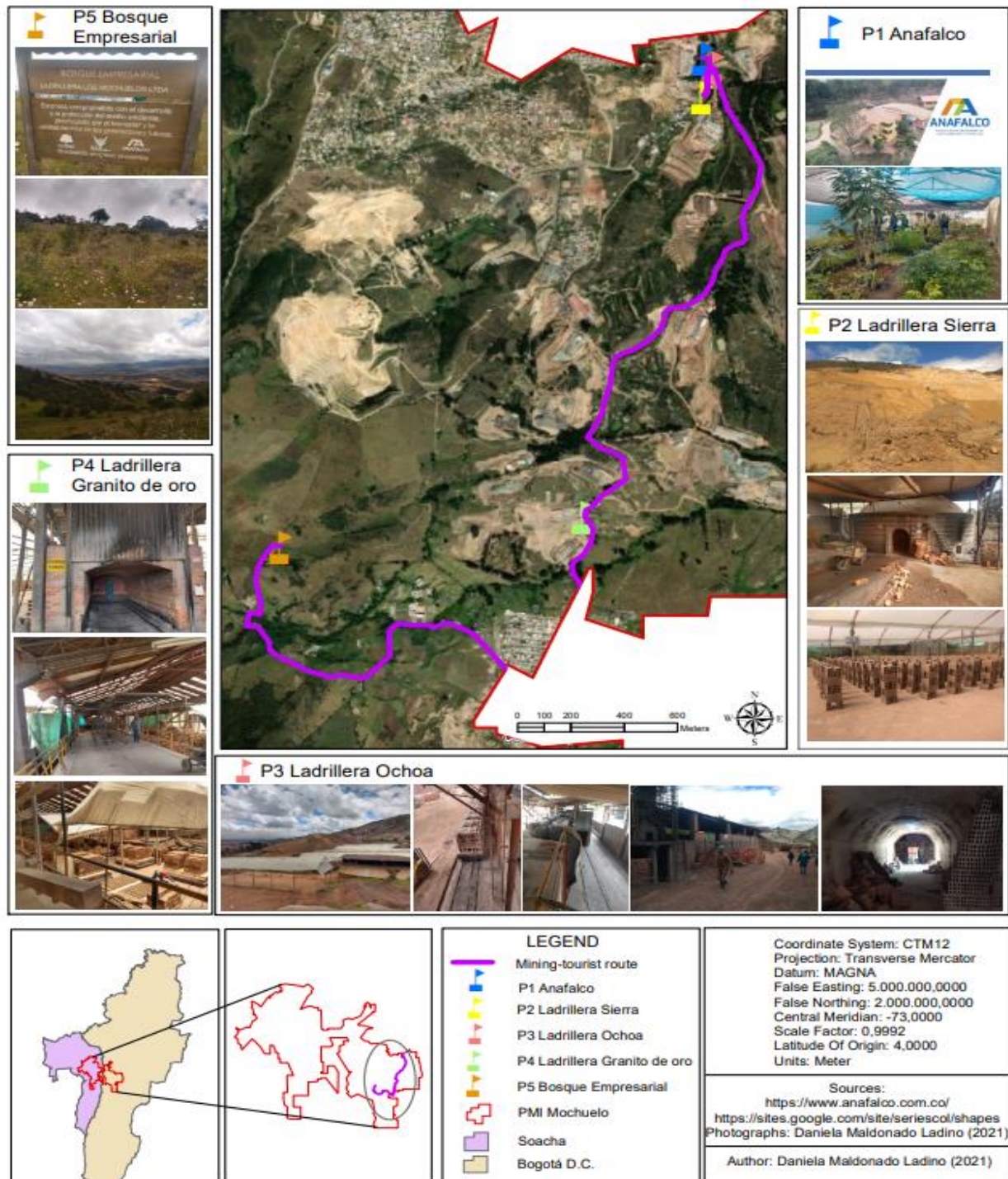


Figure 3. Mining-touristic proposal in the MP El Mochuelo

Stop 1 (ANAFALCO)

At this point, it is expected to start the contextualization of the mining-brick industry in the country. Here, the history of the brick sector and of the development of the MIP El Mochuelo in the last 60 years will be explained. In this space there would be an explanation of the minerals that are extracted in the quarries and how through the process carried on from the extraction to the production, different products of local and national demand are supplied. In here, one will also be able to identify the clayish material and its importance through the history of the country, as well as its modern artisanal use. It is expected to tour the clay museum, where the cultural and historical aspects of clay use will be explained.

The next three stops will show the evolution of clay

extraction in the MIP Mochuelo, making emphasis on the productive innovations developed throughout history and which have permitted the efficient use of clays, as well as the different materials key to the construction industry.

Stop 2. Sierra brick company

At this place, people will get familiar with the industrial infrastructure called “beehive ovens” which are used in the firing process of bricks and blocks. This infrastructure corresponds to a brick company of small size (in terms of production), which can produce between 110 to 250 tons in a month [31].

Stop 3 Ochoa brick company

At this stop, there will be the infrastructure of a semi-continuous Hoffman kiln. This production system corresponds

to that of a medium size brick company, which can produce between 1000 to 3000 tons a month. In this company, it will also be possible to identify some other products made out of clay, which through the use of specialized machinery, result in different types of bricks [31].

Stop 4 Granito de oro brick company

In this company, the most advanced system of continuous production in the MIP Mochuelo will be known. It is about an infrastructure known as Túnel-Hoffman kiln, in which a more efficient use of energy is made for the continuous production of bricks. In here, there will be found a production exceeding the 3000 tons per month [31].

Stop 5 Enterprise Forest

At the last stop of the tour there is the enterprise forest. This place will be used as a place to learn and reflect on the environment. The importance of neutralizing carbon dioxide emissions will be addressed and there will be the opportunity to plant autochthonous plant species. Moreover, this could also be used as a space of aesthetic and cultural recreation, as it is a point-view to the city.

4.3 SWOT analysis

According to the necessity of establishing the proposal's management and conservation measures, an analysis of significant aspects is established (strengths, weaknesses,

opportunities and threats) to serve as guidance when consolidating the mining-touristic route and carrying it on. In Table 6, the possibly positive aspects in the implementation of the route are described, as well as those which are to be improved or prevented.

4.4 Estimated mining-touristic tour fee

The calculation of the fee for the mining-touristic tour was a comparative regression of the 2021 costs, by having as a reference some of the geo-touristic places in Colombia, such as Zipaquirá salt mine, Nemocón salt mine, Muzo Esmeraldas mine and the coal mine in the state of La Guajira. The aspect that was taken into consideration for the 2021 cost estimate was the Consumer Price Index (CIP) from the Banco de la República de Colombia [33-36]. The variables shown in the costs are referenced in the study of Vásquez et al. [18], who defined some relevant criteria for the development of the mining route in the mining region of Muzo, Colombia. There can be found aspects such as individual transport, food, academic counseling, hydration, access to the mine(s) and biosecurity elements. These criteria were analyzed for the case of Muzo and also for the mining-tourism in Zipaquirá, Nemocón and La Guajira, where there is salt and coal exploitation. The obtained data is mentioned in Table 7.

Table 6. Analysis of the mining-touristic potential in the MIP El Mochuelo

Strengths	Opportunities
<ul style="list-style-type: none"> - There is willingness from the prioritized places to welcome tourists. - There is easy access to the place of the touristic route. (Paved and signposted avenues). - There is interest from ANAFALCO to finance the mining-touristic process. - El MIP Mochuelo is organized, structured and represented by ANAFALCO, which makes the development of the route simpler, as it allows to have clear roles in the touristic process. - It's a visually attractive place thanks to its view-points of Bogota. - The MIP Mochuelo coexists with places of conservation, which are eye-catching and represent an educational potential for tourists. - It is located inside Bogota, which means there is a considerable amount of people who could visit the spaces. - There are good relationships between the MIP El Mochuelo with some public institutions (City Hall and environmental authorities). 	<ul style="list-style-type: none"> - Gathering a significant number of tourists that would boost the local economy (cafeterias, restaurants, stores, etc.) - Promoting, through the development of tourism, the crafts made out of the extracted clay in the area. - Helping in the recognition of the importance of the mining sector in the local economy, as well as in the country's construction sector. - Fomenting the importance of minerals and their relevance throughout the history of the country - Creating spaces where students from different levels can recognize the geo-touristic potential. - Increasing the number of visitors who go to the area for its landscapes, which could easily attract more tourists.
Weaknesses	Threats
<ul style="list-style-type: none"> - The place is not considered to be a touristic destination yet. - The companies to be visited still hold to very industrial dynamics, reason why no touristic infrastructure has still been developed. (Hallways, signs, etc.) - There are industrial risks that are not handled yet. - Little geological investigation has been developed. 	<ul style="list-style-type: none"> - There are no mining-touristic attractions in the area. - The place is not designed to be inclusive or to host people with special needs (e.g., It is not possible to access the place in a wheelchair or with crutches) - The external image of the MIP Mochuelo is negative, which could affect the development of the proposal

Table 7. Fees of geo-touristic package tours in some referenced Colombian places

Package tours costs	Esmeraldas – Muzo mines (COP)	Zipaquirá salt mines (COP)	Nemocón salt mines (COP)	La Guajira coal mines (COP)
Transport per person (From Bogota to the destination)	\$ 180.000	\$ 10.000	\$ 16.000	\$ 280.000
Internal transport	\$ 25.000	\$ 0	\$ 0	\$ 30.000
Food	\$ 55.000	\$ 25.000	\$ 25.000	\$ 30.000
Beverages	\$ 5.000	\$ 5.000	\$ 5.000	\$ 5.000
Academic counseling	\$ 35.000	\$ 35.000	\$ 35.000	\$ 35.000
Access to the mine (mine and museum)	\$ 115.000	\$ 93.000	\$ 31.000	\$ 16.000
Protection elements	\$ 15.000	\$ 15.000	\$ 15.000	\$ 15.000
Bio-security elements	\$ 3.000	\$ 3.000	\$ 3.000	\$ 3.000
Total (cost per person)	\$ 433.000	\$ 186.000	\$ 130.000	\$ 409.000

Table 8. Estimated costs for the mining-touristic tour in the MIP El Mochuelo for 2021

Items	Per person (COP)	Per group of 12 people (COP)
Transport within Bogotá	\$ 5.000	\$ 60.000
Transport in the tour (Bus)	\$ 10.000	\$ 120.000
Food	\$ 16.000	\$ 192.000
Beverages	\$ 2.000	\$ 24.000
Academic counseling*	\$ 3.000	\$ 36.000
Tour fee*	\$ 16.000	\$ 192.000
Personal protection items	\$ 15.000	\$ 180.000
Biosafety elements	\$ 3.000	\$ 36.000
Total cost per person/group	\$ 70.000	\$ 840.000

It was, by considering the reference costs in (Table 7) that the proposal for the mining-tourism tour in MIP El Mochuelo was consolidated. In this particular case, some reference costs in the area related to transportation from Bogotá (in public transportation SITP 2021 costs) were analyzed, as well as those of internal transport between mines (cost of renting public transport buses for 2 hours), food and beverages (prices verified in local cafeterias). Costs related to guides were estimated based on the minimum wage amount to be paid to the person inhabiting Mochuelo and serving as a tour guide. Regarding personal protection, the referenced amount was that of renting a helmet in a warehouse in Bogotá and referring to biosecurity elements, the costs were those of a standard facemask used during the covid-19 pandemic. In what refers to the tour fee, this was based on the one charged in Cerrejon coal mines, since this was the most similar one. Table 8 Following the analysis of all this data, the results show an estimate fee of 70.000 per person, which includes all the aforementioned items and a fee of 840.000 COP for a group of 12 people; this amount may be lower in the future as the touristic place gets recognition.

5. CONCLUSIONS AND RECOMMENDATIONS

The analysis and the implementation of the methodology presented by Kubalíková, allowed the identification of the touristic potential in the MIP El Mochuelo, by initially identifying some key geological, geo-morphological, ecological, hydrological, historical, cultural, of land use, touristic and scientific aspects, which permit the recognition of the geo-touristic potential in the area. Among the most relevant features of the place, can be found the subsoil geology, from where the clay deposits stand out with concentrations of more than 85% of kaolinite, smectite and illite, which are fundamental for bricks production. Moreover, ecosystems in the area are noticeable thanks to the presence of gallery and cultivated forests, as well as to some moors.

In the same analysis, some elements that allow to identify the touristic potential in the area were identified. Here can be found the presence of geo-touristic attractions, accessibility, safety, touristic infrastructure, view-points and visibility, tour guidance and accessibility permissions to the area. In general, most of these resulted in a medium touristic potential. The aspects to be improved are explained below:

- Touristic attractions: It's considered to be low, because there is no mining or geo-tourism around the area. However, this could also be thought as an opportunity to exploit, as there are other areas with unexplored development potential.
- Accessibility: Which are good thanks to the willingness in the MIP to develop touristic activities.

- Safety: Some aspects related to industrial security are to be revised, in order to enable access to tourists.
- Touristic infrastructure: There are some conditions that are considered to be an opportunity, just as the fact of being in Bogotá, the existence of access roads and the places where it's possible to get food. Nevertheless, it is important to improve signposting and some infrastructure aspects such as the parking lots.
- View-points and visibility: There are different places in the MIP that could be used as view-points for the recognition of the mining territory and to have a complete view of Bogotá. It is suggested that the infrastructure of the exiting places be improved so as for these to be used for tourism.
- Tour guide: There is great tour guidance availability thanks to the association with ANAFALCO. There exists the possibility of making agreements with the communities in the surrounding areas, so as for these people to play the roles of guides.
- Access permission: No restrictions so far.

These aspects lead to the conclusion that there is great potential for the development of touristic activity in the MIP El Mochuelo, where there are some aspects to be adjusted and considered in the implementation of the touristic route.

In regards to the tour, it was possible to identify five strategic points to be visited, being those, important places in the identification of industrial and clay extractive processes, aside from productive processes at an industrial level, where it is possible to understand how clay can be transformed into different products. In the same way, there is a place of conservation (considered to be an environmental classroom) where the recuperation of degraded ecosystems is promoted, as well as the recovery of degraded ecosystems.

Concerning the SWOT analysis, such characterization permitted the identification of positive aspects that must be exploited at a management level, so as to consolidate the mining-touristic proposal. Among those, one can find the solid organizational structure of the MIP El Mochuelo, the existing number of tourists visiting the area and the willingness of the management of the different mines to welcome tourists and show them the production process. There are also some other significant opportunities such as those at the level of local economy; it is possible to promote the acquisition of goods and services in the area. Furthermore, geo-educational tourism could also be a good opportunity, since it is possible to encourage the knowledge about the minerals in the area as well as of the production processes. In addition to that, there are some weaknesses and areas of opportunity, such as the necessity to adapt the different mines, in order to reduce the risk of a tourist having an accident. On the other hand, there are some threats that must be addressed; there is a need of

infrastructure for people with reduced mobility.

Based on the obtained results, the importance of the implementation of the mining-touristic route, at a local level, is highlighted. This would contribute to the dynamism of the economy of the UPZ El Mochuelo, knowing this activity would increase the demand of services such as transportation (for tourists to be able to mobilize), the need for parking and cafeterias or restaurants where people could get food. Additionally, the business of clay crafts would experience a positive impact. On the other hand, it is expected that upon consolidation of the touristic development, there could be people receiving training to become tourist guides, creating new streams of income for them.

The rates for the fees to be paid, correspond to an initial and approximative estimate, based on the references obtained from activities of the same type in other places of Colombia. These estimates work as a reference to determine costs. It is recommended that market or affordability studies be conducted, so as to be able to better understand the possible future demand of tour services in the mine.

It is considered that through the present proposal a new perspective of mining has risen, since it would not only look forward to the extraction and production of materials, but also the acknowledgement of society regarding a material which has been historically used by their ancestors. In like manner, the route shows the importance of the productive reconversion of the brick industry towards more efficient technological models, with less impact on communities and the environment. The defined proposal allows, in turn, to promote the sustainability of the area, by promoting new forms of income, appropriation of the geological heritage and generation of cultural identity with a material that has been historically extracted and processed in the country and the region.

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