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Evaluation of a Paleontological Museum as Geosite and Base for Geotourism. A Case Study

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Abstract: The Santa Elena province in Ecuador has outstanding geological potential in petroleum, mining and geosite resources. All the wealth of palaeontological samples and their inherent link to the history of this territory require a recognised museum with educational and scientific material to support the potential and promotion of geotourism development. The Megatherium Palaeontological Museum is located in this province and was the first Palaeontological Museum in Ecuador. It exhibits samples corresponding to the Late Pleistocene Megafauna that inhabited the area. This study aims to evaluate the museum (a geoheritage element) as a possible (palaeontological) geosite by analysing its contributions to the geoheritage of the Santa Elena province. Thus, we also aim to enhance the geotourism of the area and promote its collections as a geotouristic attraction. The methodological process was based on: (i) information processing and systematisation in the museum and its environment; (ii) assessment of the museum's geological interest through the method of the Geological Survey of Spain, the Brilha method and the Geosites Assessment Model; and (iii) a qualitative evaluation using the Delphi and the Strengths, Weaknesses, Opportunities and Threats methodologies to define strategies and proposals for museum development. Based on the results of the applied quantitative assessment, the museum has a “very high” (277/400) degree of geological interest, due to the high values of scientific (310/400), academic (310/400) and touristic (210/400) interest. In this same way, the results obtained through the Brilha method reflect a high scientific (290/400), educational (280/400), and tourist (315/400) interest and a low degradation risk (190/400) value in the museum. Furthermore, the applied Geosites Assessment Model shows the museum as a geosite with high main and additional values, placing it between the Z₂₃ and Z₃₃ fields of the global valuation matrix. The evaluation approached through Delphi analysis and Strengths, Weaknesses, Opportunities and Threats matrix allowed us to propose improvement strategies to take advantage of the museum resources as an alternative that strengthens the geotouristic development of the area.

Keywords: geoheritage; georesource; geotouristic; palaeontological collection

1. Introduction

Natural diversity is a concept that integrates biodiversity and geodiversity [1]. According to [2–4], geodiversity is the variability of Earth's surface materials, landforms and physical processes (abiotic elements). According to Rojas [5], geodiversity is the number

and variety of structures (sedimentary, tectonic and geological materials—minerals, rocks, fossils and soils) that constitute the substratum, above which the organic—including the anthropic—activity is settled. The term geodiversity considers natural geological features such as rocks, soils and hydrological components in its definition [1,6]. In addition, geodiversity includes the evolution of these elements by geological, geomorphological, hydrological and anthropogenic processes [7–9]. According to [10,11], geodiversity should be considered in the analysis and study of the geoheritage territory to highlight the evolution of the site and, complementarily, the development of existing biological processes.

All geological sites of high scientific, cultural and educational value are considered geoheritage [1,3,12,13]. Furthermore, the definition of some elements as geoheritage highlights the geological and geomorphological characteristics of the territory to conserve and rescue these elements [14–16]. In addition, it allows scientists to monitor the evolution of the geobiological profile through systematised management and planning [17]. Therefore, the quantitative assessment of geoheritage is an essential topic in Europe, North America and Oceania, as it allows for the proper monitoring and sustainable development planning of sites with geological potential [18–20].

The term geoconservation is defined by the need to conserve geoheritage [21]. According to Burek & Prosser [14], geoconservation is the action taken with the intent of conserving and enhancing geological and geomorphological features, processes, sites and specimens. In recent years, the United Nations Educational, Scientific and Cultural Organization (UNESCO) has implemented sustainable strategies to preserve the life, cultures, ecology and knowledge of island regions [22,23]. In terms of specific geoconservation programmes, some programmes protect sites of high geodiversity potential, such as the federal geoheritage programmes in the United States [7,24].

According to Carrión et al. [25], geoheritage is formed by all those places or points of geological interest, defined as sites or geosites, that stand out from their surroundings due to their scientific and/or educational value. According to Newsome & Dowling [26], geosites are sites of geological interest with high scientific, educational and touristic value, representing the geoheritage of an area. Different types of geosites exist [27,28]: historical, geomorphological, geothermal, hydrological and hydrogeological, neotectonic, palaeogeographical, palaeontological, pedological and radio-geological.

The evaluation of geosites is based on applying different methods to identify their scientific, educational, and tourist potential. An example of such processes is the IELIG method (acronym in Spanish “Inventario Español de Lugares de Interés Geológico”) [29]. This method has a systematic evaluation process, which proposes a series of variables to evaluate geosites, such as intrinsic value, didactic potential and recreational tourism. Examples of its application are in the Las Loras Geopark and Comarca de Molina de Aragón-Alto Tajo Geopark (Spain) [30]. The Brilha method is a procedure that proposes a quantitative assessment of geosites with a more geoconservation-oriented approach [1]. This method has been implemented in different studies like the Sierra Mágina Natural Park (Spain) [31] and Arouca Geopark (Portugal) [32]. Finally, the Geosites Assessment Model (GAM) method is a preliminary model for the physical assessment of geosites considering a series of scientific/educational, aesthetic/scenic, protection, functional use and tourism variables [33]. Among the geosites assessed by GAM is the Vrdnik coal mine (Serbia) [34] and the “El Sexmo” tourist mine (Ecuador) [35].

It is essential to consider the movable geoheritage (vulnerable parts of earth science exposed to natural degradation or a human action that can or must be protected *ex situ*), which also includes geographical heritage. Their inclusion into a museum collection often represents the only chance to preserve these invaluable inanimate natural monuments [36]. According to [37], the educational potential of geodiversity elements, such as outcrops of widespread rock types that are not protected or included in geosite inventories, could be used in informal education activities.

Some museums preserve natural elements with particular characteristics and are recognised by UNESCO [38,39] such as the Liverpool Maritime Museum (Merseyside

Maritime Museum) (England), the Marsala Regional Archaeological Museum (Italy), the Museum of the World Oceans/Icebreaker Krassin (Russia) and the Geomining Museum (Instituto Geológico y Minero de España in Madrid) (Spain). There are also museums in Latin America with collections of mineralogical and palaeontological interest [38,40,41], such as the Archaeological Museum of Campeche (Mexico), the Mineralogical School of Mineral Science and Technology Museum in Ouro Preto (Brazil) and the Geology Museum (Universidad Nacional Autónoma de México, UNAM) (Mexico).

Museums in Ecuador exhibit cultural and natural heritage. For example, the Museo Nacional del Ecuador has an archaeological collection with 40,000 elements that reflect the evolution of ancient Ecuadorian cultures. These museums mainly contribute to the knowledge of the historical and cultural riches of the past [42,43]. In addition, some museums (e.g., palaeontological, mineralogical) in Ecuador are recognised in geopark projects as having a high scientific value of natural elements.

The creation of the Ecuadorian Geoparks Committee and the official declaration of Imbabura Geopark as a UNESCO Global Geopark in 2019 [44] helped in the creation of new projects for geoparks (Figure 1a) such as the Tungurahua Volcano Geopark project, Napo-Sumaco Geopark project [45], the Santa Elena Peninsula Geopark project [46], the Galapagos Geopark project, the Puyango Petrified Forest Geopark project [47], the Jama Pedernales Geopark project, the Quito Geopark Project and the “Ruta del Oro” (Gold Route) Geopark project [25].

Although there has long been a remarkable appreciation of places of outstanding natural beauty or geographical phenomena by the population, it was not until the 1990s that geotourism appeared [48,49]. According to Dowling [50], geotourism is sustainable tourism with a primary focus on experiencing the Earth’s geologic features in a way that fosters environmental and cultural understanding, appreciation and conservation and is locally beneficial. Furthermore, according to [6], geotourism development has relationships with the geodiversity values and characteristics and degrees of protection.

In the case of the Santa Elena Peninsula Geopark project (Figure 1a), an initiative that addresses the characterisation of a territory located in western Ecuador [46], sites of geological, mining and industrial interest with the potential to be used in tourism activities have been inventoried and evaluated [51]. In addition, the studies carried out have taken into account sites of cultural and architectural interest specific to the region. Among the inventoried and evaluated sites, the most important ones are: the Megatherium Palaeontological Museum of the UPSE University, the Amantes de Sumpa museum, the Real Alto cultural complex (located in Chanduy) and the Chocolatera cliff in the Puntilla de Santa Elena reserve. In general, Santa Elena province has remarkable cultural, natural, intangible, and geological characteristics with the potential to be officially recognised as natural or cultural heritage [51]. The main economic activities in the area are agriculture, livestock breeding, mining and handicrafts. Tourist activity is also noteworthy, although it is focused on traditional tourism (beach) where geotourism (cultural and natural) has not reached its full potential [52,53].

The present study focuses on the characterisation of the Megatherium Palaeontological Museum as a geoh heritage element. In concrete terms, this study aims to evaluate the MPM as a geosite of geotourism palaeontological potential through semiquantitative (IELIG, Brilha and GAM) and qualitative (DELPHI and SWOT) methods for the knowledge of geotourism development.

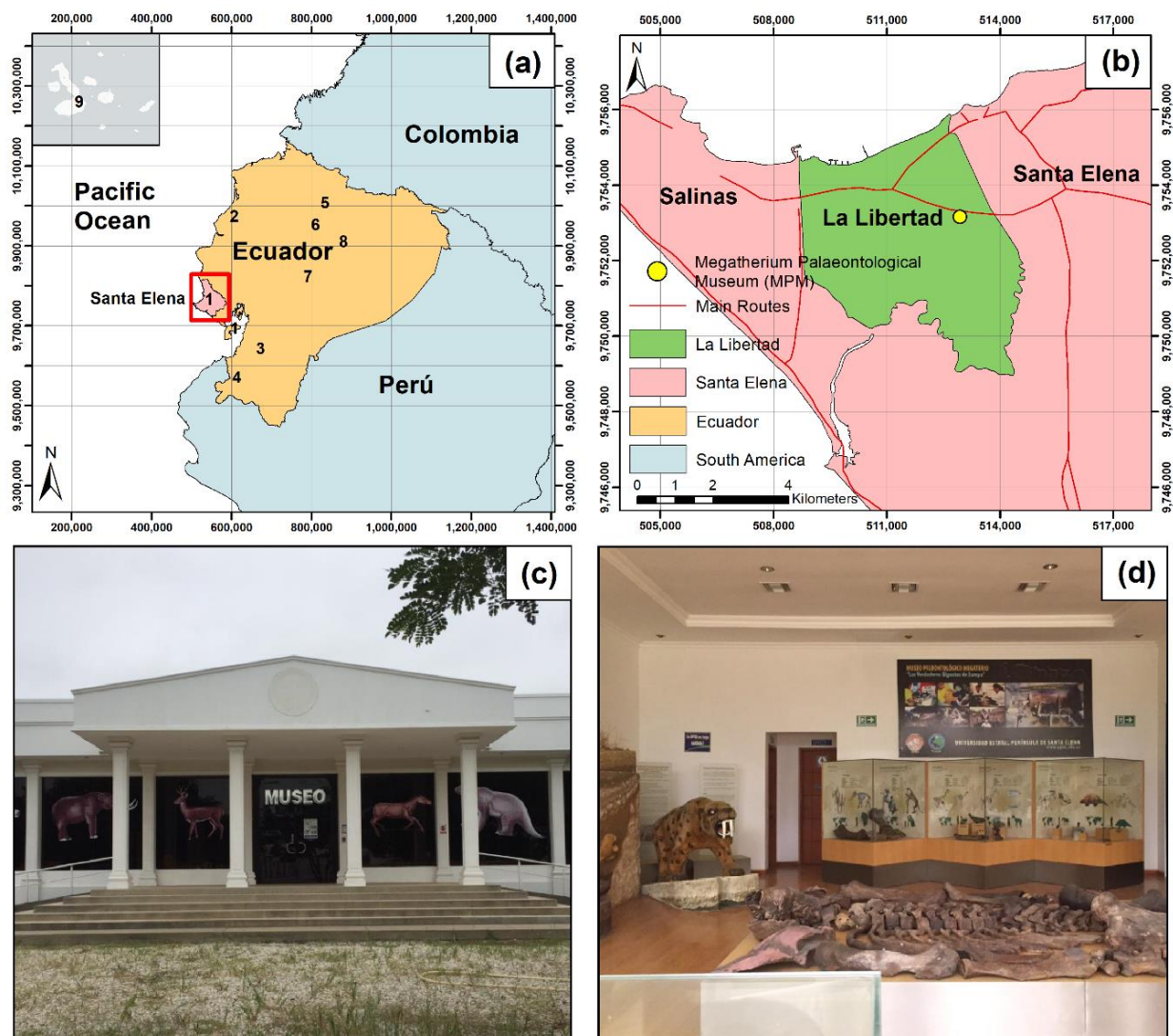


Figure 1. (a) The geographical location of the Santa Elena province, Ecuador. Information on the main geopark initiatives in Ecuador (1. Santa Elena Peninsula Geopark Project, 2. Jama Pedernales Geopark Project, 3. Ruta del Oro Geopark Project, 4. Puyango Petrified Forest Geopark project, 5. Imbabura, UNESCO Global Geopark, 6. Quito Geopark Project, 7. Tungurahua Volcano Geopark Project, 8. Napo-Sumaco Geopark Project, and 9. Galápagos Geopark Project); (b) Location of the Megatherium Palaeontological Museum (MPM), canton La Libertad; (c) Front view of the outer part of the MPM; (d) Internal section of the MPM (sabre-toothed tiger specimen and exhibits of bones and fragments).

2. Megatherium Palaeontological Museum

The Megatherium Palaeontological Museum (MPM) belongs to the UPSE University and is located in the canton of La Libertad, Santa Elena, Ecuador (Figure 1a,b). This museum (Figure 1c,d) is considered the first palaeontological museum in Ecuador [54] and was founded on 2 February 2008. The museum's significant collections correspond to the Late Pleistocene Megafauna (50,000 to 8000 years). These remains were extracted from the Tanque Loma sector (located in one of the largest and most important fossil deposits in South America) [55]. In addition, this palaeontological exhibition centre has palaeontological findings, where professionals in the area share scientific information on the existing elements (524 bones and 2,969 fragments such as tibiae, ribs, pelvises, femurs and jaws) [56,57].

The museum has an extensive collection of fossils. These collections correspond to terrestrial (e.g., megatherium mammal) and marine (e.g., shells, sharks) fossils [58]. Among

the main species of animals in the collection are the Megatherium (Species: *laurillardii*; Weight: four tonnes; Size: 4–6 m), the Mastodon (Species: *waringi*; Weight: four tonnes), the Pampaterio (Species: *occidentalis*; Weight: two tonnes), the Glosoterio (Species: *tropicorum*; Weight: four tonnes; Size: 3–4 m), the American Horse (Species: *santaelenae*; Weight: 400 kg) and the Deer (Species: *virginaunus*; Weight: one tonne) [59]. Figure S1 presents images of these fossils.

The MPM has 11 different sections (Figure 2a). Inside the MPM are the reception room, the administrative room, the laboratory and the storage room (cellar). In addition, the fossil remains are preserved in five display boards (large bones) and four showcase areas (fragments). It has a parking area suitable for cars and buses, and the main entrance suitable for receiving visiting groups.

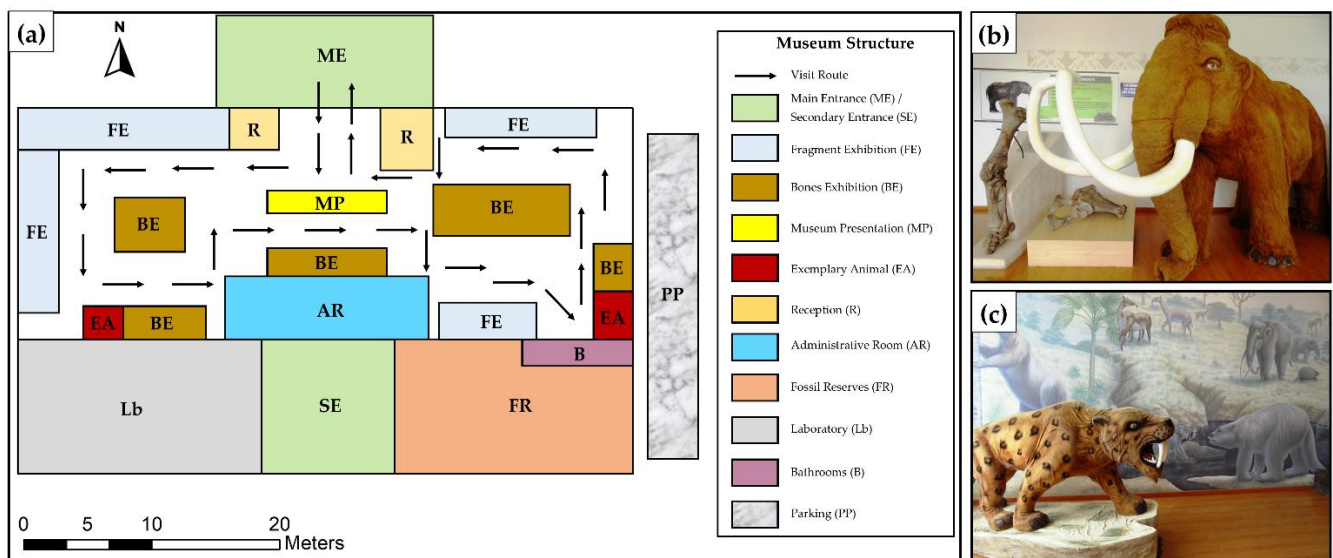


Figure 2. (a) MPM map with a description of the exhibition room's structure. (b,c) Reproductions of Mammoth and Sabre-toothed feline specimens in the exhibition room (Exemplary Animal (EA)).

3. Materials and Methods

This research was carried out in three phases (Figure 3): (i) processing and systemizing information from the MPM and its environment; (ii) semiquantitative assessment of the MPM using evaluative matrices of the IELIG, Brillha and GAM methods; and (iii) qualitative analysis using the DELPHI method and SWOT analysis.

3.1. Phase I: Processing and Systematisation of Information

This first phase carried out an analysis of the annual and monthly tourist inflow, data that were compiled in the reports presented on the official website of the Megatherium Palaeontological Museum (MPM) (e.g., [54,60–63]). In addition, the museum provided photographs of some of the bones and fragments on exhibit inside the museum (Supplementary Materials Figure S1). This work presents a compilation of information from projects and scientific articles related to MPM (e.g., [35,64–73]). Finally, this study generated general content on the history, culture, interest and representativeness of the MPM.

3.2. Phase II: Semiquantitative Assessment. IELIG, Brillha and GAM

In this phase, the MPM evaluated using the IELIG [29], Brillha [1] and GAM [33] methods. The evaluation of each method was carried out with the support of four experts on geosite analysis and assessment. Their professional opinion was based on the unanimous value of each criterion. Subsequently, the obtained information was classified into digital matrices for more straightforward data processing.

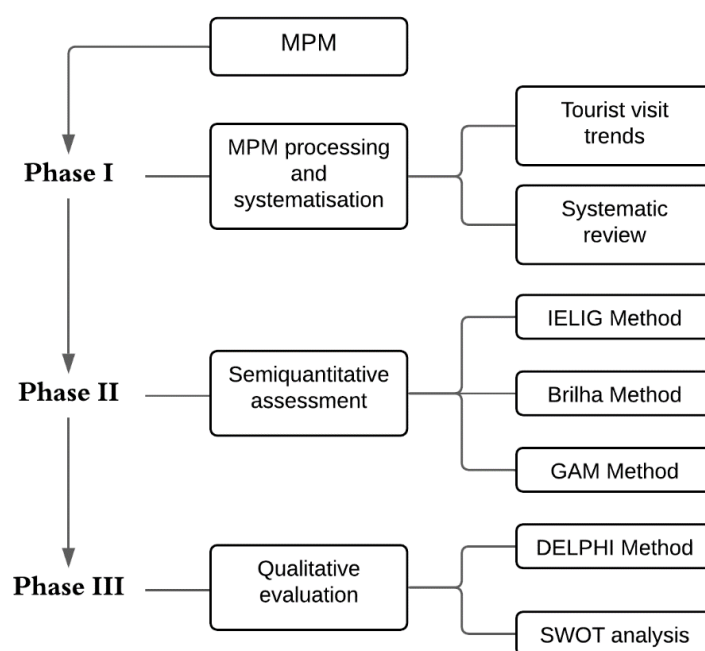


Figure 3. A flowchart of the methodology used in this study.

3.2.1. Assessment with IELIG Method

The applied IELIG method [29] is an evaluation procedure of different parameters, with scores of 0, 1, 2 and 4, where 0 is the lowest value and four the highest [29]. These parameters are grouped under three headings: (i) value class (intrinsic value, the value linked to the potential for use and protection), (ii) criteria (evaluation variables) and (iii) interest to be assessed (scientific (Sc), academic (Ac) and touristic (To)).

The total value is the weighted sum of the results obtained for each interest. This value allows classifying the site geological interest as low (<50), medium (50–134), high (134–266) and very high (>267).

The Degradation Susceptibility (DS) and the Protection Priority (PP) values are based on the results obtained in Fragility (F) and Vulnerability (V). Table 1 shows the variables, the evaluation and the weight for obtaining the necessary data in the DS equation.

Table 1. Overview of the main indicators of the IELIG, Brilha and GAM approaches.

Indicators/Subindicators	Description
Representativeness	The MPM presents unique elements at the local and national levels, symbolising the megafauna that lived thousands of years ago in the Santa Elena province. Furthermore, it increases interest in finding discoveries new that strengthen the site's scientific value. Expeditions have therefore been carried out in different parts of the province such as Atahualpa, Montañita-Olón, San Vicente and Aguadita. In addition, palaeontological work that has been carried out in other provinces, such as Guayas (Playas) and Manabí, is displayed in the museum.
Geological diversity	Fossil collection (Santa Elena basin) containing some of the largest and best-preserved Pleistocene megafauna remains, contributing significantly to the knowledge about the extinction event of the Late Quaternary in the region.
Key locality	The stratigraphic record includes 12 formations from the Early Cretaceous to the Pleistocene and it comprises a sedimentary sequence developed on oceanic crust. The formation of interest is the Pleistocene.
Conservation status	In general, all geological elements are observed to be in good condition. However, there is a possibility of the deterioration of these geological elements.

Table 1. Cont.

Indicators/Subindicators	Description
Scientific knowledge	There are projects and research work aimed at promoting the geotourism and scientific development of the museum.
Rarity	The MPM is the first and only museum of a palaeontological kind, with unique integrity on a national level. This museum presents fossil remains such as the skeleton of a Megatherium, Mastodon, American Horse, Megalodon tooth, dolphin fragment, primitive whale, turtle plate, remains of prehistoric mice, opossum and prehistoric pig.
Integrity	The excellent state of conservation of the site makes it possible to display the fossil elements to visitors that arrive at the museum.
Vulnerability	The site is located less than 100 m from a busy road and less than 5 km from an industrial area.
Accessibility	The site is located in an urban area on paved roads. In addition, the museum provides access facilities for wheelchairs.
Use limitations	The museum allows entry visitors as students and tourists (opening hours: 08H00 to 17H00).
Safety	The site has safety facilities like steps, handicapped ramp, mobile coverage and emergency services 3 km away.
Logistics	Accommodation and restaurants are within 3 km of the museum.
Density of population	Density population of the area is approximately 900–1000 inhabitants/km ² .
Association with other values	An illustrative example is the Amantes de Sumpa Museum; the site features a preceramic settlement with evidence of dwellings and a cemetery. The museum is named after two skeletons found hugging each other, belonging to the Las Vegas Culture (catalogued among the oldest ones in the American continent).
Uniqueness	The site presents a unique feature at the regional level because the museum is an example of palaeontological findings of an ancient fauna located in the Santa Elena province.
Observation conditions	All fossil elements are found to be in good condition.
Didactic potential	The guides take visitors on a tour of each museum sector, from the fragments to the Megatherium skeleton. They provide information about the history and culture of the megafauna found in the palaeontological work. In addition, they show didactic material about the information found in the museum.
Geological diversity	The site has only one type of elements, belonging to the megafauna and microfauna of approximately 50,000 to 8000 years in age.
Interpretative potential	The site presents fossil elements transparently and expressively to every visitor.
Proximity of recreational areas	The site is located less than 5 km from a recreational area and tourist attractions, such as the Amantes de Sumpa Museum, La Libertad Central Park, Santa Elena Central Park and Cautivo Beach.
Deterioration of geological elements	There is the possibility of secondary manipulation of fossil elements.
Proximity to areas/activities with potential to cause degradation	Industrial areas such as slaughterhouses, warehouses and oil refineries are less than 5 km away.
Legal protection	The museum has the legal protection of the UPSE University, municipality and ministry of tourism.
Surface	The museum has an approximate area of 334 m ² (including exhibition areas, rooms and toilets).
Surrounding landscape and nature	Tourists can enjoy an exhibition content and simulated mural of the landscape depicting the Megafauna.
Environmental fitting of sites	The site fits perfectly in its logistical location.

Once the F and V are known, the Degradation Susceptibility (DS) is given by the following Equation (1):

$$DS = (F \times V) / 400 \quad (1)$$

The total Degradation Susceptibility (DS) value has a determined weight: low (<13), medium (13–67), high (68–199), very high (200–399) and maximum (400).

With the value of the Degradation Susceptibility (DS) and the scientific (Sc), academic (Ac) and tourist (To) values, the results are ordered according to the Equations (2)–(5) of the scientific (PpSc), academic (PpAc), tourist (PpTo) and global (Pp) aspects as follows:

$$PpSc = (Sc^2 \times DS) \times (1/400^2) \quad (2)$$

$$PpAc = (Ac^2 \times DS) \times (1/400^2) \quad (3)$$

$$PpTo = (To^2 \times DS) \times (1/400^2) \quad (4)$$

$$Pp = [(Sc + Ac + To) / 3]^2 \times DS \times (1/400^2) \quad (5)$$

3.2.2. Assessment with Brilha Method

The Brilha method [1] was applied to the MPM to determine its value as a geosite. This quantitative assessment procedure mainly considers geosite geoconservation events [1]. In general, this procedure establishes: (i) Scientific Value (SV), (ii) Potential Educational Use (PEU), (iii) Potential Tourism Use (PTU) and (iv) Degradation Risk (DR). The criteria represented by indicators score from 1 to 4 points, with different weights.

In the Degradation Risk (DR) variable, there is a classification based on the total value obtained from the assessment, established in a range (low <200, medium 201–300 and high 301–400) [1].

3.2.3. Assessment with Geosites Assessment Model (GAM) Method

The application of the GAM method [33] focused on defining the site's potential from two groups of indicators: main values (Scientific/Educational, Scenic/Aesthetic and Protection) and additional values (Functional and Touristic). The process considers scores ranging from 0 to 1 [33]. Subsequently, the values obtained for each indicator are reflected in a matrix (main value on the X-axis and additional value on the Y-axis), which will allow the evaluators to obtain a panoramic image of the current state of the site.

3.3. Phase III: Qualitative Evaluation. DELPHI and SWOT Analysis

This phase carried out a qualitative analysis by UPSE University experts using the DELPHI methodology [74]. The methodology allowed the researchers to understand the current state of the MPM.

In addition, a Strengths, Weaknesses, Opportunities and Threats (SWOT) analysis has been carried out [75], considering the characteristics of the MPM and its environment. The analysis made it possible to determine the site's geotourism potential and propose initiatives for the efficient and effective use of the museum.

4. Results

4.1. MPM Processing and Systematisation

The visitor register reports that the MPM reached 14,400 visits in the period from 2018 to 2020. The year 2019 has the highest register (7253 visits) (Figure 4a). However, in the year 2020, there is a decrease in tourist influence mainly associated with the sanitary situation caused by COVID-19. This problem led to the temporary closure of the MPM, which interrupted visits from March until the end of 2020. The development of virtual activities and visits to the museum have been addressed as alternatives during the pandemic closure. However, it has not been possible to obtain these data in this study. In general, the available

data indicate that the months with the highest number of visits are July (2019: 2113 visits) and October (2018: 963 visits) (Figure 4b).

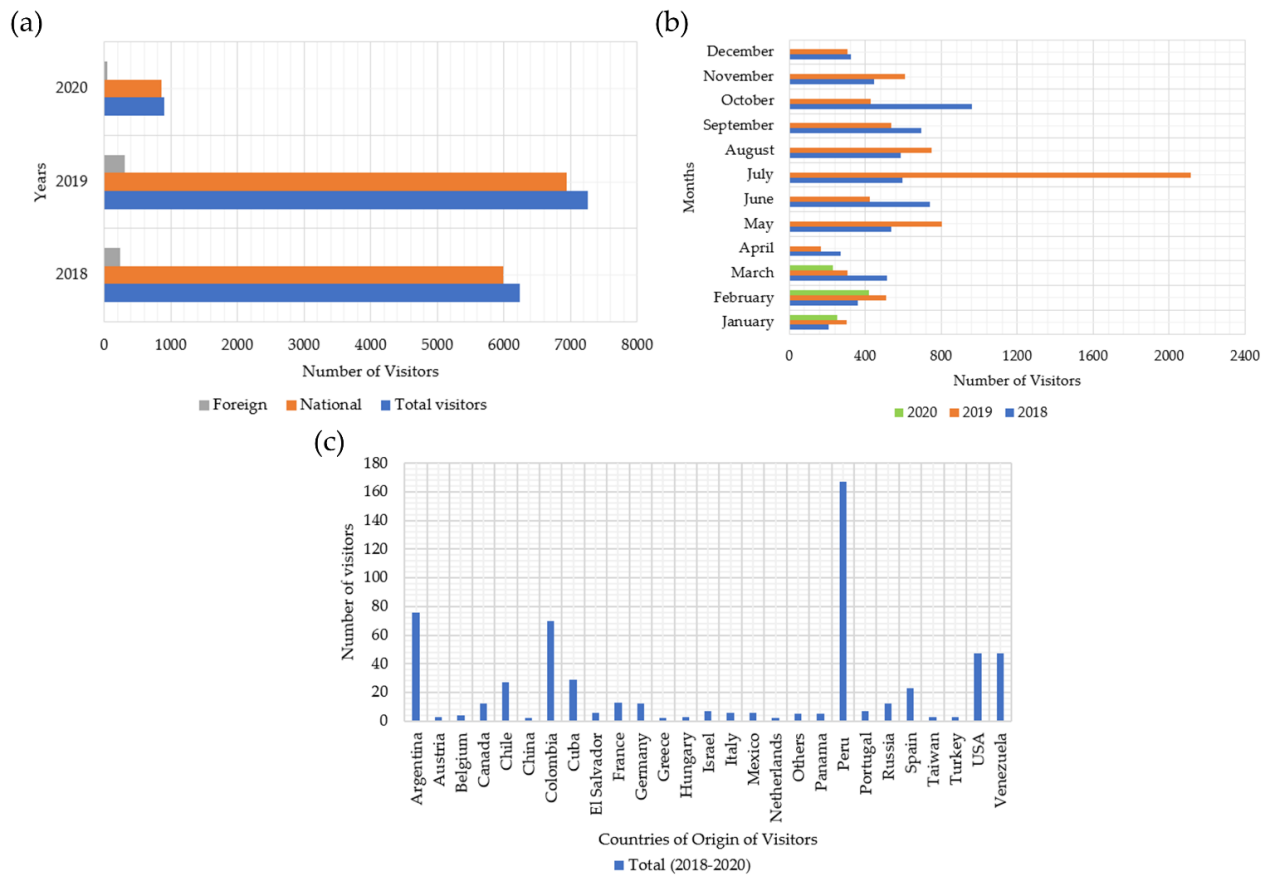


Figure 4. (a) Data on annual visits (2018, 2019 and 2020) to the MPM; (b) Data on monthly visits to the MPM in the years 2018, 2019 and 2020; (c) Cumulative data on foreign visitors to the MPM in the period from 2018 to 2020.

Regarding the visit of foreign tourists, the collected data indicate that the highest number of visits (46.6%) corresponds to tourists from Peru and Argentina (Figure 4c).

Table 2 shows the projects, and scientific articles carried out by researchers from the UPSE University with the collaboration of other authors from other institutions (national and international). Two projects were carried out related to the museum's tourism activities and development: "Megatherium-UPSE Museum: From Exhibition Hall to Natural History Museum" [64] and "Santa Elena Peninsula Geopark Project" [67]. These projects aim to strengthen the concept and geological assessment of the MPM through the development of scientific research. Finally, table presents a summary of the articles resulting from the research on the scientific content of the museum. These articles generally deal with geological assessment and palaeontological studies.

Analysis of the museum's documentation and collection yielded relevant data on the representativeness of the available collection, the preservation degree of megafauna fossil remains, the heritage and geotourism potential of the museum and, above all, the uniqueness of the available collections. In detail: (i) concerning history, the museum's name is shaped by discovering the sloth "Megatherium" and other finds of fossil remains; (ii) considering the culture, it presents a collection of 524 bones and 2969 fragments belonging to the Late Pleistocene megafauna that inhabited the Santa Elena province; (iii) from the point of view of tourist interest, analyses carried out by other authors indicate that the museum is of high interest; and (iv) regarding representativeness, the MPM has fossil elements of a particular national character and is considered the first palaeontological museum in Ecuador.

Table 2. Projects and scientific articles related to the MPM by the UPSE University.

MEGATHERIUM PALEONTOLOGICAL MUSEUM (MPM)			
	Status/Finish Date	Title	Objectives
UPSE Projects	Approved (2017)	Megatherium-UPSE Museum: From Exhibition Hall to Natural History Museum [64]	Updating the museum's scientific content through a research protocol associated with museum tasks (new fossil finds).
	Approved (2017)	Santa Elena Peninsula Geopark Project [67,76]	Developing sustainable strategies in the Santa Elena province through the use of georesources (geosites) and the expansion of the tourism offer.
	State/Journal/Conference/Institution/ Finish date	Title	Relationship with the MPM
Scientific Articles ("Geological Interest")	Published/WIT Transactions on Ecology and the Environment (2018)	Geotourism Potential in the Context of the Geopark Project for the Development of Santa Elena Province, Ecuador [46]	This study analysis of the most important geological and tourist sites in the Santa Elena province. Consideration of the MPM as part of geotourism potential sites.
	Published/IV Congreso Internacional sobre Geología Y Minería Ambiental (2016)	Ancón-Santa Elena Geopark in the Context of Land Use Planning [68]	Analysis of Global Geoparks for the Santa Elena Peninsula Geopark Project Study. Consideration of MPM as part of uniquely valuable geosites.
	Published/Sustainability (2020)	Geosites and Georesources to Foster Geotourism in Communities: Case Study of the Santa Elena Peninsula Geopark Project in Ecuador [51]	Quantitative assessment of six relevant areas of the Santa Elena Peninsula Geopark project (including the MPM) as potential geosites to promote geotourism.
Scientific Articles ("Palaeontological Studies")	Published/UPSE (2003)	Report on the discovery of Pleistocene Megafauna remains in Tanque Loma / First progress report on the Megatherium Project, Tanque Loma, UPSE [69,70]	First archaeological finds destined for the MPM by professionals and students of UPSE University.
	Published/XXX Jornadas de Paleontología de la Sociedad Española de Paleontología (2014)	New data on vertebrate fossil faunas from the Quebrada Seca area (Santa Elena, Ecuador) [71]	Geological study of the deposit found in the "Quebrada Seca" area near the deposit "Tanque Loma". Knowledge of a variety of species that are currently conserved in the MPM.
	Published/PeerJ (2017)	New findings of Pleistocene fossil turtles (Geoemydidae, Kinosternidae and Chelydridae) from Santa Elena Province, Ecuador [72]	Study of new material from fossil turtles like Geoemydidae, Kinosternidae and Chelydridae lineages. Display of remains found in the museum's exhibition halls.
	Published/Journal of South American Earth Sciences (2015)	Tanque Loma, a new late-Pleistocene megafaunal tar seep locality from southwest Ecuador [73]	New Late Pleistocene excavations at "Tanque Loma" on the Santa Elena province, Ecuador.
	Published/Palaeogeography, Palaeoclimatology, Palaeoecology (2020)	A monodominant late-Pleistocene megafauna locality from Santa Elena, Ecuador: Insight on the biology and behavior of giant ground sloths [65]	Generation of a developmental analysis of the Tanque Loma locality on the 22 individuals of the ground sloth <i>Eremotherium laurillardi</i> (species presented in the MPM).
	Published/PeerJ (2020)	Diversity and paleoenvironmental implications of an elasmobranch assemblage from the Oligocene–Miocene boundary of Ecuador [66]	New fossil finds of elasmobranch vertebrates in the Montañita–Olón fossil site. Fossil remains on display at the MPM.

4.2. Semiquantitative Assessment with IELIG, Brilha and GAM Methods

This section presents the description of the main criteria (Table 1) used in the assessment of MPM using the Brilha [1], GAM [33] and IELIG [29] methods.

4.2.1. Assessment with IELIG Method

The museum evaluation with the IELIG method indicates a very high rating in terms of scientific interest (310/400) and academic interest (310/400). On the other hand, the touristic interest shows a high value (210/400). In general, based on the results of Sc, Ac and To, the degree of geological interest is “very high” (Figure 5).

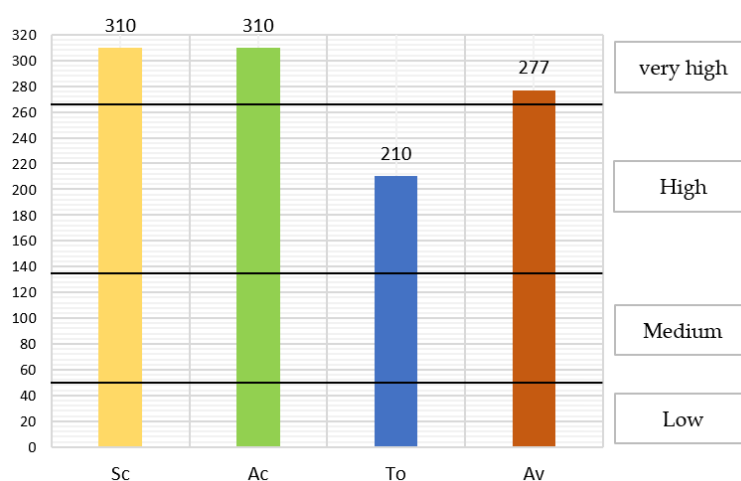


Figure 5. Results obtained regarding the value of Scientific (Sc), Academic (Ac), Tourist (To) and Average (Av) interest.

The value of fragility (160/400) and vulnerability (130/400), with intermediate results.

The value of the susceptibility to degradation (SD) (Table 3) indicates a medium score (52/400). The estimated value refers to the existing fossil collection. The potential damage mainly conditions the estimated value of 52/400 during the museum visit and the collections vulnerability. An SD reduction requires the improvement of the infrastructures that hold the collections on display to the public.

Table 3. Degradation susceptibility (DS) value.

Degradation Susceptibility (DS)	TOTAL
SD: (F*V)/400	52

Finally, Table 4 shows a moderate protection priority for the site. However, its tourism protection priority is an issue that needs to be improved.

Table 4. Protection values: scientific (PpSc), academic (PpAc), touristic (PpTo) and global (Pp).

PROTECTION	
PpSc	31.23
PpAc	31.23
PpTo	14.33
Pp	24.88

4.2.2. Evaluation with the Brilha Method

In the Brilha method, the evaluation shows moderate values of the variables in the Scientific Value (SV) (290/400) and Potential Educational Use (PEU) (280/400). However,

the Potential Tourism Use (PTU) score is higher (315/400) (Figure 6). Degradation Risk (DR) is low (190/400) due to the good logistics and legal protection of the museum.

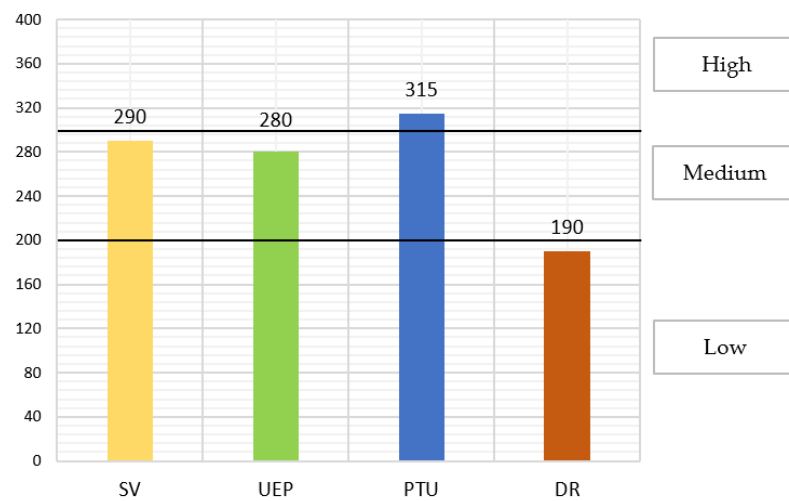


Figure 6. Results obtained regarding the Scientific Value (SV), Potential Educational Use (PEU), Potential Tourism Use (PTU) and Degradation Risk (DR).

4.2.3. Assessment with the GAM Method

The GAM assessment shows high values ranging primarily between 0.5 and 1, with an average score of 0.75. The core variables, such as the Scientific Educational Value (VSE), Scenic/Aesthetic (VSA) and Protection (VPr), add up to a total score of 8/12. On the other hand, additional values such as Functional (VFn) and Touristic Values (VTr) show a higher value (11.5 points) (Figure 7). The results place the MPM assessment between the Z₂₃ and Z₃₃ fields (Figure 8), which means it has a high geotourism potential.

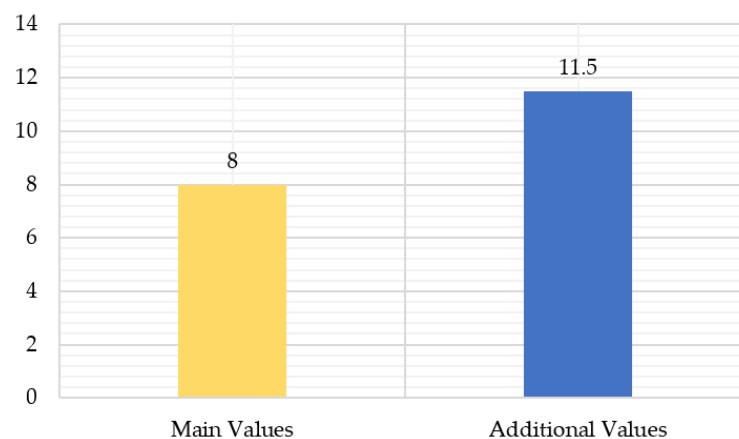


Figure 7. Results obtained regarding Main Values and Additional Values.

4.3. DELPHI and SWOT Analysis

4.3.1. DELPHI Method

The results obtained in the semiquantitative assessment indicate that the MPM is a site with geotourist potential oriented towards ex situ geoconservation. Therefore, the scientific content, service, logistics and state of infrastructure are critical variables in the MPM valuation process. However, it is necessary to consider actions caused by internal and external sources that negatively influence the museum's content, such as the constant vehicular traffic (less than 100 m), visitors who do not respect the signage and the lack of constant maintenance of the museum's infrastructure. In addition, it is essential to promote

the implementation of geotourism development strategies of the MPM at the national and international levels.

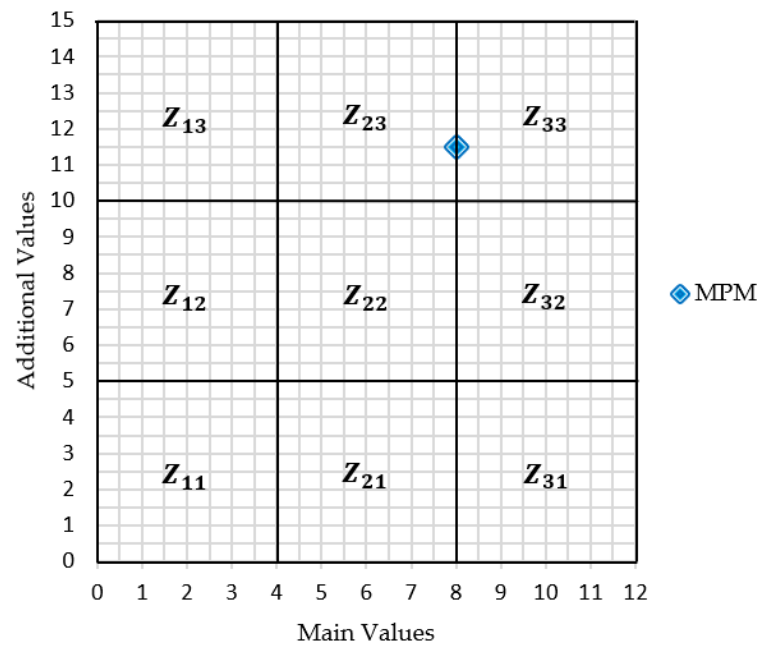


Figure 8. Position of the results obtained in GAM.

4.3.2. SWOT Analysis

The SWOT matrix analysis was generated based on the criteria used in the DELPHI method (Table 5). This analysis shows an overview of the current conditions and strategies that affect geotourism development in the MPM.

Table 5. SWOT analysis (qualitative matrix) of the MPM.

		Internal factors	Strengths	Weaknesses
External factors			<ol style="list-style-type: none"> 1. Fossil elements of particular character at the local and national level 2. Main routes in good condition 3. The museum is in a strategic location 4. Good infrastructure for the reception of visitors 5. Trained professionals to share information 	<ol style="list-style-type: none"> 1. Limited links with private and governmental entities 2. Low ICTs (Information and Communication Technologies) index towards the academic and social environment. 3. Limited funding for improvements and new development projections. 4. Limited POP (Point of Purchase) material for visitors. 5. Lack of relationship with national and international museums
		Opportunities	Strengths and Opportunities	Weaknesses and Opportunities
		<ol style="list-style-type: none"> a. Promote heritage recognition at the national and international levels. b. Create academic and tourism programmes that promote information about the museum. c. Manage job placements, internships and training programmes aimed at professionals and students of related careers. d. Develop new palaeontological discoveries for the museum's exhibition. e. Development strategies that help realise financial linkages 	<ol style="list-style-type: none"> 1.3.5.a. Promote the MPM through the Santa Elena Geopark Development Plan. 3.4.b.e. Alliances with academic and governmental entities for geotourism development. 2.4.a.b.e. Manage publicity events through the use of accessible technologies 	<ol style="list-style-type: none"> 1.3.c.d. Provide opportunities for professionals and students through external funding for future infrastructure projects and discoveries. 2.4.a.b.e. Enhance the museum's publicity of its history, culture and representativeness, locally and nationally. 1.3.d.e. Improve and increase the tourist infrastructure through institutional and municipal support. 5.a.b. Implement academic and tourism strategies
		Threats	Strengths and Threats	Weaknesses and Threats
		<ol style="list-style-type: none"> a. Lack of constant maintenance of the museum's internal and external facilities. b. Temporary closure of the entrance to the museum caused by the COVID-19 pandemic. c. Limited interest of the surrounding people about the type of culture presented by the museum. d. Weak positioning of the Megatherium context as part of a tourist attraction. e. Negative manipulation of fossil elements by visitors 	<ol style="list-style-type: none"> 2.3.c.d. Inform people about the MPM using intensive communication strategies. 1.4.a.e. Implement legal regulations and norms that promote the protection of the museum's fossil elements. 	<ol style="list-style-type: none"> 1.3.a.e. Investment in conservation methods for fossil elements of a vulnerable nature. 2.b.c. Development of tourism strategies for welcoming people to the museum 4.5.c.d. Implementation of primary demand development strategies based on tourist attractiveness.

5. Discussion

The present study allowed us to characterise the scientific, academic and tourist interest of the Megatherium Palaeontological Museum (MPM) as a geosite using qualitative and semiquantitative methods and thus broaden the knowledge about its geotourism potential. The obtained results indicate that the museum can be considered an excellent place for the generation of geotourism, corroborating the information provided in previous studies [51,57]. In concrete terms, the study carried out by Herrera et al. [51], applying the “Criteria of Geological relevance, Representativeness, Geotouristically prominent Site, Interpretation, and Conservation (GREGSIC)” method, indicates that the MPM has a “very high” interest due to its scientific, educational and touristic value. Furthermore, in this study, when applying the IELIG, Brillha and GAM methods, the MPM presented a “high” interest of global interest in all three evaluations. Therefore, the MPM can be considered to reach the level of heritage recognition as it has a specific content and a suitable environment for preserving fossil elements [77]. However, we also found that it is essential to monitor the obtained values (scientific, educational, touristic) in terms of the conservation of its collections and its limited geotouristic progress. The inclusion of strategies and programmes for the conservation and promotion of the museum are pending tasks that must be addressed in further studies (e.g., [56,78]).

There are museums worldwide that have been evaluated using the three methods (IELIG, Brillha and GAM) for their enhancement. In the evaluations, these museums score “high” and “very high” [79–82] due to their scientific and geotourism potential regarding indicators such as representativeness, rarity, logistical infrastructure, accessibility and uniqueness. However, some museums are affected by anthropogenic threats (mainly open-air museums, e.g., [83,84]). In contrast, the MPM was found to have high values in indicators such as representativeness, knowledge of the site, rarity, informational and didactic content, level of interpretation, vulnerability, use limitations, the proximity of recreational areas and tourism infrastructure. In addition, the museum collections are well protected against anthropogenic manipulation, as vulnerability and protection criteria conditions are appropriate.

In more detail, the results obtained in the MPM evaluation show that:

1. According to the IELIG method [29], the museum can become a cultural model on a national level. In addition, its degree of knowledge, rarity, the spectacular nature of the museum and its tourism potential make it a destination for research and geotourism [46].
2. According to the Brillha method [1], the museum has an adequate study area to illustrate elements related to palaeontology. In addition, the scientific progress (integrity and geological occurrence) and its historical, cultural and heritage value make the museum a place of educational and touristic interest. The risk of degradation is low, as the museum’s fossil elements are protected.
3. According to the GAM method [33], the MPM has a unique scientific value, with high values of didactic and exemplary characteristics (Figure 8). However, its scenic/aesthetic value is intermediate, as the logistics of the museum do not present a natural environment and industrial activities are less than 5 km away.

Despite the scientific potential of the MPM, the DELPHI and SWOT methods show some weaknesses and threats that negatively affect the geotourism development of the museum. For example, the lack of publicity methods, lack of links and limited funding, low ICTs (Information and Communication Technologies) index, lack of relationship with national and international museums and limited local interest in the museum. According to Álvarez & Cedeño [56], implementing a promotion plan would allow the museum to obtain optimal solutions to the threat of social and academic disinterest. The present study includes strategic content that could help improve the geotourism performance of the MPM (Table 5). This proposed plan would encourage the development of the museum and the whole Santa Elena Peninsula Geopark Project. In concrete terms, through alliances with private and governmental entities, the generation of public events through online

technological resources [85] and, mainly, the incorporation of society in the initiatives to exploit geoheritage.

6. Conclusions

The evaluation carried out using the IELIG, Brilha and GAM methods shows a high scientific, educational and touristic interest of the MPM, qualifying it as an *ex situ* geoheritage element of palaeontological character with applications in geotourism. Due to the discovered fossil remains that form part of the museum's collection, it can be considered a place with unique characteristics at local and national levels. The MPM can be part of the geotourism potential sites of the Santa Elena province to validate its importance in the context of the Santa Elena Peninsula Geopark Project.

Despite outstanding studies showing a high scientific interest in the MPM, annual visitor trends show an intermediate interest from national and foreign tourists, with approximately 14400 visits in the last three years. Therefore, the implementation of strategies is fundamental to enhance geotourism in the MPM. Financial and publicity support by entities interested in making strategic links related to geotourism in the context of geoconservation is essential.

The DELPHI and SWOT analyses were fundamental to gain a deeper understanding of the current state of the museum. These methodologies proved that the MPM is a site of geotourism potential and, can be a base for social and economic development. In addition, these analyses revealed some weaknesses of the museum, such as its limited links with private and governmental entities, low ICTs index, limited funding, and lack of relationship with national and international museums. Based on the criteria mentioned above, we propose strategies focused on solving these weaknesses, for example, the search for external funding, the promotion of the MPM within the framework of the Santa Elena Peninsula Geopark project, the generation of alliances with academic and governmental entities, the implementation of interdisciplinary programmes (academic and tourism) and, finally, the development of tourism strategies.

Supplementary Materials: The following are available online at <https://www.mdpi.com/article/10.3390/heritage4030067/s1>, Figure S1: Fossils from the Palaeontological Museum: (a) Fossil bones of Megatherium; (b) Fossil Mastodon ribs and vertebrae; (c) Evidence of Pampaterio and American Horse; (d) Evidence of Giant Glosoterio and Deer.

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