New Approach on the Quantitative Assessment of Geotouristic Potential: A Case Study in the Northern Area of the Rio De Janeiro Cliffs and Lagoons Geopark Project

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Abstract
As a trend in sustainable tourism, geotourism is being increasingly practiced, especially in territories that include geopark areas. The municipalities included in the territory of the Projeto Geoparque Costões e Lagunas do Estado do Rio de Janeiro (Rio de Janeiro Cliffs and Lagoons Geopark Project) have a geological, historical, cultural, and ecological diversity favoring the development of geotourism. The aim of this study is to carry out an inventory and quantitative assessment of the places with potential for the development of geotourism in the municipalities in the northern part of the territory of this project, namely Quissamã, Campos dos Goytacazes, São João da Barra, and São Francisco de Itabapoana. For the inventory, places listed in the literature or recognized by professionals from different areas of knowledge were used as a premise, together with observations and insights from fieldwork. The quantitative evaluation was carried out considering two methodologies. In the first, the potential tourist use was calculated through the GEOSSIT application for natural attractions. The second was determined through a new approach, combining the methodologies of Brazil (2007) and (Brilha Geoheritage, 8:119-134, 2016), to calculate the attractiveness potential of both natural and manmade attractions. Thus, of the 24 places evaluated in this study, 23 were classified as having high potential to attract visitors. The assessments carried out using these two methods are complementary and provide a broad view of the potential of each location to become a geotourist attraction.

Keywords Geoparks · Geotourism · Rio de Janeiro Cliffs and Lagoons Geopark Project

Introduction
UNESCO Global Geoparks are unified and unique geographic areas where places and landscapes of international geological importance are managed with a holistic concept of protection, education, and sustainable development (UNESCO 2021). They aim to encourage the production of handicrafts, with materials collected in the region and the involvement of local communities, in addition to the creation of commercial activities and visitor support services, such as accommodation, food, and cultural entertainment.

Geoparks can also be understood as territories with management structures capable of implementing a sustainable development strategy that aims to preserve the natural heritage, promote tourist attractions, and popularize knowledge, being recognized for their contribution to the development of geotourism (Farsani et al. 2014). Furthermore, they also create economic growth opportunities for local communities (Farsani et al. 2011).

Faced with the need to conserve a given heritage, which, at the same time, can also be used consciously, geotourism has gained strength as a global trend in terms of sustainable tourism. It can be defined as “tourism that sustains and enhances the identity of a territory, considering its geology, environment, culture, aesthetic values, heritage, and the well-being of its residents” (Arouca Declaration 2011). Moreover, it also includes geodiversity conservation through...
appreciation, learning, and research (Hose 2012; Dowling 2013). Geoparks have a strong connection with geotourism, and one of their goals is to encourage this sustainable activity.

The proposal to create the Rio de Janeiro Cliffs and Lagoons Geopark has been under discussion since 2010. The proposal covers 16 municipalities in the state of Rio de Janeiro, covering an area of 10,900 km², with rocks from the Paleoproterozoic to the Holocene being found in its territory (Mansur et al. 2012).

The northern part of the territory of the Rio de Janeiro Cliffs and Lagoons Geopark Project, especially the municipalities of Quissamã, Campos dos Goytacazes, São João da Barra, and São Francisco de Itabapoana, attracts visitors on a smaller scale compared with other sectors of this project, especially in comparison with the municipalities of the Região dos Lagos (Lakes Region). In these four municipalities, the Sun and Beach, Cultural, Business and Events, Health, Ecotourism, and Rural tourist segments predominate (Brazil 2006).

Through geotourism, visitors can expand their knowledge of historical, cultural, geological, and biological aspects, among others, contributing to raising awareness of geotourism itself. This has the potential to encourage improvements in the places visited and for their residents, in addition to the conservation of the environment.

Local culture, cuisine, festivities, and handicrafts contribute to attracting and enhancing the visitor experience. Geofood is a project developed by Magma Geopark in Norway, which proposes the appreciation of aspects of geodiversity through local cuisine (Geofood 2020). This idea comes from the relationship of the fruits and vegetables that grow in certain types of soil with the geological processes that define their composition. Geofood can make visitors aware of the local reality and specificities through food (Vale et al. 2019). The restinga, lagoons, and fishing in the Rio de Janeiro Cliffs and Lagoons Geopark Project make it possible to prepare geofood and create handicrafts made with different materials. Furthermore, festivities and cultural events are also popular in the region.

Inventory and quantification are the first two steps in the basic requirements to promote the geoconservation of an area. Inventory is the selection of locations based on evaluation criteria, description, and scale of work. Quantification, on the other hand, seeks to demonstrate the relevance of heritage to support geocconservation actions, with minimal subjective criteria (Brilha 2005).

Therefore, the aim of this study was to carry out an inventory and quantitative assessment of the places that have potential for the development of geotourism in the municipalities of Quissamã, Campos dos Goytacazes, São João da Barra, and São Francisco de Itabapoana. Thus, the locations that have geotouristic potential in this portion of the territory of the Rio de Janeiro Cliffs and Lagoons Geopark Project will be examined, in such a way as to reduce the degree of subjectivity.

**Study Area**

The study area is located in the central sector of the Faixa Ribeira, in the Mantiqueira Province. It consists of an orogenic system parallel to the Atlantic coast of southern and southeastern Brazil (Almeida et al. 1981; Heilbron 2016). The crystalline basement rocks were formed during the collision responsible for the amalgamation of the Gondwana paleocontinent and are easily visible in the areas of mountains and low hills. Subsequently, 130 Ma ago, tectonic efforts culminated in the fragmentation of this paleocontinent and the opening of the South Atlantic, giving rise to the sedimentary accumulation area of the Campos Basin, which stands out for its economic importance associated with oil and gas production.

The topography of the area is subdivided into three parts that correspond to geological and geomorphological formations, being denominated by Lamego (1945) as mountain range, plateau, and plain. The highest areas are represented by the Neoproterozoic magmatic arcs formed by the Serra da Prata Suite and the Rio Negro Complex; by the Neoproterozoic metasedimentary units formed by the Italva, São Fidélis, and Bom Jesus do Itabapoana groups; and by syn/post-collisional granites (Heilbron 2016). Most notable among the mountain range areas are the Serra do Mar and the massifs of Itaoca, Pedra Lisa, and Morro do Coco. In the Parque Estadual do Desengano (Desengano State Park) area, there are also numerous water courses, including springs and waterfalls, making ecotourism stand out.

The plateau is composed of the continental Miocene sediments of the Barreiras Formation (Fig. 1), with greater expression in the study area at the western limit of the coastal plain of the Paraíba do Sul River, outcropping in the form of boards and cliffs (CPRM 2001).

The plain constitutes the recent coverage, being represented by beach deposits, of Pleistocene and Holocene age, recent alluvial deposits, fluvial-marine deposits, swamp and mangrove deposits, and ridges and paleo ridges as extraordinary features, in addition to the delta of the Paraíba do Sul River (Rodrigues et al. 2016).

Inserting in the North Fluminense Mesoregion, the area covers the northern sector of the Rio de Janeiro Cliffs and Lagoons Geopark Project. The climate is tropical with local variations due to differences in altitude, vegetation, and proximity to the ocean. From the point of view of atmospheric circulation, for most of the year it remains under the dominion of the Atlantic Tropical Mass originating from the Atlantic Tropical Anticyclone. The vegetation is
Fig. 1 Geological map modified from Heilbron et al. (2016). Distribution of sites of interest selected for quantitative assessment.
characterized by remnants of Atlantic Forest with ombrophilous forests and lowland fields, in addition to coastal vegetation in restingas and mangroves. It occupies the hydrographic regions of the Paraíba do Sul River, the Itabapoana River; the Imbé River and the Lagoa de Cima, and Lagoa Feia, the latter being the second largest freshwater lagoon in Brazil (Mansur et al. 2012).

Local culture is expressed through festivities and demonstrations, production of handicrafts from local inputs, and through gastronomy. The Feast of the Holy Spirit, the Cavalhada, Fado dancing, the feast of Nossa Senhora da Penha, the Fogaréu Procession, the June circuit, the Reisado das Pastorinhas, the Christmas parade, and the traditional kings’ revelry are important events that attract visitors to the region. Local handicrafts made of clay, cattail, fish scales, shells, and other raw materials spread the regional identity. In addition, cuisine with fruits, flour, fish, sweets, and drinks can captivate people who are passing through to appreciate local specificities through food.

Methods

During this research, general recognition of the study area was carried out through prior consultation of the published bibliography to assess the geology, historical–cultural aspects, and tourism. Thus, the inventory carried out by Alves et al. (2003) and Mansur et al. (2012) was considered. Subsequently, fieldwork was carried out to update the inventory of representative geodiversity locations in the region that fit a geotouristic bias and to capture aerial images through the use of drone. In addition, interviews were conducted with professionals from the areas of Tourism, Geography, Geology, History, and the Environment and university professors who had a relevant contribution in the selection process of these places. It is worth pointing out that locations with more than one point of interest were grouped together as a single location in order to synthesize the analysis process.

The quantitative evaluation was carried out considering two methodologies. For natural sites, where geological elements are the main attraction, a quantitative assessment of potential tourist use (PTU) was used, through the GEOSSIT application developed by the Geological Survey of Brazil, available at cprm.gov.br/geossit/. Examples of the use of this application can be found in Ribeiro et al. (2021), Romão and Garcia (2021), Albani et al. (2020a), Santos et al. (2019), and Silva et al. (2018).

The quantitative assessment of the PTU is based on the following criteria: vulnerability, accessibility, use limitations, safety, logistics, population density, association with other values, scenic beauty, uniqueness, observation conditions, potential for dissemination, economic level, and proximity to recreational areas. Each criterion is scored as 0, 1, 2, or 4, where the value 0 is used when not applicable and the values 1, 2, and 4 represent the relevance of each criterion in ascending order. Sites with a PTU value equal to or greater than 200 will be considered of national relevance. Values less than 200 characterize places with regional or local relevance.

The research also included a new approach to quantitative assessment, in which adaptations to the methodologies of Brazil (2007) and Brilha (2016) were made, with the aim of helping assess the potential to attract visitors. The methodology of Brazil (2007) establishes priorities for choices and decisions of governors, administrators, managers, and entrepreneurs regarding the inclusion of attractions on tourist itineraries. At first, a quantitative order for attractiveness is established and a value is assigned to its characteristics, according to Table 1.

Immediately after the attractiveness characteristics, the aspects that support the objective differentiation of the potential and the degrees of importance of each attraction are evaluated, according to Table 2.

The representativeness criterion (Brazil 2007) reflects the rarity of the attraction, that is, the more it resembles other places, the less interesting it becomes. The interpretive potential (Brilha 2016) is related to the ability of a geodiversity resource to be understood by people with no geological background, that is, members of the general public. To assess these criteria, the help of the various professionals mentioned above was essential. The remaining

| Hierarchy | Characteristics |
|-----------|-----------------|
| 3         | All the attractions are exceptional and of great interest, with significance for the international market, each, in itself, being capable of motivating significant flows of current and potential visitors. |
| 2         | Attractions with exceptional aspects in a country, capable of motivating a current or potential flow of visitors from this country or abroad, together with other nearby attractions. |
| 1         | Attractions with some significant aspect, capable of interesting visitors from places in the country, who have arrived in the area for other tourist reasons, or capable of motivating regional flows (current and potential). |
| 0         | Attractions with little significance, but which are part of the tourist heritage as elements that can complement others of higher hierarchy. They can motivate local tourist flow, especially the demand for popular recreation. |

Table 1 Element attractiveness characteristics. Adapted from Brazil (2007)
criteria, being of a more objective nature, were evaluated instantly.

From this methodology, the degree of current use and local and community support criteria were removed, as these data could not be obtained due to the COVID-19 pandemic. However, it would be important to obtain these data when pandemic restrictions cease. Thus, we chose to include the interpretive potential criterion which can influence its potential to attract visitors.

Four class intervals were established, and their values defined according to amplitude. The total amplitude (24) was divided by the number of stipulated intervals (4), and the value for each class interval was then calculated (6). Thus, a place of interest will be considered as having low potential if, during this assessment, the sum is equal to or less than 6 points; with medium potential if it varies between 7 and 12 points; with high potential if it varies between 13 and 18 points; and if it is between 19 and 24 points, its potential to attract visitors will be considered very high.

It is noteworthy that the attractiveness and representativeness items have doubled weight, as they are more significant compared to the other evaluated items. This is due to the fact that the rarer and more exceptional a place is, the greater the chances of it becoming a geotourist attraction. Another point to be highlighted is that the manmade attractions, where geological elements are not the main attraction, but are complementary, were strictly quantified by the potential to attract visitors. As such, the GEOSSIT evaluation was restricted to natural places, where geological elements are the main attraction, and this methodology is more opportune to quantify places with these characteristics.

### Results

The municipalities of Quissamã, Campos dos Goytacazes, São João da Barra, and São Francisco de Itabapoana are home to a series of places of natural interest such as hills, rivers, lakes, sandbanks, cliffs, beaches, dunes, lagoons, coastal ridges, and mangroves. In addition, they also have several manmade attractions with the potential to attract visitors.

In Fig. 1, it is possible to observe the distribution of places of interest according to the inventory carried out in the study area.

#### P1 - Itabapoana River mouth - São Francisco de Itabapoana

The hydrographic region of the Itabapoana River covers the states of Minas Gerais, Espírito Santo, and Rio de Janeiro, comprising an area of about 4,900 km². The river is 264 km long and its source is in the Serra de Caparaó, in the state of Minas Gerais. The region is composed of an extensive plain of coastal ridges, identified as important Quaternary sedimentary deposits in the fluvial valley of the Itabapoana River. The geological evolution of this plain is associated with fluctuations in the relative sea level and the availability of river sediments (Albino et al. 2006).
Near the mouth of the river (Fig. 2A), in São Francisco de Itabapoana, there is a mangrove area subject to rising and falling tides and the fluviometric regimes of the Itabapoana basin. Characterized by an ecosystem of extreme importance for the reproduction of various species, fishing activities and the capture of crabs dominate in the area. In addition, it attracts tourists in search of tranquility, looking to take a boat ride or bathe in the waters, be it the river or the sea (Werneck et al. 2012; Coelho and Freire 2014).

**P2 - Antiga Casa de Câmara e Cadeia (Former Town Hall and Jailhouse) - São João da Barra**

The Antiga Casa de Câmara e Cadeia (Former Town Hall and Jailhouse) is the only property in the municipality of São João da Barra remaining from the colonial period (Fig. 2B). Building began in 1794 and was completed in 1797, being listed by the Instituto do Patrimônio Histórico e Artístico Nacional (National Institute for Historic and Artistic Heritage) in 1967. The prison operated on the ground floor and
the chamber on the upper floor, throughout the nineteenth century. It is currently the headquarters of the Centro Cultural João Oscar do Amaral Pinto (João Oscar do Amaral Pinto Cultural Center). The window frames of this property are composed of kinzigitic gneiss of 1.3-1.8 billion years old and facoidal gneiss of 560 million years old (Valeriano et al. 2012), both from the city of Rio de Janeiro. The kinzigitic gneiss at this site contains feldspar, quartz, mica, garnet, and cordierite minerals (Albani et al. 2020b).

**P3 - Atafona - São João da Barra**

Atafona is in the delta of the Paraíba do Sul River where the river meets the sea (Fig. 2C), at Atafona Beach, in the municipality of São João da Barra, bordering São Francisco de Itabapoana. Since the 1950s, Atafona has been suffering from coastal erosion, caused by natural and anthropogenic processes, which has already destroyed the heritage of many residents (Fig. 2D). This erosive process is attributed to several factors, such as the energy convergence of orthogonal waves (Bastos 1997; Souza 2011); climate and oceanographic changes, as a result of phenomena such as El Niño (Santos 2006); changes in the sedimentary discharge of the basin and the construction of dams along the Paraíba do Sul River; and the presence of drift currents to the south of the basin and the construction of dams along the Paraíba do Sul River. A few meters away there is another quay, which ended up receiving the name of Cais da Imperatriz (Emperor's quay) - São João da Barra.

In the same way that the advance of the sea has been causing damage and destruction, it is no different with the dunes in that they also affect some properties. Studies (Fernandez et al. 2009; Rocha et al. 2018) show the southern edge of the delta as an expressive area for the occurrence of frontal dunes. This type of dune is associated with the continuous input of sediments from the river and the presence of constant NE winds.

**P4 - Barra do Furado - Quissamã and Campos dos Goytacazes**

Barra do Furado attracts many tourists because of the beautiful beach, which, due to the formation of waves, is very popular, especially for surfing. There is also the Canal das Flechas located there, connecting Lagoa Feia to the sea (Fig. 2E). In the early 1980s, the Departamento Nacional de Obras e Saneamento (National Department of Works and Sanitation) built two rock jetties at the mouth of the channel. However, the extension of the mouth by the breakwaters caused a misalignment on the coast, whereby on the Quissamã side there was a widening of the sand strip and on the Campos dos Goytacazes side there was strong erosion, a trend confirmed in a survey carried out by Bastos and Silva (2000). Thus, it can be observed that anthropic actions influence coastal dynamics, promoting significant changes to this coastline.

**P5 - Gargáu - São Francisco de Itabapoana**

The Gargáu mangrove developed in the estuary of the Paraíba do Sul River and is considered the longest in the state of Rio de Janeiro. The mangrove is of significant importance to the local economy, as most of the population earns their income and livelihood through the collection and sale of crabs, shellfish, and fish (Rocha 2013). In addition, the dynamics of nutrient replacement at the mouth of the Paraíba do Sul promotes fertile soil, suitable for agricultural activities (Reis et al. 2020).

The Barracão de Gargáu (Gargau Shack) (Fig. 2F), a centenary building considered historical heritage of the city of São Francisco de Itabapoana, maintains its original architecture with walls built in solid wood and a colonial-style roof, made with handmade tiles. It played a fundamental role in the region's development process at a time when its function was that of a commercial warehouse (Soares 2015). Currently, its function is as a space for cultural activities, being named Centro Cultural Barracão de Gargáu (Gargau Shack Cultural Center). It houses a library with the most varied titles and promotes diverse social and cultural activities.

**P6 - Centro Cultural Carlos Martins (Carlos Martins Cultural Center) - São João da Barra**

The Centro Cultural Carlos Martins (Carlos Martins Cultural Center) (Fig. 2G), located in São João da Barra, was built between 1860 and 1870 in a neoclassical style and was named in honor of a painter from the city who defended its renovation. It was listed by the Instituto Estadual do Patrimônio Cultural (State Institute of Cultural Heritage) in 1978 (PMSJB 2020). It houses a rich collection and offers free dance, choir, drawing, and theater classes. A staircase built with facoidal gneiss leads to the building's main hall (Albani et al. 2020b).

**P7 - Cais da Imperatriz (Empress’ quay) / P8 - Cais do Imperador (Emperor’s quay) - São João da Barra**

When visiting São João da Barra in 1847, Emperor Dom Pedro II disembarked at the quay on the banks of the Paraíba do Sul River. A few meters away there is another quay, which ended up receiving the name of Cais da Imperatriz (Empress’ quay) (Fig. 2H). In these places, boats that make the crossing of the Paraíba do Sul River, mainly the São João da Barra - São Francisco de Itabapoana stretch, depart and arrive. The rocks found on the mosaic floor at both the
Cais do Imperador (Fig. 3A) and the Cais da Imperatriz are leptinitic and facoidal gneisses (Albani et al. 2020b).

**P9 - Casa Mato de Pipa (Mato de Pipa House) - Quissamã**

Casa Mato de Pipa (Mato de Pipa House) (Fig. 3B) was built in 1777 and holds memories of the colonial period. It was the first to receive a roof in the region and the oldest among the preserved mill houses in the north of Rio de Janeiro.

The roof tiles are made of clay, have a concave shape, and are fitted together in inverted positions to prevent the entry of water and wind. It is a historic property, listed in 1985 by the Instituto Estadual do Patrimônio Cultural (State Institute of Cultural Heritage), and stands out for being the starting point of the settlement process of what would become the municipality of Quissamã. Currently, the Associação dos Amigos de Mato de Pipa (Association of Friends of Mato de Pipa) manages the site and aims to maintain the property’s original structures and publicize its historical value.
P10 - Cine Teatro São João (São João Cinema Theater) - São João da Barra

The neoclassical-style building of Cine Teatro São João (São João Cinema Theater) (Fig. 3C) was built in 1906 to be the headquarters of the Sociedade Beneficente dos Artistas de São João da Barra (São João da Barra Artists Benefit Society). As a social function, the cinema shows documentaries and well-known films that are difficult for the population to access (PMSJB 2020). There are granite gneiss and charnockite, commercially known as Ubatuba Green, on its facade. The latter is considered a high-grade igneous or metamorphic rock, which in general presents coarse grain and dark green color given by its feldspars, also having quartz, garnet, and pyroxene in its composition. Coming from Ubatuba, in the state of São Paulo, it has an estimated dating between 600 Ma and 500 Ma (Winge et al. 2001).

P11 - Espaço da Ciência (Science Space) - São João da Barra

Opened in 2006, the Espaço da Ciência Maria de Lourdes Coelho Anunciação (Maria de Lourdes Coelho Anunciação Science Space) (Fig. 3D) is one of the most popular tourist spots in the city of São João da Barra for educational purposes. Exhibitions are held at the site, including specimens of stromatolites collected from Lagoa Salgada, in addition to lectures, fairs, and other events related to the environment, highlighting the region's ecosystems. In partnership with the Clube de Astronomia Louis Cruls (Louis Cruls Astronomy Club), observations of the Atafona sky also take place at certain times of the year (PMSJB 2020).

P12 - Farol de São Tomé (São Tomé Lighthouse) - Campos dos Goytacazes

The Farol de São Tomé (São Tomé Lighthouse) was designed by the French engineer Gustave Eiffel, who also participated in the construction of the Statue of Liberty (1888) and the Eiffel Tower (1889). The monument is 45 meters high and has 216 steps and was built by a French firm in 1877, although its inauguration was in 1882. It is located on Brazilian Navy land, serving as a reference point for navigators passing through the region (Soffiati 2020).

The region, located in the municipality of Campos dos Goytacazes, is constituted by a geomorphological feature known as a cape, that is, a strip of land that protrudes from the coast advancing toward the sea (Rossato et al. 2008). In the geological past, the Paraíba do Sul River flowed into this location, showing records of its paleochannels (Fig. 3E) over the last 120 thousand years. At a later stage, the river deviated and ended up in Atafona due to tectonic movement (Mansur et al. 2012).

Boat fishing is very common at the Farol de São Tomé Beach, even with very rough waters. The place does not have a pier to moor the vessels, which means that tractors have to be used to put them in the sea and tow them back in. This draws the attention of people curious to witness the moment when boats are towed to the sea or back to the beach.

In 1959, the Campos Basin began to be explored with the drilling of the Cabo de São Tomé well (2-CST-01-RJ) located on a farm in the town of Xexé. The well reached a total depth of 2,620 m (Barreto et al. 2000), and the objective was to obtain geological information and test for oil (Mendonça et al. 2004). Despite the proven absence of hydrocarbons, the study showed the presence of fresh water up to a depth of 350 meters (Caetano 2000).

Two aquifers occur in the locality, the Emborê Aquifer and the São Tomé Aquifer. The first has an area of approximately 350 km²; it is a confined aquifer with thicknesses of up to 220 m superimposed on older sediments. The second is also a confined aquifer, with a thickness that can reach 2,000 m near the Farol de São Tomé. This aquifer is strongly affected by normal faults, increasing in thickness toward the coastline, being superimposed on the crystalline basement and older sediments (Barreto et al. 2000).

P13 - Igreja de São João Batista (São João Batista Church) - São João da Barra

The current Igreja Matriz de São João Batista (São João Batista Mother Church) (Fig. 3F), in São João da Barra, was initially built as a chapel in 1630 by Lourenço do Espírito Santo and a group of fishermen. It was rebuilt in 1679 and renovated in 1713 in Baroque Rococo style. In 1882, a fire broke out and destroyed the central part of the chapel. Later, a gothic-style tower was built, with the church in the shape of a cross (PMSJB 2020). It has leptinitic gneiss from Rio de Janeiro, with 560 Ma, in the stonework of the main door (Valeriano et al. 2012). This rock has fine grain and light coloration. In addition to minerals such as quartz and feldspar, it contains a lesser quantity of garnet and a little biotite. The interior of the church has a baptismal font with holy water made of marble, possibly of the Carrara type.

P14 - Lagoa de Cima - Campos dos Goytacazes

Lagoa de Cima (Fig. 3G), located in Campos dos Goytacazes, has turbid water, but is suitable for bathing, being much sought after as a spa, for the practice of various water sports, and for fishing. Bars and kiosks are located around the lake, providing infrastructure for visitors. The lake was visited in 1860 by Emperor D. Pedro II, who, enchanted by its beauty, called it “Lake of Dreams,” and described it as a piece of Switzerland in the interior of Brazil (PMCG 2020).
It was formed by the obstruction of a paleolagoon and represents the oldest lake in the region. Its water is fresh and has diatomite deposits on its banks. Diatomite is a raw material of sedimentary and biogenic origin, constituted from the accumulation of diatomaceous algae carapaces (Luz et al. 2010). Studies by Nascimento et al. (2005) with the *Aulacoseira* diatoms prove that Lagoa de Cima went through several hot and humid phases and also through periods of drought over 7,000 years BP. This diatom species, being present throughout the period, was decisive for understanding the evolution of the lake area.

P15 - Lagoa Feia - Quissamã and Campos dos Goytacazes

Lagoa Feia (Fig. 3H) covers the municipalities of Quissamã and Campos dos Goytacazes, being considered the largest freshwater lake in the state of Rio de Janeiro with an area of 200 km² (Lima 2014). An old inlet where the Paraiba do Sul River flowed was closed about 7,000 years ago (Dias and Gorini 1980; Mansur et al. 2012) and is currently separated from the sea by coastal ridges, which were formed in the process of marine regression (Alves et al. 2003).

Studies by Lima (2014) emphasize that Lagoa Feia had a major change in shape as a result of decades of landfilling by farmers, which led to the reduction of its water surface. Nevertheless, the lake has potential for leisure activities, water sports, and fishing, being frequently sought out by visitors and local residents.

P16 - Lagoa Salgada - São João da Barra and Campos dos Goytacazes

Lagoa Salgada (Fig. 4A) is located partly in São João da Barra and partly in Campos dos Goytacazes. It is considered a brackish to hypersaline lagoon that harbors occurrences of stromatolites. The environment in which these structures were formed is similar to that which reigned on Earth billions of years ago (Birgel et al. 2015). Studies indicate the presence of stromatolites at the site with ages ranging from 2.220 years to the present (Bahniuk 2013). Studies that address the occurrence of stromatolites in Lagoa Salgada can also be found in Coimbra et al. (2000), Silva and Silva et al. (2007, 2008, 2013), Mansur et al. (2012, 2018), Birgel et al. (2015), and Silva et al. 2018, (2019).

The lagoon is constantly visited by students and researchers from schools and universities due to the presence of recent stromatolites, whose occurrence is rare in the world. In Brazil, they are found only in Lagoa Salgada and in the Lagoon System of Araruama, both in the territory of the Rio de Janeiro Cliffs and Lagoons Geopark Project.

P17 - Morro do Itaoca (Itaoca Hill) - Campos dos Goytacazes

Morro do Itaoca (Itaoca Hill), also known as Morro do Rato (Mouse Hill), is formed by a granitic massif that represents the most recent magmatic event that occurred during the formation of the Gondwana Supercontinent. Its crystallization age is $476.4 \pm 1.8$ Ma, composing the post-collisional magmatic suite of the Ribeira Belt, with ages ranging from Cambrian to Lower Ordovician (Neto et al. 2014; Valeriano et al. 2016; Bongiolo et al. 2016).

The highest point of Morro do Itaoca is at an altitude of 414 meters (Fig. 4B), and its area enabled the municipality of Campos dos Goytacazes to be recognized as the national capital of free flight by state law No. 8,464 in 2019. In addition to free flight, other sports are practiced on site, such as trekking, mountain biking, and downhill. In addition, religious activities are also frequent, such as the pilgrims walk, whereby people climb to the summit to pray.

P18 - Parque Estadual do Desengano (Desengano State Park) - Campos dos Goytacazes

Parque Estadual do Desengano (Desengano State Park) (Fig. 3G) covers part of the municipalities of Santa Maria Madalena, São Fidélis, and Campos dos Goytacazes, being located at the northern end of the southern segment of the Serra do Mar mountain range. It basically consists of four types of PreCambrian age rocks: the Charnockito Bela Joana, which is concentrated on the eastern and Atlantic slopes; the Porphyritic Granite of the Pedra do Desengano (Desengano Rock); the Leucogranite Itacolomi Mountain range, which outcrops on the northern continental slope; and the São Fidélis Gneiss, which outcrops at points on the continental slope and at the southwestern tip (ITB 2011).

The park area is home to a representative portion of Atlantic Forest mammals (Modesto et al. 2008), in addition to a significant number of birds, making it one of the best birdwatching areas in the state of Rio de Janeiro (Castro 2015). Several activities can be practiced inside and around the park, with emphasis on trails, crossings, climbing, rappelling, flora and fauna observation, rafting, cycling, and horseback riding. The park is an attractive area for visitors, due to the beauty and exuberance of its rapids, waterfalls, and wells, which are responsible for supplying the municipalities of Santa Maria Madalena, São Fidélis, and Campos dos Goytacazes (INEA 2011).

P19 - Parque Nacional da Restinga de Jurubatiba (Restinga of Jurubatiba National Park) - Quissamã

The Parque Nacional da Restinga de Jurubatiba (Restinga of Jurubatiba National Park) (Fig. 4C) covers part of...
the municipalities of Macaé, Carapebus, and Quissamã, being the first national park in Brazil to be comprised exclusively of restinga ecosystem. It is an important territory inserted in the Atlantic Forest Biosphere Reserve with records of endemic species (Araújo et al. 2001; Tavares et al. 2011). The presence of coastal ridges is remarkable, originating from changes in the relative sea level during the Quaternary period (Pleistocene) in the last 120 thousand years, and from the interaction of waves with marine currents that bring sediments from the Paraíba do sul River (Soffiati 2018).

Tourists are attracted by the numerous coastal lagoons found in the interior of the park, in addition to the beaches, sandbanks, and boat trips through the Campos-Macaé Channel. The practice of water sports on the lakes, rides with traction vehicles, hiking along the trails, and birdwatching are quite common.
P20 - Pedra Lisa - Campos dos Goytacazes

Pedra Lisa (Fig. 4D), located in Campos dos Goytacazes, is characterized by a pointed feature of 720 meters in altitude, being formed by post-collisional granitic rocks, with about 485 Ma. Its shape is due to the weathering that caused its fracturing and spheroidal exfoliation on its rocks (Mansur et al. 2012). Alongside, with a more rounded shape, is Pedra do Bau, both igneous plutonic rocks.

Pedra Lisa is considered one of the most beautiful formations in the north of Rio de Janeiro, in addition to being a popular place for hikers and climbers. Its main climbing route was conquered on February 15, 1953, by climbers Alfredo Maciel, Francisco Vasco dos Santos, and Tued Malta de Campo (Escaladas 2020).

P21 - Praia da Lagoa Doce (Lagoa Doce Beach) - São Francisco de Itabapoana

Praia da Lagoa Doce (Lagoa Doce Beach) is considered one of the most beautiful beaches in the city of São Francisco de Itabapoana; its toponymy is attributed to the presence of a lagoon located in its proximity. Beaches with cliffs are very common in northeastern Brazil and little recurrent on the coast of Rio de Janeiro, and usually attract countless tourists. The highest cliffs in the state are found at the site (Fig. 4E), reaching about 10 meters in height.

The cliffs at Praia da Lagoa Doce are part of the Barreiras Formation (Miocene–Pliocene), one of the most expressive units of the coastal strip in the north of the state of Rio de Janeiro (CPRM 2001). It is composed of sandstones and muddy sandstones with intercalated mudstones, in addition to the occurrence of conglomerates (Winter et al. 2007). Marine erosion, through wave dynamics, can cause a washout process at the base of the cliff, which can generate abrasion caves (Rossato et al. 2008).

P22 - Fazenda Machadinha (Machadinha Farm) - Quissamã

Fazenda Machadinha (Machadinha Farm) is one of the main symbols of opulence of the sugar aristocracy in the north of Rio de Janeiro based on the exploitation of the slave labor system, and it highlights the different ways of life of both social groups. A Casa Grande (The Big House), in neoclassical style, was completed in 1868 and is currently in ruins. In contrast, the building of the former slave quarters (Fig. 4F) is well preserved and occupied by descendants of former employees of the Engenho Central de Quissamã (Central Mill of Quissamã), the last owner of the farm. In 1979, the farm had its listing approved by the Instituto Estadual do Patrimônio Cultural (State Institute of Cultural Heritage) (INEPAC 2020).

The Machadinha Memorial works as a visitor’s center for the farm, with a collection of images and texts about the enslaved, their origins, and their contributions to the municipality’s cultural formation. Visitors are welcomed by local guides from the community who explain the dynamics of the farm during the slavery period. Members of the Associação de Remanescentes de Quilombo de Machadinha (Association of Remaining Members of the Machadinha Quilombo) manage and conduct the entire visitation process at the site.

In 2019, researchers from the Rio de Janeiro Cliffs and Lagoons Geopark Project / Universidade Federal do Rio de Janeiro donated an interpretive panel to the community of Fazenda Machadinha. It contains explanations on aspects of local geodiversity, such as the coastal ridges that show the displacement of the mouth of the Parapá do Sul River over geological time, as well as the rocks of the Barreiras Formation used in the floor of the farm’s art house.

P23 - Solar dos Airizes (Airizes Mansion) - Campos dos Goytacazes

Solar dos Airizes (Airizes Mansion) (Fig. 4G), which is home to an old sugar mill, is a typical farm building in the region, built in the early nineteenth century. The colonial-style property was the first in Campos dos Goytacazes to be listed by the Instituto do Patrimônio Histórico e Artístico Nacional (National Institute for Historical and Artistic Heritage) in the 1940s (Sagre 2013). It belonged to the noted geoscientist Alberto Ribeiro Lamego who was the director of Geology and Mineralogy at the Ministry of Agriculture in the 1950s. Lamego was one of the pioneers in using photointerpretation as a tool for geological mapping in Brazil (IHGB 2020).

P24 - Estação Ecológica Estadual de Guaxindiba (Guaxindiba State Ecological Station) - São Francisco de Itabapoana

Estação Ecológica Estadual de Guaxindiba (Guaxindiba State Ecological Station) (Fig. 4H) is an integral protection conservation unit located on the coastal plain of the municipality of São Francisco de Itabapoana. It constitutes an area of approximately 3,260 hectares endowed with natural attributes. It was created on December 30, 2002, through State Decree No. 32.576, with the objective of protecting one of the largest remnants of semideciduous seasonal forest in the state of Rio de Janeiro. The local hydrography is composed of numerous areas of swamps and some rivers, the main one being the Guaxindiba River (INEA 2020).

The geological history of this unit is linked to the sedimentary rocks of the Barreiras Formation. These formed through sediments deposited from high-energy traction processes related to an intertwined fluvial environment.
Table 3  Score of each criterion for the quantitative assessment of the 24 sites of interest in the study area. PTU = Potential Tourist Use; AP = Attractiveness Potential

| Quantitative assessment of potential tourist use (PTU) and attractiveness potential (AP) | Vulnerability (10%) | Accessibility (10%) | Use limitations (5%) | Safety (10%) | Logistics (5%) | Population density (5%) | Association with other values (5%) | Scenic beauty (15%) | Singularity (10%) | Observation conditions (5%) | Potential for dissemination (10%) | Economic level (5%) | Proximity to recreational areas (5%) | PTU TOTAL | Attractiveness (x2) | Representativeness (x2) | State of Conservation | Infrastructure | Access | Interpretive potential |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| P1 - Itapuã River mouth | 2 | 3 | 4 | 2 | 1 | 1 | 1 | 1 | 2 | 4 | 3 | 1 | 1 | 200 | 2 | 4 | 2 | 2 | 2 | 2 | 14 |
| P2 - Antiga Casa de Câmara e Cadeia | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4 | 3 | 3 | 3 | 3 | 2 | 15 |
| P3 - Atafona | 2 | 3 | 2 | 2 | 4 | 1 | 4 | 1 | 4 | 4 | 3 | 1 | 4 | 255 | 2 | 6 | 1 | 2 | 2 | 2 | 15 |
| P4 - Barra do Furado | 2 | 4 | 4 | 2 | 3 | 1 | 2 | 0 | 1 | 3 | 3 | 1 | 1 | 195 | 2 | 4 | 2 | 2 | 2 | 3 | 2 | 15 |
| P5 - Gargáu Carlos Martins | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 2 | 4 | 1 | 2 | 2 | 2 | 3 | 14 |
| P7/P8 - Cais do Imperador/Imperatriz | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4 | 2 | 2 | 3 | 3 | 2 | 14 |
| P9 - Casa da Matéria de Pipa | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4 | 2 | 2 | 2 | 2 | 3 | 13 |
| P10 - Cine Teatro São João | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4 | 2 | 2 | 3 | 3 | 2 | 13 |
| P11 - Espaço de Ciência | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4 | 3 | 3 | 3 | 3 | 3 | 16 |
| P12 - Farol de São Tomé | 2 | 4 | 2 | 2 | 4 | 2 | 1 | 1 | 2 | 3 | 3 | 1 | 4 | 230 | 2 | 4 | 2 | 2 | 3 | 3 | 3 | 16 |
| P13 - Igreja de São João Batista | - | - | - | - | - | - | - | - | - | - | - | - | - | - | 0 | 4 | 3 | 2 | 3 | 3 | 2 | 14 |
| P14 - Lagoa de Cema | 3 | 4 | 4 | 3 | 3 | 2 | 1 | 1 | 2 | 2 | 3 | 1 | 0 | 235 | 2 | 4 | 2 | 2 | 3 | 3 | 16 |
| P15 - Lagoa de Feia | 3 | 2 | 4 | 2 | 3 | 2 | 1 | 1 | 1 | 4 | 3 | 1 | 1 | 205 | 0 | 4 | 2 | 0 | 3 | 4 | 13 |
| P16 - Lagoa Salgada | 2 | 2 | 4 | 3 | 3 | 1 | 4 | 1 | 4 | 4 | 3 | 1 | 4 | 260 | 2 | 6 | 3 | 0 | 2 | 2 | 15 |
|                  | Vulnerability (10%) | Accessibility (10%) | Use limitations (5%) | Safety (10%) | Logistics (5%) | Population density (5%) | Association with other values (5%) | Scenic beauty (15%) | Singularity (10%) | Observation conditions (5%) | Potential for dissemination (10%) | Economic level (5%) | Proximity to recreational areas (5%) | PTU TOTAL | Attractiveness (x2) | Representativeness (x2) | State of Conservation | Infrastructure | Access | Interpretive potential | AP TOTAL |
|-----------------|---------------------|---------------------|----------------------|--------------|----------------|----------------------|-------------------------------|---------------------|----------------|-------------------------------|-------------------------------|-------------------|--------------------------------|-------------|-------------------|------------------------|-----------------------|--------------|---------|---------------------|----------|
| P17 - Morro do Itaoca | 3                   | 4                   | 4                    | 3            | 3              | 2                    | 3                            | 1                   | 2              | 4                                           | 4                             | 1                 | 2                          | 270         | 2                 | 4                      | 3                     | 2             | 3            | 3                  | 17       |
| P18 - Parque Est. Desengano | 3                  | 1                   | 3                    | 2            | 1              | 2                    | 3                            | 1                   | 2              | 4                                           | 3                             | 1                 | 0                          | 195         | 2                 | 4                      | 3                     | 2             | 2            | 2                  | 15      |
| P19 - Parque Nac. Restinga de Juru-barita | 3                  | 2                   | 2                    | 2            | 2              | 1                    | 4                            | 1                   | 4              | 4                                           | 3                             | 1                 | 3                          | 240         | 2                 | 6                      | 3                     | 0             | 2            | 2                  | 15      |
| P20 - Pedra Lisa | 3                   | 2                   | 4                    | 3            | 3              | 2                    | 1                            | 1                   | 2              | 4                                           | 4                             | 1                 | 0                          | 230         | 2                 | 6                      | 2                     | 0             | 2            | 3                  | 15      |
| P21 - Praia da Lagoa Doce | 3                   | 4                   | 4                    | 2            | 4              | 4                    | 1                             | 4                   | 1              | 4                                           | 3                             | 1                 | 4                          | 255         | 2                 | 4                      | 2                     | 2             | 2            | 3                  | 15      |
| P22 - Fazenda Machadinha | -                  | -                   | -                    | -            | -              | -                    | -                             | -                   | -              | -                                           | -                             | -                 | -                          | -           | -                 | -                      | -                     | -             | -            | -                  | 15      |
| P23 - Solar dos Airizes | -                  | -                   | -                    | -            | -              | -                    | -                             | -                   | -              | -                                           | -                             | -                 | -                          | 0           | 3                 | 0                      | 1                     | 3             | 2            | 9                  |        |
| P24 - Estação Ecológica Estadual de Guaxindiba | 3                  | 2                   | 2                    | 3            | 1              | 1                    | 1                            | 1                   | 2              | 3                                           | 3                             | 1                 | 0                          | 190         | 2                 | 4                      | 2                     | 2             | 2            | 1                  | 14      |
and gravitational flows associated with alluvial fans (Winter et al. 2007). This sedimentary rock overlaps the Neoproterozoic basement. Visits to the unit are carried out for educational purposes, by request, with prior scheduling and monitoring by employees.

The values of each criterion used in the quantitative assessment of the 24 sites in the study area are given in Table 3.

Despite the similar nomenclature, the calculation method is different for certain criteria, such as accessibility and access, and singularity and representativeness. Accessibility takes into account the ease and length of the path between the visitor’s transportation and the site visited. Access is limited to checking the conditions of use of the roads used to reach the site. Both singularity and representativeness refer to the rarity of the attraction. However, while the singularity criterion score differentiates national-, state-, and regional-level occurrences, the representativeness criterion does not make this distinction and deals with the rarity of the occurrence.

In addition to these places of interest, the population of these municipalities participates in improving the experience of visitors. Creativity is present in local handicrafts that are made with inputs found in the region. In Campos dos Goytacazes, the Caminhos de Barro project (Alexandre et al. 2020) trains people to learn the art of ceramics and use it as an input for the production of handicrafts.

The cattail plant, taken from the lakes, is mainly used by artisans from São Francisco de Itabapoana and São João da Barra to produce bags and mats. Fish scales and shells serve as raw materials to produce slippers, earrings, and other souvenirs. Embroidery crafts are also highlighted through the numerous embroiderers who use knitting and crochet techniques. In Quissamã, in the area of the Parque Nacional da Restinga de Jurubatiba, candles in the shape of restinga plants are sold. At Fazenda Machadinha, the residents manufacture Abayomi, which are dolls made of cloth that symbolize the resistance and tradition of black culture.

With regard to geofood, São João da Barra and Campos dos Goytacazes stand out for their typical products from a restinga environment, such as guava, pineapple, pitanga, and precocious dwarf cashew, which are sold in natura and also in the form of pulp, drinks, and candy. Quissamã is also the largest coconut producer in the state of Rio de Janeiro. The municipality of São Francisco de Itabapoana is home to several flour houses known locally as bolandeiras, where manioc flour is produced by hand and sold, becoming a source of income for many families. Campos dos Goytacazes is known for its drizzle, a sweet of Portuguese origin made from eggs, and for its famous guava candy.

Popular culture is very expressive in the region, with several festivities and manifestations. At the end of the nineteenth century, when sugarcane plantations dominated the landscape of northern Rio de Janeiro, the Fado dancing emerged in the then district of Quissamã. Occasionally presented in houses, salons, and rural neighborhoods, mainly in Machadinha, it can be considered a set of linked dances to the sound of viola and tambourine (Mattoso 2003).

Cavalhada, a manifestation of the intangible popular culture of Campos dos Goytacazes, is linked to the Feast of the Holy Spirit, which has its origins in Portuguese tradition and takes into account the calendar of the Catholic Church. It takes place preferably during the festivities at Santo Amaro, every January 15 and on November 11, São Martinho day, in the town of São Martinho, in the District of Santo Amaro (Paes 2016).

In São João da Barra, in April, the feast of Nossa Senhora da Penha takes place, attracting devotees and worshippers who participate in various religious events such as the luminous pilgrimage, the Alto de Maria River and land procession, baptisms, and outdoor mass. During Holy Week, the Fogaréu Procession takes place and in June the circuit begins. The circuit features parties in honor of St. Anthony, St. John the Baptist, and St. Peter. Reisado das Pastoirinhas is a popular operetta that marks the Christmas festivities. The city also has the Christmas parade and the traditional kings’ revelry (Albani et al. 2020b).

**Discussion**

In the study area, the Sun and Beach, Cultural, Business and Events, Health, Ecotourism, and Rural tourist segments prevail (Brazil 2006). Geotourism is not considered a tourist segment by the Ministry of Tourism of Brazil. Nevertheless, the study by Silva et al. (2021) identified characteristics for it to become a tourist segment, among which are the practice of activities that value the traditions and environmental, architectural, and historical aspects present in the places visited.

Inventory and quantitative assessment are important prerequisites for the development of geotourism in a given region. According to the results presented, it can be verified that the municipalities in the study area have places with potential for the development of this activity. In the inventory process, locations listed in the literature and/or recognized by professionals from different areas of knowledge were used as a premise, together with observations and insights from fieldwork.

The quantitative assessment was carried out considering the potential tourist use (PTU) using the GEOSSIT platform only for the 13 places where natural aspects predominate, since this platform was developed exclusively to assess natural sites. This is a tool that allows the user to record and quantitatively assess places and feed the database of the Geological Survey of Brazil.
The other stage of the quantitative assessment calculated the attractiveness potential (AP) for visitors by combining the methodologies of Brazil (2007) and Brilha (2016). At this stage, all 24 sites were quantified with this method. Thus, the attractiveness of the element was taken into account, according to its characteristics, peculiarities, and the interest it may arouse in visitors.

The following locations were nationally relevant with regard to the PTU: Morro de Itaoca, Lagoa Salgada, Praia da Lagoa Doce, Atafona, Parque Nacional da Restinga de Jurubatiba, Lagoa de Cima, Farol de São Tomé, Pedra Lisa, Lagoa Feia, and Itabapoana River mouth. As Parque Estadual de Desengano and Estação Ecológica Estadual de Guaxindiba had low scores in the accessibility and logistics category and Barra do Furado had low scores in the uniqueness and scenic beauty categories, they were classified with regional/local relevance.

When the AP of the sites was analyzed, an aptitude for geotourism was found because they are already used as such due to their geological/geomorphological foundation (natural attractions). On the other hand, places that do not have this direct relationship with geology (manmade attractions) were indirectly associated, as they contained some element of relevant geodiversity or their history was linked to geology. All the sites had high attraction potential, with the exception of Solar dos Airizes, which, due to its poor state of conservation, was classified as having medium potential to attract visitors.

When evaluating the two methods used, differences in rankings can be seen among the natural sites. For example, Lagoa Salgada ranked second in the PTU score but was third according to the AP, due to low scores on access and infrastructure. Lagoa de Cima and Farol de São Tomé were ranked fifth and sixth on the PTU, respectively, and joint second on the AP. Ease of access and the existence of infrastructure for visitors interfered in the classification of these places according to this ranking.

Both methods have their own characteristics. Some criteria have similar names, such as accessibility in the PTU and access in the AP; however, their calculation varies in each method. In summary, a high value on the PTU is related to places with low vulnerability and a good score in the scenic beauty aspect, which is associated with the use of the attraction in tourist campaigns. A high value in the AP refers mainly to the occurrence of different locations, in addition to its good attractiveness.

For manmade attractions, the AP assessment method has spaces focused on science, education, and culture at the top of the ranking. The Espaço da Ciência Maria de Lourdes Coelho Anunciação received the highest score and the Fazenda Machadinha, together with the João Oscar do Amaral Pinto Cultural Center at the Antiga Casa de Câmara e Cadeia, came immediately after in the table. Both have good ability to attract visitors, which contributed to their standing out in this evaluation. Solar dos Airizes presented an AP of 9 points, being classified as medium potential. However, the other sites had high potential, with similar values, ranging between 13 and 16 points.

The public use of conservation units certainly contributes to the increase in the number of visitors, especially in the Parque Nacional da Restinga de Jurubatiba. In this unit, people use the various lagoons for bathing, in addition to which students and researchers perform numerous activities. However, the lack of infrastructure hinders visitation in places such as Lagoa Salgada, Pedra Lisa, and Parque Estadual do Desengano. Improvement of access roads, as well as dissemination, would certainly contribute to knowledge on the importance of these places for an increasing number of people. However, it would bring with it the risk of increased vulnerability, as where there are more people circulating, there are greater chances of damage to attractions.

The quantitative assessment using AP had applicability to both natural attractions and manmade attractions as its strength. In the case of natural attractions, this method brought a complementary view to the PTU assessment method, even giving different values in the ranking for each location. As a limitation of this methodology, we can highlight the similarity in the score of each attraction, with the values being very close to each other. In addition, the final classification of Solar dos Airizes as a site with medium potential seemed to be inadequate as the property is quite deteriorated, which, in our opinion, would be more consistent with low potential.

Brilha (2016) states that subjectivity, which is inherent to both inventory and quantification, can never be totally eliminated. However, the methodologies used in this research sought to minimize the intrinsic subjectivity of the criteria used. As an example, we can highlight the scenic beauty and state of conservation criteria. The first takes into account the frequency with which the site is used in tourist campaigns and not whether it is beautiful or not. The second points out, through on-site observation, the state of conservation of the landscape that surrounds each attraction.

Therefore, the methodologies used to calculate the PTU and the total AP proved to be adequate for the proposed study. Since these methodologies already existed, the focus here was on making adaptations and not developing a new method. The total PTU and AP values were calculated in order to assist in evaluating the importance of the identified attractions, demonstrating the geotouristic potential of each attraction. The higher the total values, the greater the capacity of each attraction to be used with a geotourism slant.

Furthermore, it is noteworthy that the geotouristic potential of the study area is also reflected in the number of available activities. Visitors can undertake cultural and ecological tours, hiking trails, climbing, free flight, cycling, wildlife
watching, various water sports, boat trips, and bathing at beaches, waterfalls, rivers, or lakes in the region. They can also purchase handmade products, taste food obtained from local lands, and even participate in festivities and cultural events that take place in the region.

Conclusions

The northern portion of the territory of the Rio de Janeiro Cliffs and Lagoons Geopark Project exhibits notable natural and manmade heritage, with landscapes of expressive scenic beauty, places of scientific importance, and sites associated with relevant historical and cultural values. Through the locations selected in this study, the area demonstrates capacity for the development of geotourism due to characteristics that consider its geology, history, and heritage. Both strictly natural places and places associated with anthropic interventions are part of the list of attractions.

The method to calculate the AP proved to be adaptable both to places with natural aspects and places with anthropogenic characteristics. The method for evaluating the PTU was developed for use in strictly natural places. Therefore, these two assessments must be calculated independently in order to obtain a final ranking for each of them. Nevertheless, we can say that both complement each other and bring a broad view of the potential of each location to become a geotourist attraction. Of the 24 sites surveyed, 23 had high AP. The exception was Solar dos Airizes, which was classified as having medium potential due to its deteriorated state of conservation.

Several tourism segments already take place in the area, which can be considered an advantage as the existing services and infrastructure may come to meet a possible geotourism demand. Furthermore, the advance of geotourism can contribute to extending the stay of visitors in the region and support efforts aimed at the conservation of attractions. It is expected that the increase in the number of visitors will promote a greater contribution of resources and develop local commerce and services.

It is essential that the local population is involved in the improvement of geotourism to make municipalities less dependent on traditional tourism and focus on this form of sustainable tourism. Geotourism provides a higher level of knowledge about the localities, which favors conservation and helps to find alternative means of income for the communities that live in its vicinity.

Finally, it should be emphasized that there is a need for partnerships between the public and private sectors to stimulate the development of geotourism in these municipalities. It is essential to dialog with governments and businessmen in order to outline strategies aimed at implementing geotourism activities. Moreover, it is important to listen to the opinion of the local population, who will legitimize this activity in their territory.

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Declarations

Conflict of Interests

All authors contributed to the study conception and design. Conceptualization, investigation, inventory, quantitative assessment, writing, and editing were performed by Rafael Alkoe Albani, Kátia Leite Mansur, and Wellington Franciso Sá dos Santos. The first draft of the manuscript was written by Rafael Alkoe Albani, and all authors commented on previous versions of the manuscript. All authors read and approved the final manuscript.

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