



Bibliometric Analysis of Geosite Assessment Methods and Examination of Two Prominent Models

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Abstract

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Here, we apply bibliometric analysis and geosite assessment models from the literature. The aim was to compare the two most frequently cited models, considering their strengths and weaknesses and the contexts in which they are most effective. We also considered diversity and interdisciplinary approaches in the applications of the models, and especially their validity in different geographical environments and their scale dependencies. The findings reveal that a single model may not be sufficient in all circumstances, and it is important to adapt model-specific criteria to field conditions.

Keywords: Geosite, Geoheritage, Quantitative evaluation, Assessment Models

Introduction

The concept of geoheritage (geological heritage) has recently gained prominence, focusing on the protection of natural formations on Earth, their sustainable use, the development of local economic development, and their integration into tourism (Brilha 2018). Geoheritage encompasses all geological and geomorphological formations with scientific, aesthetic, and cultural value that

represent the Earth's natural heritage and should be passed on to future generations (Brilha 2018). These formations include rocks, fossils, and geomorphological features that contain important information about the Earth's history and geodiversity (Gordon 2018). Geosites are remarkable geological, geomorphological, or paleontological areas within geoheritage areas that are suitable for scientific research, education, and sustainable tourism (Bruno *et al.* 2014). Geosites are funda-

mental components of geoh heritage protection, and they are based on scientific assessment of their importance at local, regional, and international levels (Newsome and Dowling 2018).

Geoparks registered by the UNESCO Global Geoparks Network may include multiple geosites within specific boundaries and they are used to promote geoe ducation, geoprotection, and geotourism (Komoo and Patzak 2008). Their contributions to natural environment education and the sustainable use of existing resources are key (Carrión-Mero *et al.* 2021). With all these features, geoparks are areas and governance systems where nature is conserved through a holistic approach, and activities related to education and sustainable development are carried out (Aytaç 2025). There are 229 UNESCO Global Geoparks in 50 countries, and this number will continue to increase every year (GGN 2025).

Numerous geoh heritage studies have been conducted (Hose 1995; Gray 2008; Kazancı 2010; Kazancı and Gürbüz 2014; Brilha 2016; Çiftçi and Güngör 2016; (Newsome and Dowling 2018; Abukan 2020; Aytaç *et al.* 2025; Göktaş and Boyraz 2025; Turoğlu 2025; Göktaş *et al.* 2025). The first steps toward the conservation of geoh heritage were taken in the 1970s with the initiation of the first systematic inventory studies. During these years, various countries developed comprehensive inventory projects. In 1977, the Geological Conservation Review was initiated in the United Kingdom and was comprehensively addressed by Ellis *et al.* (1996). In 1978, national projects were conducted in Spain, followed by similar initiatives in Norway during the 1980s, while in the Netherlands, the first geosite inventory was compiled by Gonggrijp (1988). Daly (1990) took significant steps with his study conducted in Ireland in 1990, while Grandgirard (1996) carried out inventory studies in Switzerland (Bruschi and Cendrero 2009). The First International Symposium on the

Conservation of Geological Heritage, held in 1991 in Digne, France, was the first scientific event focused on the protection of geological heritage and is considered by many researchers as the starting point of the “Geopark” concept. The final declaration of this conference, titled “International Declaration of the Rights of the Memory of the Earth,” brought the conservation of geological heritage to the agenda. Following the Digne Declaration, the European Association for the Conservation of the Geological Heritage (ProGEO) was established in 1995. Through this association, efforts have been carried out in Europe for the conservation of geoh heritage (Brilha 2016). In 1996, the Global Geosites Project was initiated under the leadership of Cowie (1993), (Wimbledon 1999, as cited in García-Cortés *et al.* 2019). In the 2000s, the geosite assessment model developed by Brilha (2002) focused on evaluating geoh heritage based on its aesthetic, scientific, and educational attributes (Brilha 2002). During the same period, Zouros (2007) and Reynard *et al.* (2007) developed multi-criteria models in which the touristic and ecological characteristics of geosites were also evaluated (Reynard *et al.* 2007; Zouros 2007). The models developed by Bruschi and Cendrero (2009) are transparent and more systematic approaches in which qualitative and quantitative methods are combined, allowing for objective evaluations (Bruschi and Cendrero 2009).

From past to present, many methods have been developed for geosite assessment to identify areas that are important in terms of geoh heritage as geosites, and to determine the management and tourism requirements of these areas. In other words, these geosite assessment methods serve as guiding tools for the determination and classification of geosites, the identification of conservation priorities, and the addressing of existing shortcomings. However, the use of different criteria and the establishment of distinct evaluation measures by each model in the literature make it difficult

to compare the data obtained from these models. In particular, there is a lack of systematic analysis in the literature regarding which model should be prioritised and would yield better results in determining the specific needs of geosites (such as scientific, educational, conservation, or tourism purposes). On the other hand, from the perspective of geotourism development, the results of these assessment methods have very limited direct use, because their evaluation criteria do not reflect the needs of the general public, who represent the largest potential group of geological heritage visitors (Štrba *et al.* 2023).

Although these methods do not contribute sufficiently to the development of geotourism, their contribution to identifying areas with potential geoheritage value, defining them as geosites, analytically determining their characteristics, and identifying their management and tourism needs is undeniable. Therefore, determining the characteristics of the main methods and their applicability is a current knowledge gap.

The aim of this study is to examine geosite assessment models through bibliometric analysis. Our bibliometric analysis reveals the two models with the highest citations, the broadest collaboration/network sharing, and the most prominent role in the literature. Our findings will contribute to the development of a comparative framework for the protection and management of geological heritage.

Materials and Methods

Research Design

Bibliometrics is a method used to quantitatively analyse scientific publications and assess annual trends in scientific output, most cited publications and sources, leading authors and their productivity patterns, authors' academic output over time, keyword distribution, citation analysis, and academic collaboration networks (Aria and Cuccurullo

2017; Büyükkıdık 2022).

In this study, the literature on geosite evaluation models was systematically reviewed using bibliometric analysis. The dataset was obtained from international academic databases and analysed accordingly (Fig. 1). Within the scope of the bibliometric analysis, we generated historiographs (historical citation networks), collaboration networks of leading authors, and co-citation network maps.

This study was structured in accordance with the PRISMA-2020 guidelines for bibliometric study of the international literature on geosite assessment models.

Information Sources

The data used in this study were obtained from the international academic databases Web of Science (WoS) and Scopus, which were chosen because they enable comprehensive publication searches at an international level. 616 documents were retrieved from the WoS database, and 579 documents from the Scopus database, for the years 2000-2025. The reason for selecting 2000 as the starting point is that the

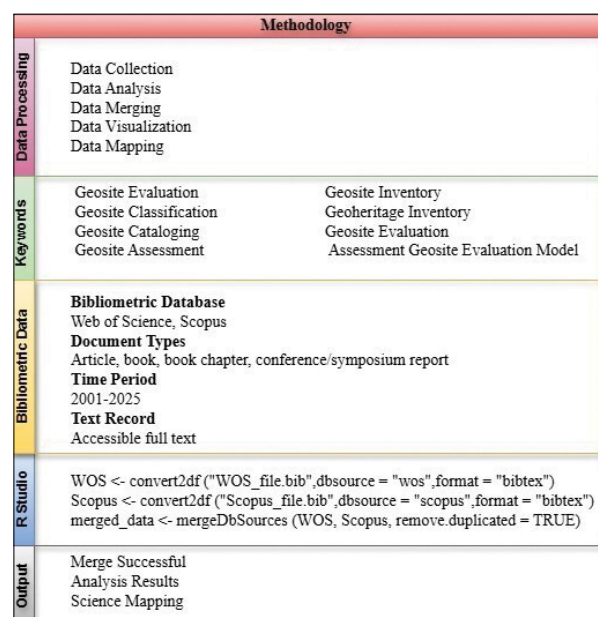


Figure 1. Research methodology and data processing protocol.

earliest relevant study is from that year. The documents from both databases were combined using R Studio, and duplicate publications were removed, resulting in a total of 580 articles for the analysis.

The search strategy was to use keywords based on the scope of the study, including: “*Geosite Evaluation OR Geosite Classification OR Geosite Cataloguing OR Geosite Assessment OR Geosite Inventory OR Geoheritage Inventory OR Geosite Evaluation Assessment OR Geosite Evaluation Model.*”

Eligible publications for inclusion were articles, books, book chapters, and conference/symposium proceedings indexed in the Web of Science (WoS) and Scopus from the years 2000-2025. We excluded publications that do not contain a geosite evaluation model and publications for which the full text is not available.

Data Analysis

The resulting bibliographic data was analysed using the R programming language, and datasets were processed using the Bibliometrix package (Aria & Cuccurullo 2017). The imported publications were converted to appropriate data formats. The main R code is summarized below.

```
# Loading the required libraries
```

```
Library (bibliometrix)
```

```
# Importing Web of Science and Scopus datasets into the R environment and format conversion
```

```
WOS ← convert2df(“WOS_file.bib”, dbsource = “wos”, format = “bibtex”)
```

```
Scopus ← convert2df(“Scopus_file.bib”, dbsource = “scopus”, format = “bibtex”)
```

```
# Merging two different datasets and removing duplicate records
```

```
merged_data ← mergeDbSources(WOS, Scopus, remove.duplicated = TRUE)
```

Results

Bibliometric Analysis Results

We found that the Brillha and Reynard models were the most frequently used in the literature, based on their co-citation networks and author collaboration analyses. These two models occupy a central position among geosite assessment models, are interconnected with other models, and have served as a foundation for the development of new models. However, the results do not assess whether these models are the most accurate or the best. There could be many reasons why these models have been widely used, cited, or are popular. For example, they were developed by experts in regions where geoconservation research is most intensive.

The historiograph analysis identifies the study by Vujičić *et al.* (2011) as the earliest highly cited work. It is observed that after 2016, various researchers began to receive a high number of citations for their methodological studies, and the two most cited works are Brillha (2016) and Reynard (2016), which have the largest network nodes, and have served as references for many subsequent studies (Fig. 2). Brillha’s studies have been particularly referenced in relation to the conservation of geoheritage and its association with tourism, while Reynard’s works have been primarily utilised for evaluating geosites in terms of their natural and landscape values.

The graph obtained from the co-citation network analysis (Fig. 3) reveals that certain authors and methodologies stand out in the field. In particular, Reynard and Brillha show the highest density in the scientific literature, indicating that both authors have introduced methodologies that are frequently used and have become key references in the field.

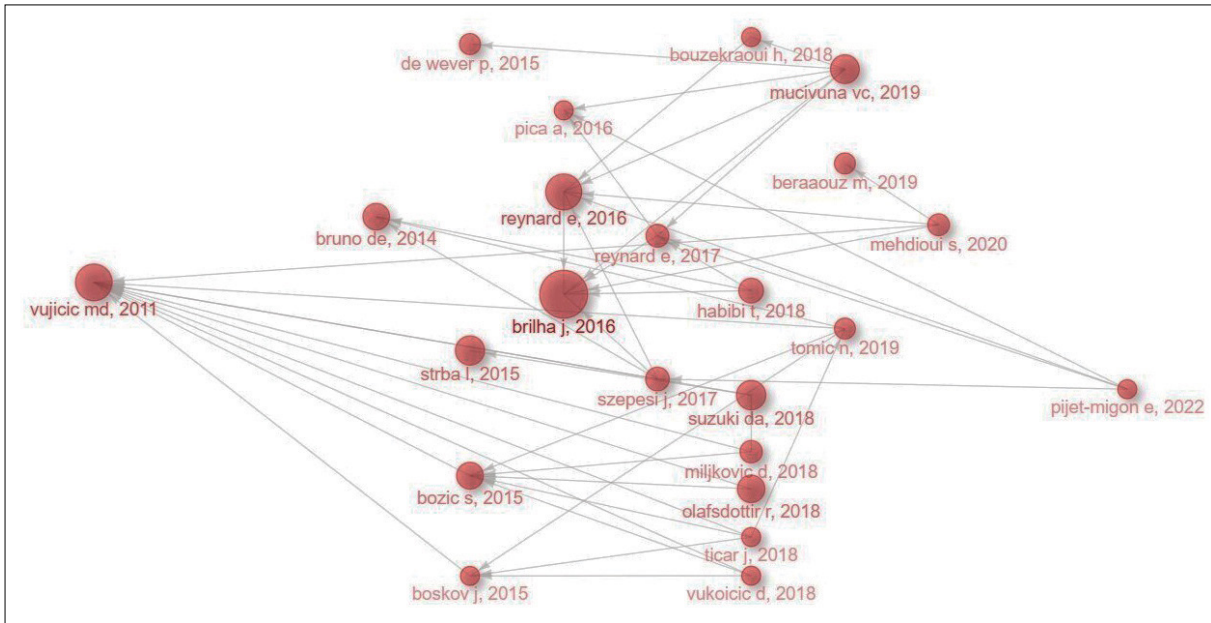


Figure 2. Historiograph, showing that Brillha and Reynard occupy the core of the network, with all citation pathways from past to present converging around them. In this way, these two authors play a central role in shaping the flow of information throughout the literature.



Figure 3. Co-citation Network, showing that the research topic has clustered around two principal authorities. An examination of the dense red zones reveals that Brillha forms an academic cluster with researchers such as Gray and Ruban, whereas Reynard forms another cluster with scholars including Panizza, Coratza, and Pereira.

The author’s collaboration network analysis results indicate that there is an extensive collaboration network in the literature. Many researchers have gained prominence through collaborative efforts (e.g., Ruban, Markovic, Berrezueta, etc.), and unexpectedly, perhaps it is observed that Brillha and Reynard have more limited collaborations with other researchers (Fig. 4).

All of these analyses demonstrate that the Brillha

and Reynard models have had the greatest academic impact in geosite assessment processes, making a comparison of these two models appropriate. The scientific frameworks of these two methodologies, along with their strengths, weaknesses, and differences in areas of application, will be compared, and an analysis regarding geosite assessment processes will be presented based on this comparison.

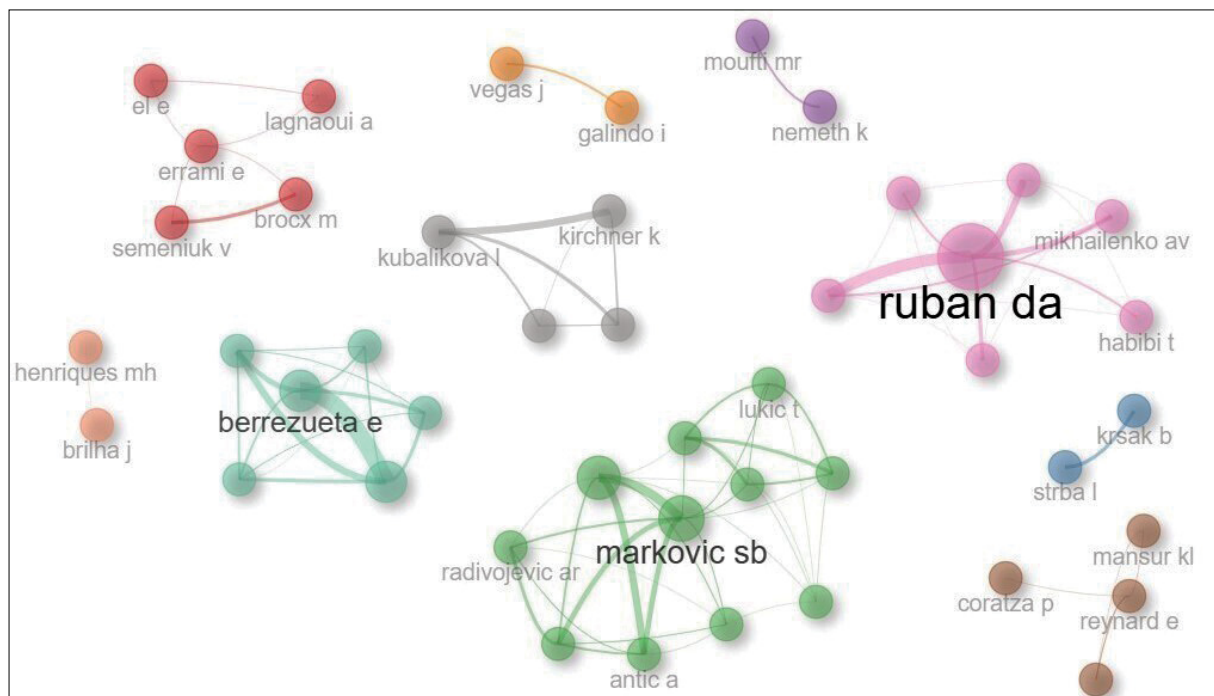


Figure 4. Collaboration Network, showing a fragmented overview of shared relationships. The groups led by Ruban and Markovic have extensive collaboration. However, Brilha and Reynard have formed smaller collaborative networks, showing that they are not cooperating intensively.

Reynard Model: A Method for Assessing “Scientific” and “Additional Values” of Geomorphosites

Reynard *et al.* (2007) developed an assessment method based on the scientific and additional values of geosites, building upon earlier methodological approaches introduced by Bruschi and Cendrero (2005). This model was developed to enable the analysis of geosites based on their scientific characteristics, with four sub-criteria, as well as their ecological, aesthetic, and cultural factors, with 12 sub-criteria (Table 1). These 12 sub-criteria are grouped into three categories: ecological, aesthetic, and cultural values. Although this method does not explicitly examine the educational perspective of a geosite, it analyses concepts such as religious, historical, artistic, bibliographic, and geohistorical significance, as well as economic value (Zafeiropoulos and Drinia 2023).

The sub-criteria are scored on a scale of 0- 0.25

-0.75 -1. A score of 1 indicates that the criterion is at the highest level, while a score of 0 indicates that the criterion is completely absent. In the applied model formula, the additional criteria under the additional value and scientific value are summed and divided by 4. The additional values and scientific values are calculated separately by summing their sub-criteria. The overall value of the geosite is obtained by summing the scores obtained from the scientific and additional values. (Reynard *et al.* 2016). The model formulae are as follows:

Scientific Value = (Integrity + Representativeness + Rarity + Paleogeographical Value) / 4

Additional Value = (Ecological + Aesthetic + Cultural) / 3

This model provides a general perspective on how geosites should be managed and how conservation efforts should be undertaken (Reynard and Coratza 2013).

Table 1. A method for assessing “scientific” and “additional values” of geomorphosites. (Modified from Reynard *et al.* 2007; Zafeiropoulos and Drinia 2023).

	Scientific Value (SV)	Additional Value (AV)		
		Ecological Value (ECOL)	Aesthetic Value (AEST)	Cultural Value (CULT)
Emmanuel Reynard, Georgia Fontana, Lenka Kozlik, Cristian Scapozza, 2007	Integrity (Int)	Ecological impact (Eci)	Viewpoints (VP)	Religious importance (REL)
	Representativeness (Rep)	Protected site (PS)	Contrasts, vertical development, and space structuration (STR)	Historical importance (HIS)
	Rarity (Rar)			Artistic and literary importance (ART)
	Paleogeographic value (Pgv)			Geohistorical importance (GEO)
				Economic value (ECON)

Scoring System: 0- 0.25 - 0.75 - 1

Applied Formula:

$$SV = (Int + Rep + Rar + Pgv) \div 4$$

$$AV = (ECOL + AEST + CULT) \div 3$$

Brilha Model: Inventory and Quantitative Assessment of Geosites and Geodiversity Sites

The method developed by Brilha (2016) is a general-purpose method that aims to evaluate any type of geosite using four criteria: scientific value (SV), potential educational use (PEU), potential tourist use (PTU), and degradation risk (DR) (Table 2). Seven criteria are considered to assess the scientific value of a geosite, including representativeness, scientific knowledge, rarity, and geological diversity. Twelve criteria, including sensitivity, accessibility, and didactic potential, are used to assess the educational potential of a geosite. Thirteen criteria are used for the assessment of geotourism potential; the first ten are like educational criteria, and the remaining three consider interpretive potential, economic level, and proximity to recreational areas (Zafeiropoulos and Drinia 2023).

In applying the Brilha (2016) method, each assessment criterion is assigned a score between 0 and 4. These scores are combined using a weight-

ed sum method to yield quantitative results across three main dimensions: potential educational use (PEU), potential tourist use (PTU), and risk of degradation (DR). The PEU assessment is based on the scoring of a total of 12 criteria, including the educational suitability of the site’s geodiversity elements, low sensitivity, easy observability, safe visiting conditions, and appeal to different age groups. The PTU assessment, on the other hand, comprises 13 criteria, including aesthetic appeal, easy comprehensibility, low risk of degradation, and tourist infrastructure. The DR assessment also includes five sub-criteria, including accessibility and population density, which are advantages for PEU and PTU, while they are risks for DR. An area may receive a high DR score through factors such as intense human activity, low legal protection, and vulnerability to environmental threats. This provides a multifaceted understanding of both the potential for use and the need for protection for each area, providing a solid basis for strategic management decisions (Table 2).

Table 2. Inventory and quantitative assessment of geosites and geodiversity Sites (Modified from Brilha 2016; Zafeiropoulos and Drinia 2023).

	Scientific Values (SV)		Potential Educational Use (PEU)		Potential Touristic Use (PTU)		Degradation Risk (SR)	
	Criterion	Weight	Weight	Criterion	Criterion	Weight	Criterion	Weight
José Brilha, 2016	Representativeness	30	10	Vulnerability		10	Deterioration of geological elements	35
	Key locality	20	10	Accessibility		10	Proximity to areas / activities with potential to cause degradation	20
	Scientific knowledge	5	5	Use limitations		5	Legal protection	20
	Integrity	15	10	Safety		10	Accessibility	15
	Geological diversity	5	5	Logistics		5	Density of population	10
	Rarity	15	5	Density of population		5		
	Use limitations	10	5	Association with other values		5		
			5	Scenery		15		
				Uniqueness	10			
				Observation conditions	5			
			Didactic potential	Interpretative potential	10			
			Geological diversity	Economic level	5			
				Proximity of recreational areas	5			

Scoring System 1, 2, 3, 4 (Value of 3 is committed at SV)

Total weighted	Degradation risk
<200	Low
201 – 300	Moderate
301 – 400	High

Discussion

The two fundamental approaches that stand out in the literature for the assessment of geological and geomorphological heritage, Reynard *et al.* (2007, 2016) and Brilha (2016) were developed with a similar aim, but they differ in terms of content, scope, and methodological perspective.

Brilha (2016) defines geological heritage (geoheritage) as being embodied in the exceptional elements of geodiversity, including minerals, fossils, rocks, landforms, soils, landscapes, and active geological and geomorphological processes, thereby encompassing all Earth science disciplines such as geology, mineralogy, petrology, geomorphology, and palaeontology. Within this broad framework, Reynard conceptualises geomorphosites as a specific subcategory of geosites, defined as spatially well-delimited portions of the geosphere with geomorphological interest, formed by landforms and the present or past processes associated with them (Reynard 2004; Reynard *et al.* 2007). Importantly, the value of geomorphosites in Reynard's approach extends beyond their core scientific significance to include additional ecological, economic, and cultural dimensions, reflecting a key difference between the two methods. By employing the term "geomorphosite," Reynard emphasises a holistic understanding in which scientific and additional values are inherently combined within a single concept, treating geomorphosites as multidimensional heritage components and integrating socio-cultural meaning into scientific analysis. In contrast, Brilha (2016) distinguishes between "geosites" and "geodiversity sites," so that scientific value is separated from use-related values. Through this conceptual separation, the Brilha method prioritises methodological clarity by distinguishing scientific value from use value.

Reynard *et al.* (2007) aimed to address subjectivity in geosite assessment by developing a method that ensures consistency in geomorphosite inven-

tories and integrates qualitative and quantitative evaluations through the separation of scientific and additional values. Although this approach represented an important methodological advance (Villalobos *et al.* 2004; Bruschi & Cendrero 2005; Zouros 2007), its application revealed limitations related to objectivity, scalability of criteria, protection-use conditions, accessibility, and safety. In response to these shortcomings, Reynard *et al.* (2016) expanded the method by introducing an integrated framework that established a selection–assessment–use–management–evaluation cycle and placed greater emphasis on the social use of geosites, incorporating indicators of accessibility, safety, tourism infrastructure, interpretive resources, and educational potential.

The method developed by Brilha focuses on geodiversity and geosite assessment, seeking to avoid the interchangeable and often incorrect use of concepts such as "geosite," "geological heritage," and "geodiversity," and the uncertainty regarding the verifiability of inventory results. While various methods in the literature aimed to increase the scientific value by grouping touristic and educational values under the same category, Brilha (2016) was the first to propose a model to evaluate geosites based on their scientific value and their educational or touristic potential. In this approach, a geosite is defined solely by its scientific value; aesthetic, cultural, or economic qualities are excluded from the scientific assessment and examined under independent categories. The model established seven criteria for assessing scientific value (Representativeness, Key Locality, Scientific Knowledge, Integrity, Geological Diversity, Rarity, Use Limitations), and it defined separate criteria for evaluating educational or touristic potential. In this respect, the Brilha approach offers a more detailed, quantitative, and comparable structure in terms of scientific value and introduces a multilayered and more informative structure instead (Table 3). The Brilha method does not include economic value in

Table 3. Comparison of the Reynard *et al.* (2007, 2016) and Brilha (2016) models.

Criterion	Reynard Model	Brilha Model
General Approach	Allows for the joint evaluation of scientific and additional values. The scientific, cultural, and economic values of geosites are taken into account.	Evaluates scientific, educational, and touristic values separately. Priority is given to the conservation requirements of geosites.
Main Objective	Assessment of geomorphological heritage in terms of scientific and additional values.	Ranking of geosites based on their scientific, educational, and touristic values and determining conservation priorities.
Scientific Value Criteria	Integrity Representativeness Rarity Paleogeographical value	Representativeness Key location Scientific knowledge Integrity Geological diversity Rarity Use Limitations
	The scientific value criteria such as scientific significance, rarity, and representativeness are common criteria widely accepted in most geosite assessment methods.	
Additional Value Criteria	Cultural value Economic value Ecological impact	Potential educational use Potential touristic use degradation risk
Quantitative Assessment	Includes semi-quantitative and qualitative assessment. In related studies, it is a common approach across all evaluation methods to convert qualitative concepts into quantitative data for generalization, and then conduct qualitative evaluations based on these quantitative values.	Includes semi-quantitative and qualitative assessment. Each geosite is scored to create a ranking.
Conservation Priority of Geosites	Includes a qualitative assessment of conservation measures and threats.	Creates a numerical priority ranking based on the degradation risk factor.
Usage Areas of Geosites	Evaluation for scientific research Geotourism planning Conservation prioritization	Determining the conservation priority of geosites Use for geotourism and educational purposes National and international geosite inventory studies
Data Sources	Based on literature review, field studies, expert opinions, and quantitative analysis methods.	Includes field studies, literature review, expert opinions, and quantitative analysis methods.

Methodological Flexibility	Applicable at different scales (micro and macro). It is more commonly applied at the scale of specific areas.	More suitable for large-scale inventory studies.
Integration with GIS	Can be partially integrated with Geographic Information Systems (GIS).	Can be fully integrated with Geographic Information Systems (GIS), allowing for spatial analysis of geosites.
Strengths	<p>A comprehensive model that includes both the scientific and additional values of geosites</p> <p>Inclusion of aesthetic, economic, and cultural factors provides an advantage in geotourism planning</p> <p>Can be used to determine conservation priorities</p>	<p>Offers a systematic and quantitative methodology, facilitating the comparison of geosites</p> <p>Includes a mechanism for determining conservation priorities</p> <p>By evaluating educational and tourism potential separately, it allows geosites to be adapted to different usage scenarios</p>
Weaknesses	<p>Additional values may be subjective; especially the evaluation of aesthetic and cultural values can vary depending on the observer</p> <p>Conservation prioritization is less systematic compared to the Brilha model.</p> <p>As scientific and cultural values are intertwined, prioritizing geosites can sometimes be challenging</p>	<p>Since the scientific, educational, and touristic values of geosites are evaluated separately, geosites that are not scientifically significant may sometimes receive high scores.</p> <p>Requires a comprehensive and time-consuming process</p> <p>The ecological and cultural aspects of geosites are addressed to a lesser extent</p>
Recommended Use Scenarios	<p>Geotourism planning and management</p> <p>Evaluation of geosites with a focus on aesthetic and cultural aspects</p> <p>Projects supported by GIS for spatial analysis of geosites</p>	<p>National and international geosite inventory studies</p> <p>Prioritization of geosite conservation</p> <p>Geosite assessment for geotourism and educational purposes</p> <p>Projects supported by GIS for the spatial analysis of geosites</p>

the assessment, and educational (PEU) and touristic (PTU) assessments are carried out under separate categories.

Reynard’s method includes four scientific criteria (representativeness, rarity, integrity, palaeogeographical value), and these are mostly based on physical characteristics, as well as components

such as the landscape aesthetics, cultural background, economic benefit, or ecosystem integrity of the area. This approach, by analysing the social, cultural, and visual values of geomorphosites on the same plane as the scientific value, offers a highly suitable evaluation structure for geotourism, cultural landscape management, and local development projects. Reynard’s method is both

qualitative and semi-quantitative; the scores range from 0–1 and allow a wide space for expert interpretation. Reynard includes economic potential and the impact of touristic income in the evaluation criteria, so the social, cultural, and landscape relationships of a geomorphosite become strongly visible (Table 3).

The two models differ in their treatment of threat and risk analysis. The Reynard model addresses degradation risk qualitatively by identifying natural and human-induced threats, leaving its interpretation largely to expert judgment without numerical scoring. In contrast, the Brilha model evaluates degradation risk through an independent, systematic, and numerical framework, allowing scientific value and risk to be jointly interpreted to define conservation priorities. As a result, the Brilha model provides a more measurable and management-oriented approach to risk-based geosite conservation.

The Reynard and Brilha models differ significantly in their treatment of educational value. In the Reynard model, educational value is not assessed directly but is embedded indirectly within additional values related to aesthetic, cultural, and geomorphological qualities, reflecting a holistic view of heritage. In contrast, the Brilha model evaluates educational value as an independent component through a detailed and numerical framework, providing a clear and measurable indicator of a geosite's educational suitability. Consequently, Reynard's approach is more contextual and landscape-oriented, whereas Brilha's method is more technical and systematic in assessing educational potential.

The methods also differ in terms of application scale and purpose. The Reynard method is designed mainly for regional-scale geological-geomorphological heritage inventories. The Brilha method, however, was developed to ensure comparability in national and international inventories

and has become a widely used approach in official processes such as UNESCO Global Geoparks applications.

Conclusion

Our bibliometric study revealed that the two preferred methods in the literature are those developed by Brilha (2016) and Reynard *et al.* (2007, 2016). These two models offer different yet complementary approaches to the assessment of geological heritage. The Brilha model stands out for standardising inventory, assessment, and management processes and for enabling the quantitative and comparable evaluation of scientific value; however, it also has limitations, particularly its strong reliance on expert judgment and its failure to directly address visitor perception and aesthetic experience. The holistic approach developed by Reynard and colleagues provides a conceptually robust and multidimensional framework that integrates scientific, cultural, and environmental values, but its predominant reliance on qualitative assessments and expert interpretation constrains comparability and objective decision-making processes.

In both models, educational and tourism potential, as well as visitor experience, are assessed through indirect or limited criteria, while degradation risk and criterion weighting do not sufficiently reflect temporal, regional, and dynamic variations. Consequently, despite their respective strengths, these approaches require support from quantitative decision-support mechanisms and user-oriented evaluations to ensure effective and sustainable geological heritage management and the development of geotourism.

In future work, GIS-supported analyses should be developed to determine the spatial distribution and conservation priorities of geosites. This should enable analysis of the economic impact of geotourism, developing and testing new geosite

assessment methods, and proposing more comprehensive models for geoparks and protected areas. Any new analysis method should include criteria that contribute more effectively to the development of geotourism, and tourism experts should participate in the development of the method alongside geoscientists. Consequently, striking a balance between scientific accuracy and sustainable use and conservation strategies is essential for effective geological heritage management. A common model that combines the strongest aspects of the Brilha and Reynard approaches while also synthesising existing new methods may offer a more comprehensive and applicable framework for geosite assessment processes.

Author's Contributions

Abukan (40%) was responsible for defining, implementing, and writing the models. Göktaş (30%) was responsible for defining and writing the method. Aytaç (20%) and Boyraz (10%) contributed to the literature review.

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Data Availability

All data for this study are available from the corresponding author and will be available upon request via email.

Conflict of Interest

The authors declare no conflict of interest.

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